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Glulam in Architecture of Latvia and Lithuania

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***Abstract* – Latvia and Lithuania are producers of glulam and both have managed building projects with glued timber structures, but only as few as 1–2 projects per year. As it is difficult to find information about glulam projects it is possible that many projects are not known even to the audience of architects. The aim of this study was to collect information related to the glulam projects in both countries and the questionnaire was used to get the architects' opinion on the use of timber and glulam.**

***Keywords* – Architecture, engineered timber, glulam, Latvia, Lithuania, wood.**

Introduction

Glued laminated timber (glulam, GLT) production is developing every year expanding opportunities to use it in various structures. During the 20th century, production technology and equipment and composition of the adhesive was significantly improved [26], [35]. The number of the manufacturers of glulam was increasing worldwide [25] as well as in the Baltic countries [17], [18]. At the same time, the number of construction projects [15] using glulam was increasing and getting bigger, higher and more complex.

Historically, untreated wood and logs, sawn timber and engineered timber are all typical building materials in the Baltic and many other countries [11]. For centuries, wood has been used for the construction of residential and public buildings of different sizes. Timber was glued with natural glues and used for production of furniture and musical instruments. The first glued timber plate material – now called plywood − was patented in the end of the 18th century, but it was not used for construction [10]. Some buildings with glued timber construction are mentioned in literature [22], [28] in the 19th century in the United Kingdom. But Otto Hetzer (Weimar, Germany) was the first who demonstrated how beams and arches can be industrially laminated together into units with great composite sections and could be used in structures for wide span. In 1906, Hetzer got the patent for the invention that laminates boards to curved members [11]. At the beginning of the 20th century, when steel in Europe became a commodity in short supply, Guttorm Brekke bought the patent and spread glulam production in Scandinavia [12].

In the last quarter of the 20th century, production of glulam started in the Baltic countries, in *Jūrės medis* (Lithuania). *Jūrės medis* is one of the largest manufacturers of glue laminated timber structures in the Baltic states. The company has produced glulam structures since 1974 [18]. In Estonia glulam production started in 1979 under the name of *Põlva KEK* (now *Liimpuit*) [10]. The first glulam factory in Latvia started production in 2001 [32]. At moment, there are 4 big and some smaller glulam producers in the Baltics. Precise data of buildings with glulam structure are not available in Latvia and Lithuania. To compare the number of known glulam projects with the total number of buildings put into service in the country [6], it is less than 1 %. All glulam factories in the Baltics produced for foreign projects and exported most of production.

Estonia is not included in this research because the situation with information and promotion of wood architecture is different there. Since 2002, in Estonia wood architecture competition with a special prize for glulam projects has been organized [31]. That is the reason why the information about glulam projects is better summarised than in other Baltic countries.

There are different possibilities to use glued timber − straight and curved, double curved and block glued [13], [14], [25], [31]. By laminating a number of smaller pieces of lumber, a single large, strong, structural member can be manufactured, and resources are used more wisely and economically. Some of the glulam projects are very rational and glued timber is used as a functional building material, but some projects are designed to use aesthetics and other benefits of wood [16]. The factories producing glulam are able to deliver bigger dimensions, longer structures and new shapes [16], [26]. Parametric modelling and other digital instruments (computer-controlled fabrication, CNC) [35] provide new possibilities for glulam use in wood architecture.

Important factor for increasing the use of glulam in projects is a unified European certification of timber products and Eurocode for design of timber structures [7]. The standard for glulam production is EN14080 "Timber Structures – Glued Laminated Timber – Requirements" [8]. In construction, only the glulam produced according to the requirements of this standard can be used. Accordingly, it ensures the quality of the glulam in the structure of building and reduces the customer's concerns. Glulam has much lower embodied energy than reinforced concrete and steel and it is a good solution to reduce the environmental impact [3]. Glulam is a sustainable building material, easy to access, design and erect, with good technical parameters [33]. So, there is no reason why glulam is not used more extensively in the architecture projects of Lithuania and Latvia. In Europe there are some papers [19], [26] that have examined the use of glulam in architecture, and there is Glulam Handbook [10]. Similar studies in Norway and Sweden determine the attitude of architects and engineers to use wood [4], [5],[15], [24].

The objective of this research is to determine current situation concerning the use of glulam structures in Latvia and Lithuania and to investigate the main motivation and barriers for architects to use wood, especially the glued laminated timber as main building material. The study has a purpose to ascertain the situation in the market, access to material, demand for glulam, the type of glulam that is used and whether it is an added value to the architecture of building.

I. Methods

The methods used in this descriptive research were chosen to determine the current situation regarding glulam projects in both countries – Latvia and Lithuania. The study was conducted in four phases with the objective to cover the widest possible range of information about glulam – production, design, construction (Phase 1, 2, and 3) and demand, information, barriers, and motivation (Phase 4). The qualitative and quantitative research methods [26] were combined to identify today's situation in use of glued timber in wooden architecture.

In the first and second phase, quantitative research methods were used to explore the glulam projects and analyse them by assigning points (Appendix, Table II). In the third phase the qualitative research method or design evaluation [29] was used to describe six glulam projects. During Phase 4, questionnaires were developed to collect stakeholders' opinion among wider audience of architects. All used research methods were coordinated to have deeper understanding and to investigate where and why glulam is used or is not used.

A. Data Collecting

To collect the information about glulam projects, primary and secondary data were used. The data about architecture objects with use of glulam were collected about the projects erected from 1987 till 2019. The information was searched in the magazines and other media on Architecture and Construction, in the project lists of awards in Architecture and Construction and other web sources. The requests for information about glulam projects were sent to the three glulam factories in Latvia, Lithuania and Estonia. Information was not requested from the producers, such as *Silales Medis* (Lithuania), Easywood, EHI (Latvia), etc., producing smaller dimension glulam for private houses. After completing the list of glulam projects, the information was verified and some projects were removed because of lack of information or wrong information.

B. Analysis of Glulam Projects

All projects in the list were analysed by four parameters according to use of glulam in the interior and exterior − two evaluations (EXT1, EXT2) of the exterior and two evaluations of the interior (INT1, INT2).

Table I. Evaluation of Exterior and Interior of Glulam Projects [Authors of the article]

1	2	3	4
EXT1	EXT2	INT1	INT2
Wood is visible in the exterior and is the part of the architectural wholeness	Wood is not visible in the exterior but impacts the form of the building	Wood is visible in the interior and is part of the interior aesthetics	Wood is not visible in the interior but impacts the inside space of the building

EXT1 − some parts of glulam elements can be seen in the exterior of the building, for example beams or columns, and it plays an important role in the aesthetics of the facades. The overall shape of the building belongs to the form of elements, for example the curve of the roof is the same as the curve of the beams.

EXT2 − the overall form of the building is similar to the form of elements, for example the curve of the roof is the same as the curve of the beams. There are no visible wooden parts in the exterior of the building, and it is difficult to say what material is used to build the structure of the building without entering the building.

INT1 – the glulam elements are inside the building and their appearance is included in the wholeness of the interior aesthetics. Beams or columns make rhythm or meter in the space warming the interior by the colour and texture of wood.

INT2 – there are buildings where the wooden glulam elements are hidden in the ceilings, walls or floor.

For execution of the parameter projects were awarded 1 point. Each project could be awarded 0 or 1 for each parameter. The final score could be 1 or 2 points.

C. Evaluation of Glulam Projects

Phase 3 of the research consisted of selecting and evaluating several projects by the criteria whether glulam is an added value to the architecture of building. The main parameters for selection were two awarded points during the analysis and the use of glulam as structural material. An additional requirement for selected projects was function. The sports buildings were excluded because the use of glulam is due to the need for wide span.

The purpose of evaluation was not to determine the value of the architecture, but to identify additional value of wood in the architecture.

D. Questionnaire for Architects

Another important part of the study was collecting the opinion of architects of Latvia and Lithuania. This stage was started by creating a seven-question questionnaire [1], [23]. It was drawn up in English and then translated into Latvian and Lithuanian to make it easier for respondents. The Likert scale survey questions and open questions were used to find out the main reasons and barriers for glulam use. The Likert scaling was used as a scaling method [30], which is measuring either positive or negative (agree or disagree) response to a statement about wood architecture and wood as a building material. Open questions were not compulsory but offered to express any different opinion and give the comments.

II. Results and Discussion

The results of the investigation were merged to gain an insight into the situation regarding glulam projects in Lithuania and Latvia. The main outcomes of the research are a list of glulam projects and the architects` opinions on the use of wood.

E. List of Glulam Projects

During the first stage of research a list of glulam projects in Latvia and Lithuania was completed. The data selection process

Fig. 1. Holiday park in Zibininkai [Photo: A.Gabrenas, 2018].

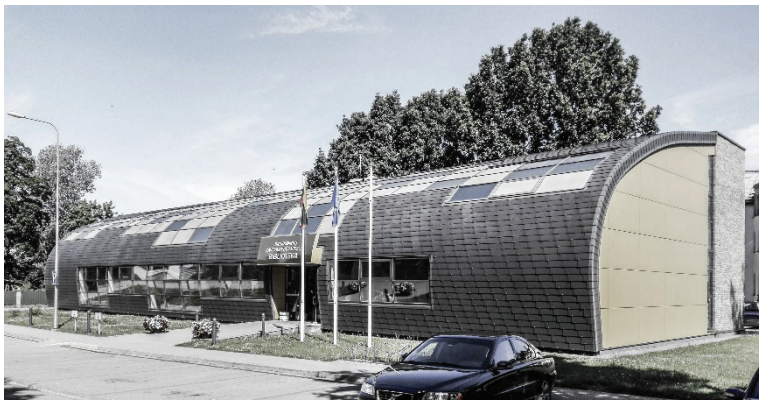

Fig. 2. Library in Druskininkai [Photo: A.Gabrenas, 2018].

Fig. 3. Sightseeing tower in Meteliai [Photo: A.Gabrenas, 2018].

started in Latvia. The printed media *Latvijas arhitektūra* (Latvian Architecture) and *Latvijas būvniecība* (Latvian Construction) were reviewed for years 2016 to 2018. There was information about wooden architecture projects, but the description of materials was short and general. Similar situation was in online media − www.a4d.lv [2], information about the materials was too general. In the list of projects of Annual Architecture competition in Latvia each year 1−2 projects with use of wood can be found [20]. Since 2015, award for a construction *Gada Būve (Building of the Year)* in Latvia had a nomination *Koka būve (Wooden Building)* [9]. Only once, in 2008, there was Wood Architecture Award in Latvia and the list of final projects are still available on internet [21]. Because of lack of accurate information about the use of materials media and award lists were not analysed in Lithuania.

A more accurate information was provided by glulam producers. The abundant **list of project**s was received from the *Jūrės medis* factory in Lithuania. Glulam producer *Superbebris* in Latvia and *Liimpuit* in Estonia did not answer to the request for information. Information about projects in Latvia was found in the web page of company Innovations in Timber Bridges and Structures or IKTK [17], operating since 2012.

For glulam projects list public buildings and projects were selected. Agricultural and industrial buildings and private houses were not selected for analysis and evaluation.

The list consisted of 43 glulam projects in Latvia and Lithuania. After additional verification of information of each project it was found that 2 projects were not located in Lithuania or Latvia, but in one project glulam was not used. The final list of 40 verified glulam projects − 20 from Latvia and 20 from Lithuania− was drawn up.

F. Analysis of Glulam Projects

The main function of glulam projects (Appendix, Table II) is sports buildings − swimming pools, SPA centres, sports halls, ice arenas. The rest of the projects have a wide range of public functions – libraries, churches, bus stations, offices, car showrooms, and shopping malls.

In total, 18 projects have wood visible in the exterior (EXT1), 36 projects have wood visible in the interior (INT1). There was no project with wood not visible in the interior (INT2) and in 5 projects glulam is not visible outside, but it has impact on the structure and form of the building (EXT2). The listed glulam projects (Appendix, Table II) were evaluated by impact of glulam on interior (1 point) and exterior (1 point). Each project could get 1 or 2 points, and 19 projects got 2 points.

G. Evaluation of Glulam Projects

From the glulam project list (Appendix, Table II) projects for deeper evaluation of value of architecture were selected. The list was shortened to 19 projects that had been given 2 points. From this list 3 glulam projects from each country (LV1, LV17, LV18, LT2, LT18, and LT20) were selected to evaluate if the use of wood in the project resulted in additional value of architecture [26].

H. Glulam Projects in Lithuania

Holiday Park by architect Stasys Juska built in 2015 in Zibininkai, Kretinga area, near Palanga (Fig. 1). It is a complex of buildings with a conference centre, hotel and SPA. The most important and interesting space is in the biggest building having a form of a circle in the plan. There is the main hall of pools covered using the GLT beams to have a capacious space with three different types of pools under one roof. The space is attractive and looks cozy regarding the colour and texture of the wooden elements. The wooden elements are connected to the aesthetic structure holding the roof. Some GLT beams are visible outside the building and the wooden structure impacts the form of the roof. Also, the wood is used for facade cladding for almost all buildings of the complex. An accent of all composition is the tower planked with wooden boards.

Library in Druskininkai (Fig. 2) by architects Justina Padvarskaitė and Danutė Padvarskienė was built in 2012.

Fig. 4. Kipsala International Exhibition Centre [Photo: BT1, 2015].

Fig. 5. Saldus Music and Art School [Photo: Made Architects, 2018].

From the exterior of this building looks like a metal tube or a modern train. No wooden elements can be seen from outside, this form is realized using the wooden GLT beams. Beams are used not only to hold the metal shell of the building, they also harmonize the wholeness of the architecture. In the interior beams play an important role of warm the atmosphere of the library. Also, the well-visible wooden elements are dividing the long space of the building. The building looks a bit cold from the outside but nice and warm inside so there is an interesting aesthetical contrast.

Sightseeing tower (Fig. 3) **in Meteliai** by architect Arvydas Gudelis was built 2015. This building provides the possibility to see beautiful lakes of the area from the above. GLT columns were used to make aesthetics of the architecture. The columns are holding stairs, railings, and floors. The columns are composed in a special way to have a dynamic and modern form. Wood in the construction of this building makes good associations with the nature and traditional architecture of the area. This building is one of the most interesting sightseeing towers in Lithuania and shows the aesthetical and technical possibilities of the GLT elements as well.

I. Glulam Projects in Latvia

Kipsala International Exhibition Centre (Fig. 4) by architecture office *Pilsētprojekts* was started in end of the 80-ties. Initially it was planned as Sports Arena for Riga Technical University.

It was replication of glulam structure of Sports Arena built in Panevezys in Lithuania. Because of changes of political and economic situations, after erection of glulam arches the construction process was stopped for some years. After finding partners and changes in the design of the building the construction process was completed. Now this is the biggest specialised exhibition complex in the Baltic countries. Wooden arches are not seen from outside and the building looks as a regular hangar with a semi-circular roof, whereas inside the beauty of wood construction and cladding are the main part of interior.

Saldus Music and Art school (Fig. 5) by architect office Made (architects Mikelis Putrams and Linda Krūmiņa) was built in 2013. The school is a municipality owned building designed by the winners of competition in 2007. Glued timber is used for wall panels and it is not a traditional use of glulam. Timber wall panels are enveloped with glass outside and gypsum inside according to legislation. The facade consists of massive timber panels covered with profile glass. These panels form a part of an energy efficient natural ventilation system, which serves to preheat inlet air during winter. Good climate for people and for musical instruments inside the classrooms is reached with accumulation of humidity through the massive wood walls with lime plaster. The materials and structure of the building work as passive environmental control at the same time exhibiting its functionality. Inner concrete walls and through the glass visible outside massive wood wall exhibit their natural origin.

Office building in Dundaga (Fig. 6.) by architects' office *5. iela* (architect Ija Rudzīte) was built in 2016. The building is the Customer Centre of northern region of Kurzeme of Latvia's State Forests. It is an office building with two floors with visible timber in interior and exterior. Glulam is used for load-bearing structure and wood is used for cladding as well. The building has well-considered architectural solutions that are combined with modern design, use of natural materials, and low energy consumption. The project demonstrates wide range of opportunities of using wood. This was a pilot project with use of different wood structures for the architects' office as well as for the construction company. The result is a good example of wooden architecture, which had received awards of local and international competitions.

The evaluation shows that all projects use the appearance and aesthetics of wood or technical advantages of glulam to cover wide spans. All the selected projects have wood visible in exterior or interior, but in four projects in both − exterior and interior.

Fig. 6. Office building in Dundaga [Photo: LVM, 2017].

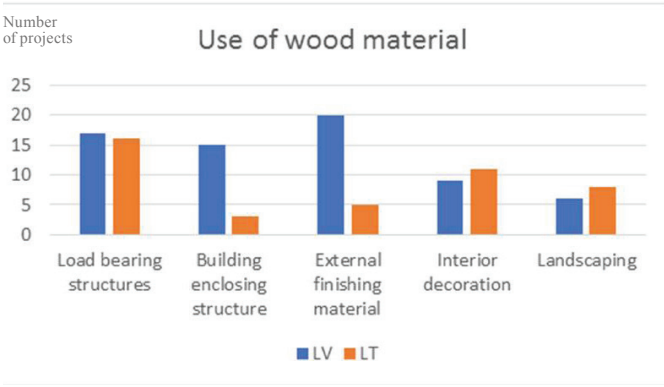

Fig. 7. Use of wood in respondents` projects [Authors of the article].

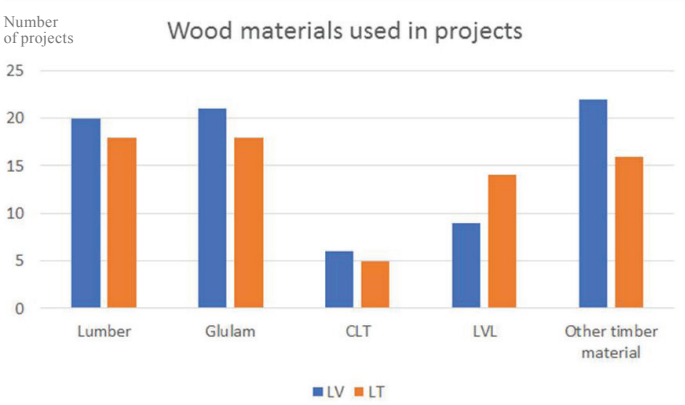

Fig. 8. Wood materials used in respondents` projects [Authors of the article].

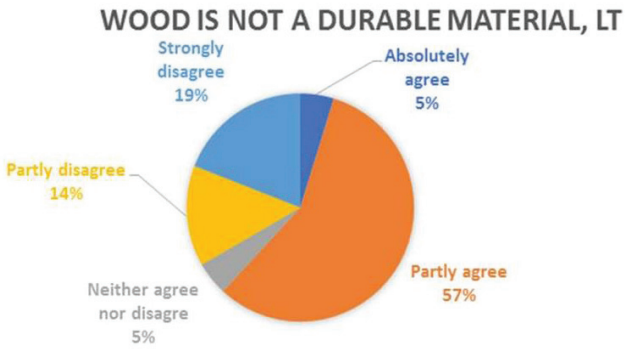

Fig. 9. Lithuanian architects' opinion about wood properties [Authors of the article].

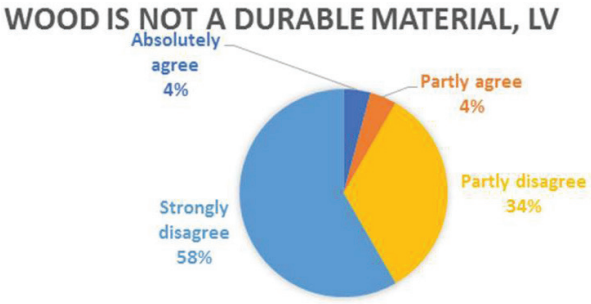

Fig. 10. Latvian architects' opinion about wood properties [Authors of the article].

J. Architects' Opinion

Another major stage of investigation was creating of a questionnaire with seven questions and collecting opinions of architects in both countries [29]. Six questions with options and one open question were included. The questionnaire was made as an online tool and spread via e-mail to 25 addresses in each country during a 10-day period in September 2019.

In total 44 answers of architects were received – 21 from Lithuania (LT) and 23 from Latvia (LV). The respondents in both countries mostly were architects with 21 and more year work experience.

Two questions were about the use of wood in the projects developed by respondents and one question was about the requirements of clients. Lithuanian respondents mostly use wood in interior and landscape, but Latvian respondents mentioned wood mostly as an external finishing material. The results showed that, though not very often, wood is used for load bearing structures (Fig. 7). To be more precise regarding wood material – Lithuanian architects use glulam, LVL and other timber products (OSB, I-beams, etc.). Latvian architects have used lumber and glulam and very rare CLT and LVL (Fig. 8). The clients of Lithuanian architects rarely ask to use timber for load-bearing structures. More often they ask it for interior finishing. In Latvia, the clients request wood as an external finishing material and sometimes as load-bearing structures of the building as well.

The answer to the question on **evaluating wood properties** had five options: expensive material, not a durable material, elements weight is too light, not a fireproof material, and it is not suitable for high-rise buildings. Latvian architects in general denied all the mentioned weaknesses. There were some agreements regarding flammable and expensive material. As opposed to the answers of Lithuanian architects, Latvian respondents disagree with evaluating wood as not durable material (Figs. 9 and 10).

The question on the opinion about **the future of wooden architecture** had three options: the number of projects with use of wood will increase, decrease, and will be the same as nowadays. Most respondents in both countries agree that wood will be used for more buildings as a sustainable material coming from renewable sources.

To find out the **barriers for use of wood,** eight options were given – legislation, lack of knowledge, lack of experience, qualification of architects, qualification of engineers, stereotypes, lack of information, no professional advices, and lack of carpenters. Each barrier could be evaluated by – Absolutely agree, Partly agree, Neither agree nor disagree, Partly disagree and strongly disagree. Lithuanian architects agreed that the main barriers for

the use of wood are qualification of architects, lack of experience and legislation. Latvian architects evaluated lack of experience, knowledge and information and legislation as main barriers.

Conclusions

This research highlighted several aspects of glulam use in wood architecture in both countries – Lithuania and Latvia. **Lack of information** about wood architecture projects, structural materials used, and the benefits of glulam makes glulam structures less competitive in the Baltic market. Producers of glulam are too busy to answer to requests and questions, it means that external communication is weakly organised. There is missing industry-driven glulam promotion or communication with stakeholders as well.

In both countries' glulam is used for sports buildings and water attraction or swimming pools where wide span and moisture or corrosion resistant structure is needed. Other typology buildings – libraries, schools, shops, etc. with glulam structures exist in one or other country, but it is mostly an exception. Unfortunately, nowadays they are not used as replicable **pilot projects**.

Mostly glulam is used to highlight aesthetics of wood. In all analysed projects wood is seen in the exterior or in the interior, or in both. Most of glulam structures are straight and only 6 projects in Latvia and 5 projects in Lithuania were designed with **curved glulam structures**. Designers use the materials and structures that they know better and have experience with until there is no request for something else.

More glulam projects and wider available information for professionals about them including structure, producers and technical data could prevent lack of information for architects and wider public including potential customers. There should be more information about successfully realized projects and types of wood materials but theoretical knowledge and practical skills and experience of architects could be developed with the support of glulam producers.

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Appendix

Table II. Results of the Analysis of Exterior and Interior of Glulam Projects [Authors of the Article]

	Project name, location	Wood is visible in the exterior and is part of architectural wholeness	Wood is not visible in the exterior but impacts the form of the building	Wood is visible in the interior and is part of the interior aesthetic	Wood is not visible in the interior but impacts the inside space of the building
		EXT1	EXT2	INT1	INT2
1LV	**Kipsala Exhibition Hall** in Rīga	0	1	1	0
2LV	**Swimming pool Līvu Akvaparks**	0	0	1	0
3LV	**Sport hall "Taurenitis",** Jūrmala	1	0	1	0
4LV	**Car Showroom,** Rīga	0	0	1	0
5LV	**Swimming pool** in Inčukalns	0	0	1	0
6LV	**Sports Hall** in Saldus	0	0	1	0
7LV	**Church** in Roja	0	0	1	0
8LV	**Swimming pool** in Balvi	0	0	1	0
9LV	**Office building** in Umurga	1	0	1	0
10LV	**Golf Club** in Aplokciems	1	0	1	0
11LV	**Market Roof** in Daugavpils	1	0	1	0
12LV	**Office building, roof floor,** Rīga	1	0	1	0
13LV	**Sports Hall** in Sabile	0	0	1	0
14LV	**Shopping Centre Diton** in Daugavpils	0	0	1	0
15LV	**Swimming pool** in Ludza	0	0	1	0
16LV	**Ice Arena** in Ogre	0	0	1	0
17LV	**Office building** in Dundaga	1	0	1	0
18LV	**School building** in Saldus	1	0	1	0
19LV	**Pedestrian bridge** in Tērvete	1	0	0	0
20LV	**Ice Hall** in Jelgava	1	0	1	0
1LT	**Shopping Centre** in Justluka	1	0	1	0
2LT	**Library** in Druskininkai	0	1	1	0
3LT	**Cafe** in Šeduva	0	1	1	0
4LT	**Monastery** in Palendrė	0	0	1	0
5LT	**Shopping Centre** Mega	1	0	1	0
6LT	**Hotel** in Klaipeda	1	0	0	0
7LT	**Football hall** in Marijampolė	0	1	1	0
8LT	**Arena** in Šiauliai	0	0	1	0
9LT	**Sports Centre** in Panevezys	1	0	1	0
10LT	**Gym** in Kaunas	0	0	1	0
11LT	**Vichy Water Park** in Vilnius	0	0	1	0
12LT	**Horse farm** in Prienai district	0	0	1	0
13LT	**Shed** in Prienai district	1	0	1	0
1LT	**Administrative building** in Klaipeda	0	0	1	0
15LT	**Swimming pool** in Birštonas	1	0	1	0
16LT	Hermis **SPA Centre**	0	0	1	0
17LT	**SPA Centre** in Druskininkai	0	1	1	0
18LT	**Swimming pool** in Žibininkai	1	0	1	0
19LT	Kedainiai **pedestrian bridge**	1	0	0	0
20LT	**Tower** in Meteliai	1	0	0	0
		18	**5**	**36**	**0**