

Technical requirements and practical guide for sawn timber and glulam applications in wooden constructions

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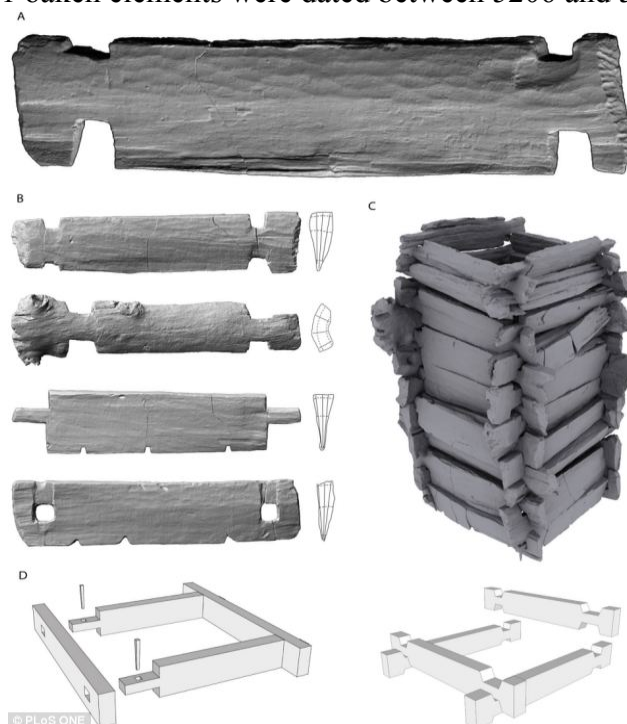
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Abstract: *Technical requirements and practical guide for sawn timber and glulam applications in wooden constructions.* The paper presents sawn timber and glulam as a construction materials widely applied in European building industry. Overall the topic of the paper are: the most important principles of design and making safety wooden building constructions and the most popular problems and mistakes occurring in Poland as a result of not keeping principles of design.

Keywords: structural timber, wooden constructions, glulam

From the very beginning it is possible to find many examples of buildings which are mostly or partly made of wood. It was one of the first materials used by humans to make a shelter, initially in a form of primitive sheds. As the time passed, humans learned more and more, and their buildings became more sophisticated. First signs of using wood as a building material in a form of more complicated construction were found by archaeologists near Leipzig. Four wells made of oaken wood are the oldest known timber constructions made by carpenters in the world (Fig. 1). According to the tests and studies made by research team from the Institute of Forest Growth of the University of Freiburg, the Archaeological Heritage Office of Saxony in Dresden, and the Swiss Federal Research Institute WSL in Birmensdorf, Switzerland all the 151 oaken elements were dated between 5206 and 5098 BC.



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Fig. 1 Construction elements and model of a well (Internet)

It is possible to find many timber constructions all over the world, which have survived to modern times in condition that allows constant use despite several hundred years of exploitation. The church in Karpacz can be an example in Poland. Then why do projects of timber or glulam constructions cause so many emotions and objections among some people? In many cases wood is the most likely used material by some designers. In this article the authors would like to present the advantages of timber and glulam trying to answer the most common accusations and dispel all the doubts that sceptics can have.

Timber has many advantages, one of them is the fact that the nature gives it every day, and the growing process helps to improve the quality of air. It can be used to create friendly interiors. Additionally glulam and wood based composite materials (for example lvl or cross-laminated timber) allow to give the construction an interesting shape. This year one of the finalists in the *European Union Prize for Contemporary Architecture. Mies van der Rohe Award* was Metropol Parasol in Seville – a specific wooden construction made of 2500m³lvl (Kerto Q). The structure is approx. 150m long, 75m wide and 28m high and creates the roof over the market.



Fig. 2 Metropol Parasol in Seville (Pictures: © MERK Timber GmbH)

Generally speaking wood is material willingly used by designers. Like any other material, also timber and glulam require certain rules and regimes at each stage of the building process. Failing to meet standard regulations or adjusting the project to material specifics at the designing phase, as well as not obeying regulations connected to the production and mistakes during the montage can cause incorrect work of the construction and be a reason for the opponents to question the legitimacy to use this material.

So what is necessary to know to design and accomplish a safe wooden construction, and then equally safely exploit it?

1. First of all, it is very important to remember about using right static schemes and regulations during designing. If somebody uses Eurocode 5 (PN-EN 1995-1-1) as a base for calculations but took characteristics strength from the old standard PN-EN 338:1999 instead of valid standard PN-EN 338:2011, they could cause an accident. It is forbidden to mix standards – Eurocodes cannot be used together with other national standards (PN, DIN etc.)

2. Designer is obligated to follow all the necessary steps. Designing construction made of timber or glulam cannot be minimized by the designer and transferred to the manufacturer. The designer is a person, who knows all the loads and forces they create. That is why it is necessary to obey designing regulations. Supervisor should not allow to use as a base for tender a project, where design of timber construction is reduced to a rough drawing and information that dimensioning of the structural elements (and connections) should be made by the manufacturer.
3. Fire resistance requires certain calculations according to EN1995-1-2. It is not allowed to shift the responsibility for fire resistance to the manufacturer.
4. Timber can be used as structural or not structural material. Timber is structural when the elements are able to carry loads and the load carrying capacity is suitable for required class. Structural timber has to meet the following requirements for the admission to trading. Only strength graded timber is considered as a structural product and it must be CE marked to be used as a building material (obligatory since 01.10.2012). The first act regulating products classification system in EU was Directive 89/106 EEC published in December 1988. CE marking means that the product is compatible with harmonized standard, and the compatibility was confirmed using methods described in that standard. PN-EN 14081 is harmonized standard for structural timber. First part of this standard contains:

- regulations concerning strength grading,
- rules for initial type testing,
- rules for implementation and conducting factory production control,
- rules for CE marking,
- system of attestation of conformity: 2+.

Basis for CE marking is manufacturers conformity declaration after certification of factory production control (FPC) made by notified body (procedure acc. to PN- EN14081 – 1:2005 +A1:2011)

Task for manufacturer:

- initial type testing,
- factory production control,
- testing of samples according test plan.

All the documentation must be kept by manufacturer minimum ten years. Strength grading is one of the most important phases of structural timber production. There are two methods of strength grading: visual and machine grading. Machine grading (in Poland almost never used) allows to classify timber directly (using non-destructive measurement) according to PN-EN 338:2011. By visual grading, timber is classified indirectly using standard PN-EN 1912 to transfer visual grading classes to strength classes. Polish visual grading classes (acc. to PN-D 94021:1982, being revised) are not yet introduced into that standard, so it is necessary to use Table N.2 coming from National Annex to PN-EN 1995-1-1:2010 to change Polish visual grading classes KW, KS, KG into C classes.

Visual strength grading bases on visual inspection to ensure that the pieces do not have visible defects in excess of the limits specified in the relevant grading rule.

Timber can be used as structural building material when it is produced and marked correctly and meets all the expectations from PN-EN 14081-1:2005 + A1:2011

5. Timber elements used as structural material have to be dry, it means to have moisture content below 20%. Polish National Annex to Eurocode 5 points the moisture content 18% as maximum for interior used timber (protected) and 23% for exterior used timber (unprotected).

6. Glulam must be produced of timber graded in the way described in point 4 of this article, according to the standard EN 14080. CE is an admission to trading, but the marking refers to the final product.
7. A notified body must perform the initial type testing, and the factory production control must be assessed. Notified body provides certification of product instead of factory production control certificate required for timber. CE for glulam is mandatory since 01.12.2011. The producer is also obliged to declare conformity to the individual project.

Facts presented below are the reasons of problems with wooden constructions:

- a. In reality, designing of wooden constructions means often transferring calculations and drawings on the producer, including static. Design of connections, which is integral part of the project, is also incorrectly called for example mounting construction project, to justify the lack of it in the documentation done by the designer.
- b. The designers don't take into consideration used material (for example transfer solution right for steel or concrete to the timber construction). One of the biggest mistakes is designing undercuts or holes without providing necessary protection.
- c. Many times the designers minimize parameters of cross-section using very high strength class of timber. It is done to fulfill (in the designers' minds) criterion required by the investor, to keep price as low as possible. Nearly no one remembers, that high quality causes higher price. To make matters worse in a realization stage nearly no one cares to buy strength class of timber acc. to the project.
- d. Most of the timber supplied at the building side and used as structural is neither strength graded nor have the moisture content below 20%. It is also delivered without CE.
- e. It still happens that the glulam does not meet the requirements of PN-EN 14080 standard, has no CE, etc.
- f. Executive regulations are not obeyed.
- g. Wrong exploitation.

The analysis of the forgoing points shows that, when it comes to wooden constructions, the lack of complex analysis of the investment is quite common. The availability of the designed cross-sections or classes are not checked at the designing phase. No one really checks if the designed solutions are possible and adequate to the certain construction.

Then there is the contractor (investor), who uses cheap, wet and unsorted timber or glulam without certificate and doesn't think about consequences of sparing money, like:

- Changes in temperature and moisture content of timber construction (for example during intensive drying after plastering) cause shrinkage and swelling. It is not only unaesthetic, but most of all it reduces strength and elastic properties. Randomly selected wood (without strength class) may not carry designed loads. Delivered elements meet C18 class at most.
- Glulam members may not carry the designed loads when it is made of improper timber, when the glue is not proper or the product is made not by the books. In glulam can appear delamination and also cracks. **Note—seasoning cracks occurring in exposed members should not be confused with delamination. If cracks are parallel to the grain and not exceed ca 30% of the cross-section width, they are usually not dangerous.**

At the end, it is impossible to forget about one more reason, why the wooden constructions are sometimes rejected. It is unreasonable fear of fire. Unfortunately, it concerns not only the final user/investor, but also the firemen giving opinions about the projects. It still happens that the conception of public building meets with the strong opposition from the fireman. The fireman rejects wood and points concrete constructions as much safer. In fact, properly designed construction (and connections) allows to get one hour fire resistance without any other protection. Now we are back to the project, which has to be professionally designed instead of being transferred on the manufacturer.

CONCLUSIONS

The authors mentioned only few examples of actions, that can cause problems. All the pointed reasons of problems caused by both – timber and glulam construction, are not coming from the material properties but from human errors. Polish designers have more and more amazing, innovatory projects, often putting our designers at the forefront of European or even global designers. If we manage to provide the right realization, we would be able to compete on the area of timber structures with the existing incumbents. The process of educating about the right designing, executing, controlling and exploitation of timber constructions has already begun in Poland. Let's hope that in the nearest future all the phases of the building process will be executed correctly and we will enjoy some new, safe realizations.

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STANDARDS:

1. PN D-94021:1982 Stress-graded coniferous sawn timber for structural use
2. PN-EN 338:2011 – Structural timber – Strength classes
3. PN-EN 1194:2000 – Timber structures – Glued laminated timber – Strength classes and determination of characteristic values
4. PN-EN 14080:2006 – Timber structures – Glued laminated timber and glued solid timber - Requirements
5. PN-EN 14081-1:2005 + A1:2011 – Timber structures – Strength graded structural timber with rectangular cross section – Part 1: General requirements
6. PN-EN 1912: 2011 – Structural Timber – Strength classes – Assignment of visual grades and species
7. PN-EN 1995-1-1:2010 – Eurocode 5: Design of timber structures Part 1-1: General- Common rules and rules for buildings
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Streszczenie: *Wymagania techniczne i praktyczne wskazówki dla stosujących drewno konstrukcyjne lite i klejone w budownictwie.* W referacie wskazano zalety drewna litego i klejonego warstwowo z tarcicy jako szeroko stosowanego w budownictwie europejskim materiału konstrukcyjnego. Przedstawiono najważniejsze zasady projektowania i wykonywania bezpiecznych konstrukcji drewnianych oraz najczęściej występujące w Polsce problemy i błędy wynikające z nieprzestrzegania tych zasad.

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