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Research Article

Industrial Timber Construction Systems in Turkey: A Study on Applicability and Potential

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Abstract

Turkey is located in a highly active seismic zone and has experienced numerous destructive earthquakes throughout its history, most recently the 2023 Kahramanmaras earthquakes, which caused extensive loss of life and structural damage. This context necessitates the exploration of alternative construction systems that can enhance seismic resilience while meeting contemporary sustainability criteria. Timber, as a lightweight and ductile material with a high strength-to-weight ratio, offers significant advantages for earthquake-resistant construction.

Following its long-standing use in traditional building practices, timber construction has undergone substantial transformation since the Industrial Revolution. The emergence of engineered wood products and industrial timber systems has enabled improved structural performance, material efficiency, and durability, while also supporting environmentally responsible construction. These developments position timber as a viable alternative to conventional building materials in modern construction.

This study evaluates the applicability and potential of industrial timber construction systems in Turkey through an assessment of their structural, environmental, and technological characteristics. In addition, contemporary timber construction techniques are reviewed, and a recent industrial timber housing application in a seismic region of Turkey is examined as a case study. The findings aim to contribute to the ongoing discourse on resilient and sustainable construction practices and to support the wider integration of industrial timber systems into the Turkish building sector.

Keywords: Earthquake-Resistant Structures, Engineered Wood, Industrial Timber Systems, Sustainable Construction, Timber Construction.

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INTRODUCTION

Turkey is located in a highly active seismic zone, where destructive earthquakes have consistently revealed the vulnerabilities of the built environment. The 2023 Kahramanmaras earthquakes, which resulted in extensive structural damage and significant loss of life, have once again underscored the necessity of re-evaluating construction practices in terms of seismic safety and resilience. In this context, the exploration of alternative building systems that can respond to both structural and environmental challenges has become increasingly critical. Despite its historical presence in traditional architecture, timber has remained largely underrepresented in contemporary construction practice in Turkey. Over the past few decades, the limited inclusion of timber design, construction techniques, and seismic performance in engineering education has led to a decline in technical knowledge and skilled labor. Consequently, both the construction of new timber buildings and the maintenance or rehabilitation of existing ones have been neglected. In addition, challenges related to cost, material supply, technical infrastructure, and project management continue to restrict the development of the timber construction sector.

Nevertheless, timber presents significant advantages as a structural material, particularly in earthquake-prone regions. Its low self-weight, high strength-to-weight ratio, and inherent flexibility contribute positively to seismic performance. Alongside these structural benefits, timber also offers advantages in terms of thermal performance, environmental sustainability, and adaptability to different site conditions. Recent advancements in engineered wood products and treatment technologies have further enhanced the durability, fire resistance, and dimensional stability of timber, enabling its use in more complex and large-scale applications.

In the global context, timber construction has gained renewed momentum, particularly in countries with advanced construction technologies and strong environmental policies. In addition to Japan and Canada, several European countries—including Germany, Austria, Sweden, and Finland—have widely adopted industrial timber systems, supported by research, innovation, and regulatory frameworks. In contrast, the use of such systems in Turkey remains limited, despite the presence of traditional timber structures that have demonstrated considerable resilience over time.

Within this framework, this study focuses on the current position and future potential of industrial timber construction systems in Turkey, considering their structural, technological, and environmental dimensions. Particular emphasis is placed on evaluating their practical implementation through a contemporary housing application in a seismic region.

In order to better understand the potential of industrial timber construction in Turkey, it is first necessary to examine timber as a construction material, its technological development, and engineered wood products used in modern construction.

TIMBER CONSTRUCTION: MATERIAL PROPERTIES AND TECHNOLOGICAL DEVELOPMENT

Timber has been one of the earliest and most widely used building materials throughout human history, initially employed in mass (solid) constructions and later evolving into lighter, more flexible frame (carcass) systems (Herzog et al.,

2004). This evolution reflects not only changes in construction techniques but also the material's shaping, detailing, and functional adaptation over time.

A pivotal point in industrial timber construction was the development of the "Balloon Frame" system in Chicago, USA, in the 1830s. By enabling mass production of standardized small-section timber elements, this technique reduced labor time and costs, facilitating large-scale housing construction and laying the foundation for modern industrial timber systems. Simultaneously, innovations in panel production, such as plywood, allowed small, otherwise unusable wood pieces to be efficiently utilized, further expanding timber's applicability in engineered construction.

The Industrial Revolution accelerated these developments, introducing advanced processing technologies that improved precision, speed, and quality in timber fabrication. Chemical treatments and adhesives enhanced wood's durability, mechanical properties, and resistance to environmental impacts. Over the past fifty years, engineered timber products such as Glued Laminated Timber (Glulam), Cross-Laminated Timber (CLT), and Laminated Veneer Lumber (LVL) have emerged, offering lightweight yet high-performance structural solutions suitable for modern construction.

Technological Solutions to Timber's Weaknesses

Contemporary timber technologies address traditional limitations such as fire susceptibility, biological degradation, moisture-induced deformation, and mechanical constraints. Modern techniques allow timber to resist fire for up to 90–120 minutes through proper sizing, char layer formation, and fire-retardant treatments (Kartal, 2015). Biological degradation is mitigated via moisture control and advanced modification processes like Thermowood, which significantly improve durability without harmful chemicals. The modular structure of timber enables the local repair or replacement of damaged elements, thereby contributing to long-term sustainability and cost-effective maintenance.

Advantages of Timber as a Construction Material

Engineered timber offers significant structural, environmental, and functional benefits. Its lightweight nature reduces dead loads on foundations and structural elements, particularly advantageous in seismic regions (UNECE/FAO, 2020). High strength-to-weight ratios, predictable mechanical behavior, and low thermal conductivity make timber efficient for energy performance and structural reliability (Green et al., 1999). Prefabricated timber systems reduce construction time and cost, while carbon storage potential contributes to sustainability. Timber's acoustic properties, ease of fabrication, and compatibility with modern modular design enhance both occupant comfort and architectural flexibility (Frangi et al., 2009; Rice, 2006).

Industrial Timber Products

Industrial timber is produced by assembling wood components (planks, veneers, strands, or particles) using adhesives or mechanical fasteners under controlled factory conditions, yielding homogeneous, high-performance structural elements (Forest Products Laboratory, 2010). Key products include:

- Cross-Laminated Timber (CLT): High-strength, prefabricated panels with orthogonal layers offering excellent seismic performance and modularity for multi-story buildings (Brandner et al., 2016; Pei et al., 2013).
- Glued Laminated Timber (Glulam): Laminated elements enabling large spans and versatile structural applications, with enhanced strength through parallel or reinforced laminations.

• Laminated Veneer Lumber (LVL): Engineered beams and columns with high dimensional stability, suitable for structural framing and supporting tall or complex structures.

• Nail-Laminated Timber (NLT) and Dowel-Laminated Timber (DLT): Multi-layered panels connected mechanically with nails or wooden dowels, offering modularity and sustainability.

• Thermowood: Heat-treated timber with enhanced durability, dimensional stability, and environmental compatibility.

Industrial timber systems provide advantages in seismic resilience, lightweight construction, sustainability, rapid assembly, and reduced carbon footprint. Countries like Japan, Canada, Germany, Austria, and Sweden have successfully integrated these systems into their construction practices, offering valuable models for seismic regions such as Turkey.

These technological developments and engineered wood products have enabled the emergence of various industrial timber construction systems. Therefore, the following section discusses the classification and structural characteristics of industrial timber construction systems.

INDUSTRIAL TIMBER CONSTRUCTION SYSTEMS

Industrial timber construction systems have gained significant attention in contemporary architecture due to their lightweight, sustainable, and rapid assembly characteristics. These systems integrate traditional timber techniques with modern prefabrication technologies, allowing for efficient and environmentally conscious building solutions.

General Classification of Systems

Timber construction systems can be broadly categorized into three main types based on their structural principles and assembly methods (Ramage et al., 2017; Green, 2012):

1. Mass Timber Systems – Solid or engineered timber elements stacked and interlocked to form load-bearing walls.

2. Timber Panel Systems – Prefabricated panelized elements such as walls, floors, and roofs, often using cross-laminated timber (CLT) or glulam.

3. Timber Frame Systems – A skeletal framework of columns, beams, and braces that carries the structural loads, with non-load-bearing infill walls.

This classification provides a clear framework for understanding the design, construction, and performance characteristics of industrial timber structures.

Industrial Timber Construction Systems
Mass timber systems

Mass timber systems consist of horizontally stacked timber elements that are interlocked at corners to create structural walls (Çobanoğlu, 1988). Modern mass timber construction typically combines traditional techniques with factory prefabrication: CNC machining, laser cutting, and pressing technologies allow for highly precise, modular components.
Advantages:

- Structural stability and durability
- Seismic performance due to lightweight and flexible behavior
- Rapid on-site assembly

Mass timber structures are increasingly used in residential and public buildings, reflecting both aesthetic and structural benefits.

Timber panel systems

Panel-based timber systems involve prefabricated wall, floor, and roof panels designed according to structural requirements. Typical panel dimensions range from 5–45 cm in thickness, up to 4 m in height, and approximately 20 m in length.
Innovative Materials:

- Cross-Laminated Timber (CLT)
- Glued Laminated Timber (Glulam)
- Structural Composite Elements

Advantages:

- High level of prefabrication and modularity
- Fast assembly and reduced on-site labor
- Improved quality control and energy efficiency (Ramage et al., 2017; Gustafsson et al., 2019)

These systems enable construction of mid-rise and high-rise timber buildings, demonstrating the scalability of industrial timber solutions.

Timber frame systems

Timber frame systems rely on a load-bearing timber skeleton, with walls serving mainly as infill. Columns, beams, and braces transfer loads to the foundation. This approach has a long history in North America and Northern Europe, including variants such as Balloon Frame and Timber Frame. In Turkey, traditional "hımış" structures represent a local adaptation.
Construction Process:

1.Construct the primary timber frame.

2.Integrate cross braces for lateral stability.

3.Insert insulation materials into the cavities.

4.Apply interior and exterior finishes (timber cladding, OSB, gypsum boards).

Advantages:

- Lightweight and high seismic resilience
- Prefabrication enables rapid and efficient assembly
- Environmentally sustainable with renewable materials
- Design flexibility and modularity

Timber frame construction combines traditional craftsmanship with modern engineering, providing sustainable, adaptable, and safe building solutions.

Prefabrication of timber elements

Prefabrication in controlled factory environments enhances quality, speed, and sustainability:

- Production: CAD/CAM, CNC machining, laser cutting, and automated assembly ensure precise, standardized components (Green, 2012; Dinwoodie, 2000).
- Speed: A 100 m² building can be prefabricated and assembled in 14 days, while in Europe, this duration can be as low as 2 days.
- Durability: Kiln-dried and impregnated timber resists decay, insects, and fire (Ross, 2010).
- Sustainability: Reduced energy use, minimal material waste, recyclability, and low carbon footprint.

Prefabricated timber systems combine quality, speed, and environmental benefits, making them a modern, efficient alternative in industrial construction. Understanding these structural systems is particularly important in seismic regions, where material behavior and structural design directly influence earthquake performance. For this reason, the next section examines the relationship between earthquakes, architecture, and material behavior, with a focus on timber structures.

EARTHQUAKE, ARCHITECTURE AND MATERIAL BEHAVIOR

Earthquake and Architecture

Earthquakes, caused by the continuous movement of tectonic plates, are natural phenomena that occur frequently and can sometimes result in catastrophic destruction. During seismic events, shock waves generate high-amplitude horizontal forces on buildings, whereas most structures are primarily designed to resist vertical loads. This mismatch makes buildings particularly vulnerable to lateral stresses, leading to damages ranging from minor cracks to partial or total collapse.

Scientific research and technological developments in earthquake engineering have therefore focused on improving building safety in tectonically active regions (Mazzolani & Dolce, 2009). Among various parameters affecting seismic performance, material selection plays a decisive role. Lightweight and flexible materials such as timber perform better under seismic loads because they can absorb and dissipate energy more effectively than rigid and heavy materials.
In practice, seismic performance is influenced by both engineering-based reinforcement systems and the intrinsic properties of structural materials. For example, pendulum systems, tuned mass dampers, and flexible foundation systems are widely used in tall buildings to reduce structural sway. However, the efficiency of these systems largely depends on the mechanical behavior of the structural material itself. Materials with high ductility, particularly timber, improve energy dissipation capacity and increase overall structural resilience (Ceccotti et al., 2013).

Architectural design decisions are equally critical for earthquake-resistant buildings. Irregular mass distribution, asymmetric geometry, soft stories, or discontinuities in load-bearing elements can negatively affect seismic performance. Therefore, earthquake resistance must be considered from the earliest stages of architectural design, ensuring that structural systems and architectural decisions are developed together. This integrated approach improves safety while maintaining functionality and architectural quality.

Seismic design principles can be broadly categorized into three main groups:

1. General geometric form — the building's three-dimensional form, mass distribution, and orientation, which directly influence seismic behavior;

2. Architectural details prone to failure — such as weak connections, structural discontinuities, and plan irregularities;

3. Non-structural elements — including partition walls, ceilings, façade elements, and mechanical installations that may pose risks during earthquakes if inadequately designed (Alecci et al., 2019).

Finally, seismic behavior cannot be evaluated independently from soil conditions. Soil type significantly affects the propagation of seismic waves. Soft soils may amplify ground motion and increase structural stresses. When the natural period of the ground matches that of the building, resonance can occur, especially in mid- and high-rise structures. Also, soil liquefaction in water-saturated sandy soils may cause settlement, tilting, or collapse, regardless of the structural system.For

this reason, modern building codes such as TBDY 2018 require site-specific seismic design that considers soil–structure interaction. In weak or heterogeneous soil conditions, advanced engineering solutions such as seismic isolation systems or deep foundation systems may be required to ensure structural safety.

Wooden Construction and Earthquake

The earthquake resilience of buildings depends not only on engineered reinforcement systems but also on the inherent properties of construction materials. Timber, in particular, performs well under seismic loads due to its ductility and its ability to absorb and dissipate seismic energy. Its fibrous cellular structure allows significant deformation before failure, enabling timber structures to resist lateral forces more effectively than brittle materials such as masonry or poorly detailed concrete (Smith et al., 2003).

Another important advantage of timber is its low weight. Since seismic forces are directly proportional to the mass of the structure, lighter buildings are subjected to lower inertial forces during earthquakes. This significantly reduces the seismic loads acting on the structure. However, optimal seismic performance requires a balance between stiffness and flexibility. Overly rigid systems may fail suddenly and brittlely, whereas overly flexible systems may lead to excessive displacement and user discomfort. Experimental studies show that massive timber buildings, especially when combined with steel connectors or hybrid structural systems, perform very well under both vertical and horizontal loads due to their high energy dissipation capacity.

From an architectural perspective, earthquake-resistant buildings must not only ensure structural safety but also address post-disaster needs such as emergency shelter, rapid construction, logistics, and community recovery. Timber construction, particularly industrially produced massive timber systems, meets these requirements through high seismic performance, fire resistance, low carbon footprint, and recyclability.

Industrial timber construction systems are typically prefabricated in factory conditions, which ensures high precision in joints and connections. Openings for mechanical and electrical installations can be pre-planned and integrated into panels, which significantly accelerates on-site assembly and reduces construction errors and labor requirements. This system also allows flexible interior layouts and supports architectural variation through different material combinations and façade systems.

Furthermore, the natural properties and environmental benefits of timber help reduce the environmental and psychological impacts in earthquake-affected regions. For these reasons, timber construction can be considered a safe, sustainable, and rapidly deployable building solution for post-earthquake housing production.

Seismic Resistance of Timber Structures: Historical and Experimental Insights

Historical and contemporary earthquake records indicate that timber structures often perform better than masonry buildings and poorly detailed reinforced concrete structures. After major earthquakes such as the 1509 Istanbul earthquake and the 1755 Lisbon earthquake, timber-based structural systems were developed as earthquake-resistant construction techniques. Examples include the Turkish hımış system, the Portuguese gaiola pombalina, the Italian casa baraccata, and the Latin American quincha and bahareque systems. These systems were designed as lightweight, flexible, and energy-dissipating structural solutions.



Figure 1. Earthquake shake table tests of a cross-laminated timber (CLT) earthquake-resistant building (UL Solutions, 2023).

Observations from more recent earthquakes, including the 1894 Istanbul, 1994 Northridge, 1995 Kobe, 1999 Kocaeli, and 2023 Kahramanmaras earthquakes, further demonstrate that well-designed and properly maintained timber structures generally suffer less damage compared to heavy masonry buildings. However, poor workmanship, material decay, insufficient bracing, or inadequate connections can significantly reduce seismic performance.

Recent experimental studies have confirmed these observations, particularly with modern engineered wood products such as Cross-Laminated Timber (CLT), Laminated Veneer Lumber (LVL), and Glulam (GLT). Large-scale shake table tests conducted in the United States, Europe, and Turkey have shown that massive timber buildings with advanced connection systems, self-centering shear walls, and hybrid structural solutions can withstand strong seismic forces with minimal structural damage while maintaining post-earthquake functionality (Ceccotti et al., 2013).

Overall, both historical evidence and experimental research demonstrate that the seismic performance of timber structures depends on structural design, connection detailing, material durability, and proper maintenance. By combining traditional construction knowledge with modern engineering technologies, timber emerges as a resilient, sustainable, and strategic material for earthquake-resistant architecture.

Considering the seismic performance, sustainability, and construction efficiency of timber structures, it is important to evaluate their applicability in earthquake-prone countries. Therefore, the following section discusses the applicability and development potential of industrial timber construction systems in Turkey.

APPLICABILITY OF INDUSTRIAL TIMBER SYSTEMS IN TURKEY

Current Situation of Timber Construction in Turkey

The development of the construction sector in Turkey has been largely based on reinforced concrete structures. Today, almost the entire building production system, including education, design software, regulations, and construction industry infrastructure, is organized around reinforced concrete construction. As

a result, timber construction represents a very small portion of the building stock in Turkey (Figure 1, Table 1).

According to statistical data, timber structures account for less than 1% of total construction production in Turkey. Between 2002 and 2018, only 13,988 timber houses were built out of a total of 1,497,420 housing units, corresponding to approximately 0.93% of all residential construction. This data clearly indicates that timber construction has a very limited role in the Turkish construction sector.

Total Number of Timber Houses	Total Number of Houses	Percentage (%)
13,988	1,497,420	0.93

Table 1. Proportion of timber buildings based on building permit data (2002–2018). Turkish Statistical Institute (TÜİK).

The distribution of timber construction companies across the country also reflects this limitation. Most timber construction companies are located in the Marmara region, while only a few companies operate in the Aegean, Central Anatolia, Black Sea, and Mediterranean regions, and almost none in Eastern and Southeastern Anatolia. This uneven distribution demonstrates that the industrial timber construction sector in Turkey is regionally limited and underdeveloped (Figure 2).

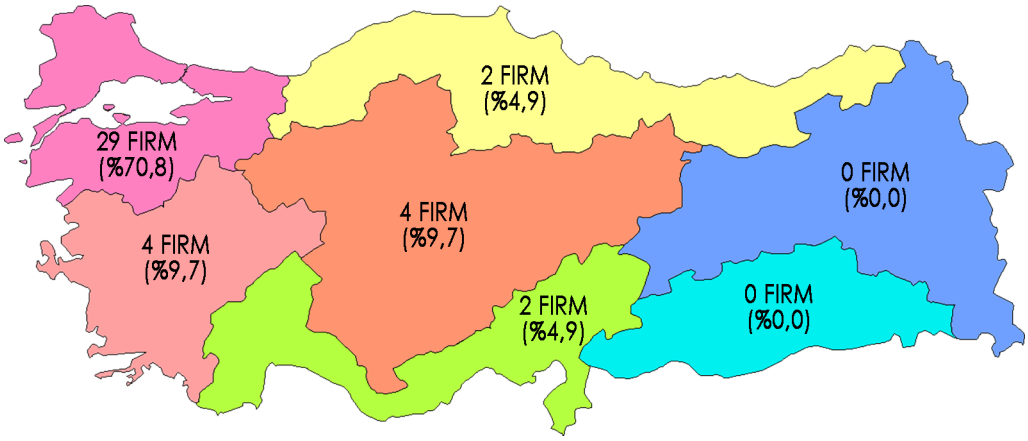


Figure 2. Distribution of timber construction companies by geographical regions (Kurul, 2019).

Earthquake Risk and the Need for Alternative Structural Systems

Turkey is located in one of the most active seismic regions in the world and has experienced numerous destructive earthquakes throughout its history. Since the 16th century, more than twenty earthquakes with magnitudes greater than 7 have occurred in different regions of the country. Major earthquakes such as Erzincan, Elazığ, Van, Izmir, Gölcük, Düzce, and most recently the 2023 Kahramanmaras earthquakes caused significant loss of life and property.

The 2023 Kahramanmaras earthquakes resulted in tens of thousands of casualties and the collapse or severe damage of hundreds of thousands of buildings. These events once again demonstrated the vulnerability of the existing building stock and the urgent need for safer, more resilient construction systems.

When earthquake experiences from other seismic countries such as Japan, Canada, and the United States are examined, it can be observed that timber structures generally perform better during earthquakes and result in fewer casualties compared to heavy masonry or poorly constructed reinforced concrete buildings. This situation indicates that timber construction systems could be an important alternative structural solution for earthquake-prone regions such as Turkey.

In contrast, earthquake experiences in other seismic countries demonstrate the advantages of timber construction. Research conducted by the Institute for Research in Construction in Canada shows that even in strong earthquakes, timber buildings rarely collapse compared to masonry or poorly detailed reinforced concrete buildings (Institute for Research in Construction, Canada, 2023). Furthermore, data compiled by Karacabeyli (2023) indicates that fatalities directly caused by the collapse of timber frame buildings are extremely rare and in many cases recorded as zero. This highlights the importance of timber structures in terms of life safety, which is the primary goal of earthquake-resistant design. The life-safety performance of timber frame buildings observed in past earthquakes is summarized in Table 2.

Table 2. Seismic performance of timber frame buildings in terms of life safety (Karacabeyli, 2023).

Earthquake	Magnitude (Richter)	Total Deaths	Deaths in Timber Frame Buildings	Timber Frame Buildings Exposed to Severe Shaking
Alaska, 1964	8,4	130	<10	–
San Fernando, CA, 1971	6,7	63	4	100 000
Edgecumbe, NZ, 1987	6,3	0	0	7 000
Saguenay, QC, 1988	5,3	0	0	10 000
Loma Prieta, CA, 1989	5,7	66	0	50 000
Northridge, CA, 1994	7,1	60	20	200 000
Hyogo-ken Nanbu, Kobe, Japan, 1995	6,7	6 300	0	8 000

Barriers to the Development of Timber Construction in Turkey

Despite its advantages, timber construction has not developed sufficiently in Turkey due to several structural, economic, technical, and educational factors. One of the main reasons is the industrial structure of the construction sector. In Turkey, the cement, steel, and ready-mixed concrete industries are highly developed and constitute a significant part of the construction economy. Engineering education, vocational training, and structural design software are also predominantly based on reinforced concrete systems. As a result, both engineers and contractors are more familiar with concrete construction systems, which reinforces their preference in design and implementation practices and further limits the consideration of alternative structural systems.Another important limitation is the lack of industrial production infrastructure for engineered wood products such as CLT, LVL, and Glulam. These materials are widely produced and used in Europe and North America, but in Turkey production capacity is still limited and most high-performance engineered wood products are imported, which increases construction costs.

In addition, the number of skilled workers and craftsmen experienced in timber construction has significantly decreased over time. Traditional timber construction knowledge has not been sufficiently transferred to modern construction practices, and timber construction has been largely neglected in engineering and architecture education for many years.

Forestry policies and raw material production also affect the development of timber construction. Although Turkey has significant forest resources, the production of structural timber suitable for engineered wood products is limited. Suitable species for structural timber production are not systematically cultivated, and high-quality structural timber is often imported. Furthermore, long-term forest management and sustainable timber production policies are not sufficiently integrated with the construction sector.

Economic factors also play an important role. Timber construction is often perceived as more expensive than reinforced concrete construction in Turkey. The dependence on imported engineered wood products, limited number of contractors, and lack of industrial-scale production increase costs and reduce competitiveness.

The development of timber construction in Turkey is closely related to building regulations, seismic codes, and technical design standards. Due to the country's high seismic risk, earthquake regulations in Turkey have a long history and have been continuously updated after major earthquakes based on engineering experience and scientific research. Over time, Turkish seismic regulations have evolved from prescriptive rules to more advanced performance-based design approaches.

The current Turkish Building Earthquake Code (TBDY 2018) includes modern seismic design principles such as performance-based design, site-specific seismic hazard assessment, and advanced structural analysis methods. With its comprehensive content and analytical approaches, TBDY 2018 is considered one of the modern seismic design codes internationally. This regulation provides a strong framework for earthquake-resistant structural design, including timber structures.

However, specific regulations and design guidelines for modern industrial timber structures have only recently begun to develop in Turkey. For many years, existing standards were mainly focused on traditional timber construction systems, and there was a lack of detailed technical guidance for modern engineered timber systems such as CLT, Glulam, and LVL. This lack of comprehensive regulations and design guides for multi-story timber buildings has slowed the development of industrial timber construction systems in Turkey.

An important milestone in this field is the publication of the Timber Structures Regulation in 2025. This regulation represents the first comprehensive national guideline specifically addressing the design, calculation, detailing, and construction principles of modern timber structures in Turkey. The regulation provides engineers and architects with a clearer legal and technical framework and reduces uncertainties in design approval and construction processes. Therefore, this development is expected to encourage the wider use of timber construction systems in the coming years.

Despite these regulatory developments, the practical implementation of industrial timber construction still requires improvements in industrial production capacity, education, technical expertise, and supply chains. In this context, recently constructed industrial timber housing projects in Turkey provide valuable case studies for evaluating the practical application of these regulations and construction systems under real conditions.

Opportunities for Industrial Timber Construction in Turkey

Despite these limitations, Turkey has significant potential for the development of industrial timber construction. The country has a large housing demand, high seismic risk, and increasing interest in sustainable construction materials. Industrial timber construction systems offer several advantages for Turkey, including:

- Lightweight structures with better seismic performance
- Prefabrication and rapid construction
- Reduced construction waste
- Lower carbon emissions

- Sustainable and renewable building material
- Suitable for post-disaster housing production
- Flexible architectural design possibilities

In recent years, especially after the 2023 earthquakes, interest in timber construction has increased again, and several pilot projects and government-supported initiatives have been initiated. However, for industrial timber construction to become widespread in Turkey, improvements are needed in industrial production, education, regulations, forestry policies, and public awareness.

In conclusion, although timber construction currently represents a very small portion of the construction sector in Turkey, the country's high seismic risk, growing housing demand, and sustainability goals create significant potential for the development of industrial timber construction systems. However, industrial production capacity, education, regulations, and economic conditions must be improved in order for these systems to become a viable alternative to reinforced concrete construction in Turkey. The Osmaniye Industrial Timber Housing Project, discussed in the following section, provides an important case study for evaluating the practical applicability of these systems under real construction conditions.

In order to better understand the practical implementation of these systems in Turkey, the following section presents the Osmaniye Industrial Timber Housing Project as a case study.

CASE STUDY: OSMANİYE TIMBER HOUSING PROJECT

Project Background and General Description

The Osmaniye Industrial Timber Housing Project was previously examined in a study focusing on earthquake-resistant timber housing design in Turkey (Plekhanova & Erdoğan, 2025). In the present study, the project is re-evaluated within a broader framework to discuss the applicability and development potential of industrial timber construction systems in Turkey.

Following initiatives such as the 2022 "Timber Use Promotion Workshop" held in Ankara, Turkey initiated one of its first collective industrial timber housing projects in Osmaniye, a region located in a high seismic zone. The project was commissioned by the General Directorate of Forestry (OGM), designed by NMK Architecture, and constructed by NASWOOD. The project was intended to serve as a pilot application for the development of timber construction regulations and the wider adoption of industrial timber construction systems in Turkey (Figure 3).

The development consists of three residential blocks with three floors and a basement, forming a residential complex with 36 apartments (3+1 units). The site also includes shared facilities such as parking areas, sports areas, playgrounds, and green spaces. Each residential block has a footprint of approximately 740 m², and the total construction area of the site is approximately 2200 m².

Due to seismic safety requirements and functional needs, a hybrid structural system was adopted in the project. Reinforced concrete was used in the basement floors, building cores, and some shared spaces, while the residential upper floors were constructed using industrial timber structural systems. This hybrid approach combines the rigidity of reinforced concrete with the lightness and flexibility of timber structures, improving overall seismic performance.

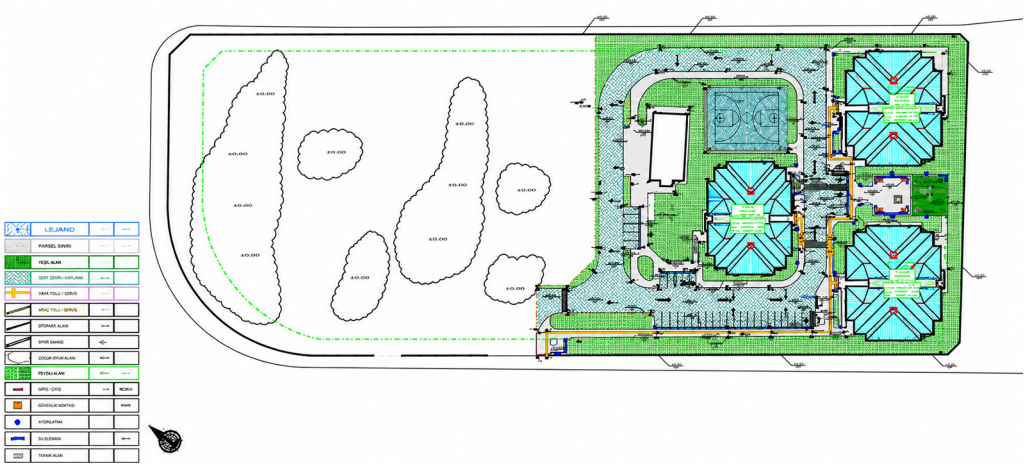


Figure 3. Site plan of the Osmaniye Timber Housing Project (Unpublished company working report, 2023, NASWOOD).

Timber was selected as the primary construction material due to its fast construction potential, low weight, seismic resilience, natural insulation properties, and environmental advantages. The project not only provides comfortable and sustainable housing but also represents an important step toward integrating industrial timber construction into the Turkish construction sector and promoting earthquake-resistant and environmentally responsible building design.

Use of Engineered Timber in the Osmaniye Housing Project

The Osmaniye OGM Housing Project was designed to promote both environmental sustainability and the wider use of timber in residential construction. Engineered wood products were used as the primary material for structural elements such as columns and beams, as well as for non-structural components including walls, roofs, façade cladding, and window frames. This approach ensured structural strength, durability, and energy efficiency while maintaining architectural quality.

Exterior façades were covered with timber cladding to emphasize natural aesthetics, while OSB panels were used in wall systems to improve thermal insulation and structural performance. Interior spaces such as corridors included timber panel applications, and MDF furniture and laminated wood surfaces were used in apartments to create a warm and natural interior atmosphere. This integrated material approach combines structural performance, environmental benefits, and architectural aesthetics, positioning timber as a key material for modern housing design.

For the main load-bearing structural system, glulam spruce timber was used in large cross-sections for columns and beams. The timber elements were kiln-dried to a moisture content of approximately 10–12% to ensure bonding quality and prevent cracking. The elements were then planed, calibrated, defect-checked, and classified before lamination. Long structural members, up to 8.87 meters in length, were produced using finger-jointing techniques. MUF adhesives were applied, and elements were cold-pressed to produce high-strength glulam structural components.

CNC machining technology was used for precise cutting, drilling, and detailing of structural connections (Figure 3, Figure 4). This significantly improved assembly speed, structural accuracy, and seismic performance. Accurate connection detailing ensured structural rigidity while allowing controlled energy dissipation under dynamic loads such as earthquakes. Finished structural elements were tested, labeled for traceability, protected against moisture and damage, and delivered to the construction site in assembly order (columns, beams, floors, walls, roof elements).



Figure 4. Wall frame of the Osmaniye Timber Housing Project (Unpublished company working report, 2023, NASWOOD).

This production process demonstrates a high level of engineering precision, quality control, and sustainability, enhancing not only structural performance but also construction efficiency and seismic resilience. Overall, the project represents one of the first modern applications of glulam structural systems in multi-story residential construction in Turkey.

Assembly Process of the Osmaniye OGM Timber Housing Project

The Osmaniye OGM timber housing project demonstrates how prefabricated industrial timber systems can significantly shorten construction time, reduce labor requirements, and improve construction quality. Structural elements were produced in a factory environment using CNC technology, classified according to assembly sequence, and transported to the construction site. This process minimized on-site labor, reduced construction errors, and improved overall construction efficiency.

Construction began with reinforced concrete raft foundations. Although timber structures are relatively lightweight, raft foundations were preferred due to seismic safety requirements, soil conditions, and the presence of basement floors. While foundation construction was ongoing on site, timber structural elements were simultaneously engineered, digitally processed, and manufactured in the NASWOOD production facilities, demonstrating the advantages of parallel construction processes in prefabricated building systems.

On-site assembly followed a systematic sequence. Timber columns were first anchored to the foundation, followed by the installation of beams forming the main structural frame. After the structural frame was completed, prefabricated floor elements, partition walls, and roof structures were installed. Finally, façade cladding, windows, mechanical systems, and interior finishes were completed.
The project applied a hybrid structural system combining reinforced concrete structural elements with a timber superstructure. This hybrid system provided structural rigidity in the lower levels while maintaining the lightweight and sustainable characteristics of timber in the upper floors. Prefabrication and CNC production significantly improved construction speed, precision, and seismic safety, making this project an important example of modern hybrid timber construction in Turkey.



Figure 5. Column anchorage connection of the Osmaniye Timber Housing Project (Unpublished company working report, 2023, NASWOOD).

Seismic Design Principles of the Osmaniye Timber Housing Project

The hybrid timber–concrete structural system was specifically designed to improve earthquake performance. The low weight and elastic behavior of timber reduce lateral seismic forces and allows controlled deformation under seismic loads. Structural stability was improved through symmetrical placement of columns, orthogonal load-bearing systems, and balanced façade openings. Connections were designed as energy-dissipating elements using CNC-machined timber joints combined with steel plates and bolted connections (Figure 5). Approximately 850 m³ of timber was used in the superstructure, and the structural system was designed to provide flexibility rather than excessive rigidity, ensuring safer structural behavior during earthquakes.

From an architectural perspective, the project also addresses post-disaster housing needs by allowing rapid assembly and flexible interior layouts. Prefabrication enables different combinations of timber structural elements and building configurations, allowing adaptable housing solutions. In addition, the natural appearance, warm material character, and environmental benefits of timber help reduce the environmental and psychological impacts in earthquake-affected regions, improving occupant comfort and well-being.

Overall, the Osmaniye Timber Housing Project demonstrates that industrial timber construction systems can be successfully applied in seismic regions of Turkey and can provide a viable alternative to conventional reinforced concrete construction in terms of seismic performance, sustainability, and construction efficiency.

CONCLUSION

Turkey's seismic history and the devastating consequences of the 2023 Kahramanmaras earthquake highlight the urgent necessity of rethinking material choices and construction practices. This study has demonstrated that industrial timber construction systems, when integrated with modern engineering and architectural strategies, offer significant advantages in terms of seismic resilience, sustainability, and housing quality. With its lightweight, ductile, and energy-absorbing characteristics, timber reduces earthquake-induced forces, while prefabricated production technologies improve construction precision, speed, and quality control.

The OGM Osmaniye Timber Housing Project stands out as one of the first hybrid systems (reinforced concrete–industrial timber) implemented in Turkey. Being realized in a high seismic risk zone, the project demonstrates that timber structures can be a strong alternative for earthquake-resistant construction. The buildings, constructed using approximately 850 m³ of timber, achieved structural precision and reliable seismic performance through CNC-fabricated joints and steel connection details that ensured durability and structural integrity. Environmentally, the project contributed to sustainability by storing approximately 701 tons of CO_2, significantly reducing its carbon footprint. Beyond structural safety, the design emphasized the natural texture and warm atmosphere of timber, combined with passive climate control strategies, to create a comfortable, aesthetic, and user-centered living environment. As a pioneering example, the project provides both a technical reference and a practical model for future timber housing initiatives in seismic regions.

Ultimately, the integration of industrial timber construction into Turkey's housing sector represents not only a structural and technological innovation but also a cultural and environmental transformation toward more resilient, ecological, and human-centered construction. However, for industrial timber construction systems to become widespread in Turkey, improvements are needed in industrial production capacity, forestry policy, education, technical expertise, and regulatory frameworks. Continued research, policy support, and professional training will be essential to expand their application and unlock timber's full potential in shaping earthquake-resistant and sustainable urban development in Turkey.

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