Energy Efficiency in Cross Laminated Timber (CLT) Buildings

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PREFACE

In our book called *Architectural Sciences and Technology, the subjects below have been discussed*:

- Implementation of systems approach in material selection in the building
- Evaluation of climate-compatible elements in rural architecture: case of Diyarbakır province Erimli neighborhood
- Questioning the use of travertine as a construction materials in historical buildings within the context of sustainable architecture: the case study of Evdir Han
- The analyzing of architectural ornaments on historical Antakya houses, pavilion design as an example of the re-ornamentation
- Concept of “Aesthetic Value” lost in the modern-day anthropocene era and lessons to be derived from vernacular Nubian architecture
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- Spatial learning through landmarks

I would like to express my gratitude; to the lecturers of the department who contributed to our book with their valuable scientific studies, to the lecturers who contributed to the chapters with refereeing, to the staff of Livre de Lyon Publishing House for their contributions in all the publishing processes of the book in these difficult days of the pandemic process.

I hope our book titled **“ARCHITECTURAL SCIENCES AND TECHNOLOGY”** will be useful for the reader.

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chapter 10

ENERGY EFFICIENCY IN CROSS LAMINATED TIMBER (CLT) BUILDINGS

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1. INTRODUCTION

Worldwide energy consumption has been increasing very fast depending on population growth, industrialization, competing demand for buildings, and technological developments. Despite advancing technology, use of renewable energy resources in buildings (solar power, wind energy, etc.) is insufficient, and the most part of energy consumed for the purpose of heating, cooling, and electric still has been derived from fossil fuel such as natural gas and coal.

The production and consumption of electricity accounted for one third of the building energy use in 2019. Beside this, fossil fuel usage increased by 0,7% from 2010 to 2019. Carbon emissions “CO2” induced by buildings reached all-time high in 2019 (Abergel and Delmastro, 2020). Energy efficiency in buildings has to be taken into consideration not only for equipment which requires heating, cooling, and electricity usage but also all building materials. Concordantly, demand for ecological and sustainable building materials which can be derived from renewable resources has gradually increased in recent years. Practicing native materials in architecture and incorporating them into sustainable development processes have resulted in a significant increase in energy conservation (Korjenic, 2011). Decreasing energy consumption and fossil fuel quantity in buildings according to the needs also reduces quantity of C02 and S02 which are released into the atmosphere. Instructions prepared for building energy performance suggest that buildings be designed in such a way as to decrease energy amount required for operating system and that more precautions taken in order to enhance energy performance in existing buildings (Papadopoulos and Giama, 2007).

Building materials selection, heat insulation applications and environmental performances of these materials allow for analysis of energy efficiency and construction costs. Type and thickness of insulating materials can be changed even in early design stage. For selection of construction materials and elements, a great variety of criteria such as thermal and physical characteristics, environment, energy, and cost are evaluated based on an integrative approach (Anastaselos et al., 2009). Moreover, another prominent one of sustainability precautions to decrease carbon footprint, energy use, and greenhouse gas emissions in buildings is the use of insulating materials (Rakhshan et al., 2013). Application methods, thickness, and types of the materials are determinative factors for their performance (Papadopoulos, 2005). Wood is one of high-performance insulation materials. It is possible to generate insulation panels consisting of particles with several types and dimensions by using wooden materials (Viot et al., 2015).

At the first part of the study, structural-physical-environmental-economic characteristics, use-application styles in buildings, insulating properties, earthquake resistance, advantages-disadvantages, etc. of the material Cross Laminated Timber (CLT) is examined thoroughly, and some CLT building samples in Turkey and the world are shown. The second part focuses on a comparative evaluation of energy performance in a sample building that is assumed to be erected in a mild humid climate region by using CLT materials and different traditional building materials.

2. CROSS LAMINATED TIMBER (CLT)

The most important building material used in architectural sectors is wooden materials. Mechanical properties such as weight, resistance, density, structural characteristics, insulating properties, and also high thermal characteristics play a significant role in using wooden construction materials (Breyer et al., 1999).

Today, having been built by using engineering wooden materials (Glulam Laminated Veneer Lumber (LVL), Parallel Strand Lumber (PSL), Laminated Strand Lumber (LSL), Cross Laminated Timber (CLT), high-rise structures covering large spans are drawing more attention. These materials have been used in numerous fields such as bridges, coach stations, education facilities, sport halls, industrial buildings and dwellings other than single-story wooden structures (Rowell, 2012). CLT was developed in Switzerland in the early 1990s, and took its today form in 1996 in Austria because of industry-academy cooperation. In 2000s, building with CLT gained speed. Austria, Sweden, Switzerland, Norway and the United Kingdom are prominent countries in using CLT for dwellings, education facilities, etc.

Among the advantages of CLT materials are to make undersized pieces of saw timber into oversized building materials, to be eco-friendly, to shorten construction period, to be lighter in proportion to concrete and steel materials, to provide convenience in building process due to prefabrication, to have a high load capacity, to be made from solid wood, to have a high fire-resistance, to have a good heat insulation, to allow for flexibility in architectural design (Crosslam, n.d.; KHL, 2019). Together with its advantages, there are also some usage restrictions for the material. For instance, finished panel designs before starting site works, a properly founded base for panel applications, and face veneer or coating in order to provide weather-resistant building envelope are required (Greenspec, n.d.).

2.1. Structural Properties and Installation

CLT is a wooden construction product with 3, 5, 7, 9 or more layers as a result of gluing and pressing solid wooden panels together in a way that fiber directions are perpendicular to each other. CLT consists of minimum 3 layers that are glued together and the layer thickness changes depending on structural requirements. The layers are fastened by using nature friendly glue containing formaldehyde not less than 1% of the product (Stora Enso, 2017). For cross-laminated timber materials produced with commercial purpose, some techni-cal properties taking place in literature are given in Table 1.

Table 1. Some Technical Properties of CLT Material (Greenspec, n.d.)

Thermal conductivity: 0.13 W/mK
Density: 480–500 kg/m (spruce)
Compressive strength: 2.7 N/mm (perpendicular to grain of boards) 24–30 N/mm (parallel to grain of boards)
Bending strength: 24 N/mm (parallel to grain of boards)
Elastic modulus: 370 N/mm (perpendicular to grain of boards) 12,000 N/mm (parallel to grain of boards)

Combined wooden panels as in Figure 1 is defined as dovetail connection (joint). In this joint system, a dovetail made from wooden or steel material is added to CLT wall panels and the walls are combined. Among the most remarkable advantages of the joint type used both to produce CLT panels and to fasten wall panels are having a high resistant to disintegration, allowing for a fast and easy montage, and being flexible, versatile and affordable (Sustainable Construction Services, n.d.).

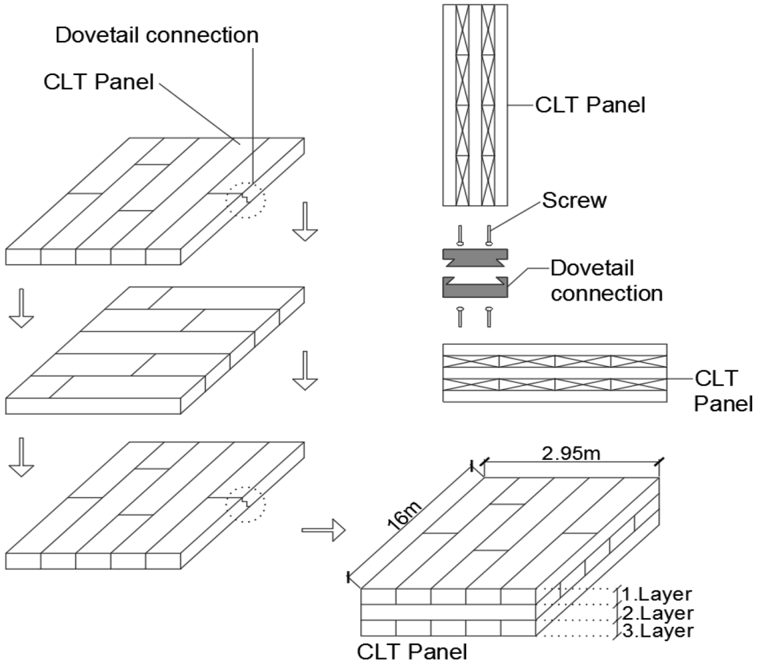


Fig. 1. Connection system in CLT assemblies (Stora Enso, 2017; Sustainable Construction Services, n.d.)

Due to being a prefabricated material, construction time of CLT is quite short. CLT panels can cover a 7 to 7,5mt span without an extra bearing element and can be produced by 20m-length through end to end joint (finger joint) upon request (Wood Solutions, 2014) (Figure 2). Furthermore, CLT panels compose a system with a higher shear strength which is structurally stronger and lighter when compared to concrete and steel material (Crosslam, n.d.).

Fig. 2. Finger joint system between CLT panels (Cree Buildings, 2015; Crosslam, n.d.)

CLT panels can be used for roof, wall, and floors in buildings. Figure 3 shows detail drawing of alternative layers that could be used for roof, wall, and floor mounting in a building. These details were obtained from different sources and rearranged.

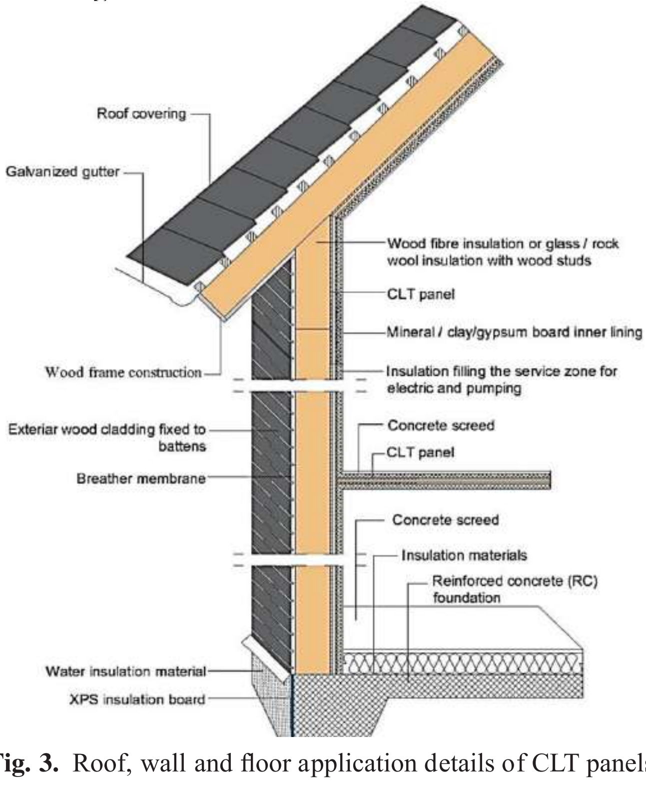


Fig. 3. Roof, wall and floor application details of CLT panels

CLT panels are transported to the construction site after being manufactured. The panels which are numbered according to the installation plan are moved to a proper place with the help of cranes. The panels, thereafter, are fastened by means of predetermined junction sections, screws, and bolts. The wall panels that are lifted up with the help of cranes considering the number coding system are placed and fixed on the prebuilt base of the building by means of fixing sections (Wood Solutions, 2014; Crosslam, n.d.). Due to being prefabricated, CLT structures reduce the risk that design problems arise. CLT panels are cut in compliance with installation projects at CNC countertop, and electricity wiring and water system are installed.

Wooden products are a good preference for most green building projects including both construction and renewal (Crosslam, n.d.). The total cost of buildings erected by using CLT materials is less by 0.9 -1.3% than the cost of traditional reinforced concrete buildings (Jayalath et al., 2020). During the installation stage, CLT buildings provide savings on cost and time when compared to concrete buildings (Ceccotti, 2010; Kayakıran and Kishalı, 2019; Van De Kuilen et al. 2011).

2.2. Fire Performance

Wooden buildings are the structures more resistant to fire than the steel ones. Because of leading to fast heat dissipation, steel allows fire to spread around rapidly. While steel material becoming substantially soft after fire causes a building to collapse, wood materials char equally at a speed of 1mm/min in case of fire, and thus create a carbon later which prevents fire from going on (Crosslam, n.d.). CLT panels with 30, 60, 90-min fire endurance period can be produced. CLT composition can put up resistance to massive fire during 120 minutes without sacrificing the structural system of the building. The main reason is that the mass ratio is high (Greenspec, n.d.; Crosslam, n.d.). In spite of the fact that CLT materials do not need to be covered with various materials on the purpose of putting up resistance to fire, the laws concerning fire regulations require that they be covered with fire-resistance sheets (Henek et al., 2017).

2.3. Earthquake Performance

Wood is a light material resistant to tensile and strain. Wood is lighter 15 times than steel, 5 times than reinforced concrete (Turer, 2006). Tensile-resistance wood material can cover large spans (Kuban, 1992). Wood changing shapes when force is applied resumes its original shape when force is removed (Alih and Vafaei, 2019). Due to being light, wood reduces lateral pressure (horizontal force) (Avlar, 2002).

CLT panel is a material that is light, flexible, earthquake-resistant, and has high value of the rigidity and bearing capacity. That is the reason why it is a building material often preferred in earthquake-prone regions. That build-ings are light reduces the risk of collapsing (Stora Enso, n.d.; Tobriner, 2000). Owing to the durability and dimensional stability, CLT panels develop very good resistance to lateral load. When compared to other materials, CLT struc-tures can be repaired more easily, safely and faster when they are damaged because of earthquake (Crosslam, n.d.). Problems arising during an earth-quake are usually caused by junction breakages (Mohammad et.al, 2013).

2.4. Heat Insulation Performance

Of wood materials, energy consumption and thermal characteristic are better in proportion to those of concrete and steel. According to the declarations by American Wood Council (AWC), the insulating value of coniferous wooden materials is roughly one third of that of fiberglass insulation with the same thickness. The same value is higher 3 times than that of concrete material and approximately 400 times than steel material (Canada Wood, 1995). However, energy consumption is 1,7 times higher at reinforced concrete structures and 2,4 times at steel structures than wooden ones (Tokyay, 2017). Heat conduc-tivity of wood material is low (Table 2), which makes it suitable for both heat and sound insulation (Upton, et al., 2008).

Table 2. Thermal Conductivity Of Some Materials (TS 825, 2008)

Material	Density (kg/m3)	Conductivity (W/m.K)
Concrete	2400	1,93
Brickwork	1700	0,77
Reinforced Concrete (RC)	2300	2,5
Gypsum	1200	0,43
Timber (softwood, plywood, chipboard)	500	0,13

Through the method of adhesive bonding which is employed for CLT panel production, high-grade impermeability is procured throughout panels. Moreover, CLT panels have high specific heat capacity, which can considerably reduce heating and cooling costs and also enhance indoor comfort by creating sort of thermal mass action. In order that a building with CLT materials has a high energy performance, extra insulation on the building envelope is required (Cross Timber Systems, n.d.).

At wooden buildings, heat insulation is carried out generally on exterior surfaces. Conducted in Chang, et al. (2019), a study indicates that exterior-insulated CLT walls have lower thermal bridges. External insulation allows for the continuity of insulating layer around structures. However, insulating layer is interrupted at wall-floor or wall-ceiling junctions in internal insulation applications. In order to enhance building energy performance and decrease thermal bridges, the continuity of insulation is so important. Beside this, external insulation reduces expansion in walls by protecting CLT panel against external climate conditions (Greenspec, n.d.).

2.5. Environmental Properties

When an approach to reducing environmental effects and climatic changes is brought, utilization of wooden materials instead of such materials as concrete whose consumption of energy and Cis high is a good solution. It is known that wooden structures lead to less C emissions during their life cycles when compared to the systems based on concrete, steel or brick (Upton, et al., 2008). Due to having a key feature of carbon sequestration, wooden materials can store 28,5 tons of carbon dioxide which a 216 square- meter house produces and which is equal to the quantity of carbon dioxide that a car exhales for 7 years (Tokyay, 2017). Utilization of CLT for structures contributes to the preservation of biological diversity, forest ecosystems, and soil-water resources, and reducing greenhouse gas effects caused by carbon emission (Crosslam, n.d.).

3. CLT BUILDINGS

Around the world in recent years, CLT buildings serving many different purposes but generally as dwelling houses have been built. In this section of the study, CLT building samples, the designs of which are done, in the country and abroad are shown.

3.1. Kea Boumanstraat

The house built between the years of 2012 and 2013 in Amsterdam, the capital of the Netherlands was designed to serve as a 240-square-meter and 3-storey plus basement home for a family of 4. In order to shorten the construction time and maintain the sustainability, the house was built by using CLT panels. Beside this, it was designed to be an energy efficient house with features such as solar panels on the roof and a tank in the garden to store rain water for reuse (Meesvisser, n.d.).

Fig. 4. Kea Boumanstraat building (Meesvisser, n.d.)

3.2. Lct One

The 18-storey building, which was built between the years of 2015 and 2017 in Vancouver, belongs to the University of British Colombia, and has gained the title of the tallest wooden building in the world, is 53 meters in height and provides 404 students with the spaces for accommodation, education, and recreation. The building was erected on a concrete basement by using a 17-storey solid wood system with 5-layer CLT panels. Owing to the wood system utilized for the building, 1753 metric ton of carbon dioxide was stored and 679 metric ton production of greenhouse gas emission was prevented (Build Up, 2013; Cree Buildings, n.d.)

Fig. 5. Lct One building (Gayle, 2012)

3.3. Ubc Brock Commons

The office building with an 8-storey modular and hybrid (CLT-concrete) structural system was built between the years of 2011 and 2012 in Dornbirn, Austria. For the flooring of the building with 27-meter height, 13-meter width, and 24-meter length, a wood-concrete composite rib unit was developed. For the building, a good heat insulation level was provided and the thermal transmittance (U) for the main external walls and the roof was calculated respec-tively 0,12 W / (m^2 K) and 0,07 W / (m^2 K) (Naturally Wood, n.d.; UBC Sustainability, n.d.; Think Wood, n.d.).

Fig. 6. Ubc Brock Commons building (UBC Sustainability, n.d.)

3.4. Minneapolis T3

The office building was a solid wood building with LEED Gold certificate, constructed in 2016 in the USA. The 7-storey building has a 20500-square-me-ter construction site. For the columns, walls, and floors of the building, 3600-square-meter wooden materials (CLT) were used. During the physical life, the building that was once the biggest CLT building of the North America continent was assumed to store 3200 tons of carbon (MGA A Katerra Design Partner, n.d.; Arch Daily, n.d.; Bilgiç, 2017).

Fig. 7. MINNEAPOLIS T3 building (MGA A Katerra Design Partner, n.d.; Arch Daily, n.d.)

3.5. The Tree (Treet)

Fig. 8. Treet building (Urban Next, n.d.)

The 14-storey dwelling house with 52,8-meter height, which was built between the years 2015 and 2017 in Bergen, Norway, has a 7140-square-meter con-struction site. For the construction, CLT and Glulam were used. Beside this, each flat was provided with its own self-balancing ventilation system by using an 80% - efficient heat recovery ventilation system (Urban Next, n.d.; Abrahamsen and Malo, 2014).

3.6. Grand Ottoman Hotel

The building serving as a hotel is located on the riverside of Yeşilırmak in Amasya, Turkiye. The 2-storey project, the walls and floors of which CLT was used for, has a 1000-square-meter construction site was built by the firm, ASMAZ Ahşap Karkas Yapılar (Wood-Frame Buildings).

Fig. 9. Grand Ottoman hotel (Asmaz, n.d.)

4. BUILDING COMPONENT AND CASE ANALYSIS

The CLT building design and its characteristics were explained in detail at the first part of the study. As for this section, the data of the sample building, the energy simulation of which was made were shared here. In order to make a comparative energy efficiency evaluation and thermal analysis of the sample building which was made from CLT and other construction materials, DesignBuilder Simulation program was used. Such descriptions as the con-struction materials, thermal zones, heating-cooling system, spaces, and cli-matic data of the sample building were made (Figure 10).

The scope of the study was bounded by Istanbul located in mild humid climate region (Turkey, 2nd degree-day region). Of Istanbul, the climatic data based on long term averages are seen in Table 3 (Turkish State Meteorological Service (n.d.).

ISTANBUL	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Max. Temp.	22.4	24.6	29.3	33.6	36.4	40.2	41.5	40.5	39.6	34.2	27.8	25.5
Min. Temp.	-13.9	-16.1	-11.1	-2.0	1.4	7.1	10.5	10.2	6.0	2.2	-7.2	-11.5
Average Temp.	5.8	5.5	7.3	11.2	15.7	20.5	22.9	23.4	19.9	15.8	11.0	7.8
Average Max. Temp.	8.5	8.7	11.0	15.5	20.1	25.0	26.9	27.2	23.8	19.2	14.2	10.4
Average Min. Temp.	3.5	2.9	4.4	7.8	12.2	16.7	19.7	20.4	16.8	13.2	8.5	5.5
Average Rainy Days	15.2	13.2	11.7	8.9	6.6	4.7	3.0	3.4	5.5	9.0	11.2	14.5

Table 3. Long-term Average Temperature Data in Istanbul (1929-2019)

The building modelled as part of the study is a one-story rectangular structure having a usable area of 80 m2 with the dimensions of 8m by 10m. The modelled building contains a lounge, a kitchen, bedrooms, a circulation area, and a bathroom (Figure 10). A hipped roof and standard double-glazed wooden windows were selected for the building.

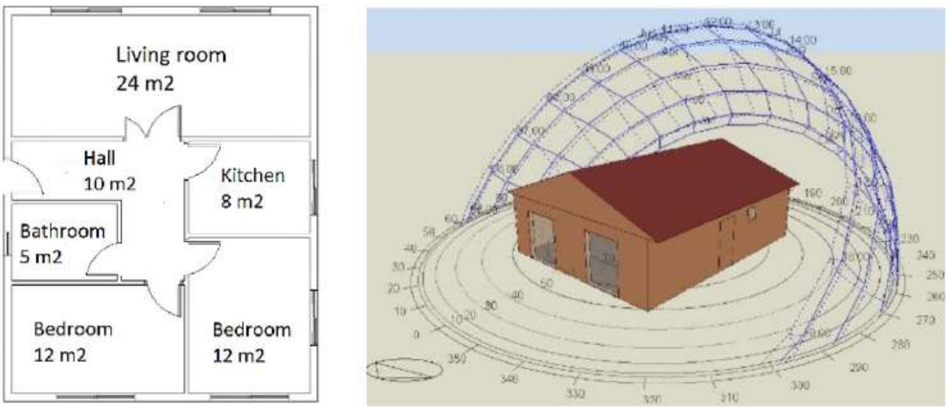
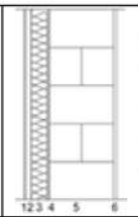
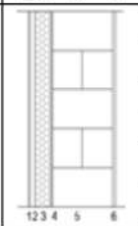
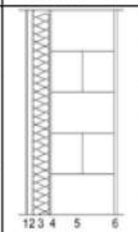
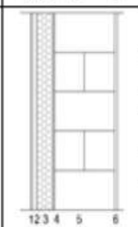
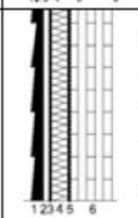
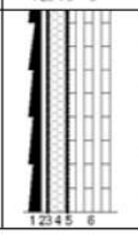


Fig. 10. Floor plan and 3D rendering of model building

Among the alternative options for the walls were brick, gas concrete, and CLT that are commonly preferred. The options were based on the U values of exterior walls determined for the second climate zone in conjunction with the TS 825 standard. Sections that are commonly practiced in today's house designs were generated, and the same thickness and type of insulation were selected (as 5cm and Rock wool, EPS) for all the options. For the CLT walls, the panel thickness was 10cm (the most-preferred one in practices). Of the materials shaping the alternative wall layers, the technical specifications are given in Table 4.

Table 4. Thermophysical Properties of Wall Materials (TSE 825, 2008)

WALL LAYERS		No	d (m)	Materials	λ W/mK	P Kg/m^3	c J/(kg.K)	U (W/ m^2K)
BRICK WALL (Rock wool)		1	0,005	Gypsum plaster	0,16	600	1000	0,442
		2	0,015	Cement mortar plaster	0,42	840	1200	
		3	0,05	Rock wool	0,038	40	840	
		4	0,005	Cement mortar plaster	0,42	840	1200	
		5	0,19	Brick	0,30	1000	840	
		6	0,01	Cement rendering	0,42	840	1200	
BRICK WALL (EPS)		1	0,005	Gypsum plaster	0,16	600	1000	0,456
		2	0,015	Cement mortar plaster	0,42	840	1200	
		3	0,05	EPS	0,40	16	1400	
		4	0,005	Cement mortar plaster	0,42	840	1200	
		5	0,19	Brick	0,30	1000	840	
		6	0,01	Cement mortar plaster	0,42	840	1200	
GAS CONCRETE BLOCK WALL (Rock wool)		1	0,005	Gypsum plaster	0,16	600	1000	0,413
		2	0,015	Cement mortar plaster	0,42	840	1200	
		3	0,05	Rock Wool	0,038	40	840	
		4	0,005	Cement mortar plaster	0,42	840	1200	
		5	0,19	Gas concrete	0,24	750	1000	
		6	0,01	Cement mortar plaster	0,42	840	1200	
GAS CONCRETE BLOCK WALL (EPS)		1	0,005	Gypsum plaster	0,16	600	1000	0,425
		2	0,015	Cement mortar plaster	0,42	840	1200	
		3	0,05	EPS	0,40	16	1400	
		4	0,005	Cement mortar plaster	0,42	840	1200	
		5	0,19	Gas concrete	0,24	750	1000	
		6	0,01	Cement mortar plaster	0,42	840	1200	
CLT WALL (Rock wool)		1	0,03	Wood cladding	0,13	700	1200	0,381
		2	0,015	Air gap	-	-	-	
		3	0,0001	Vapour retarder	2,3	130	2300	
		4	0,05	Rock Wool	0,038	40	840	
		5	0,0001	Water insulation material	0,23	1,3	1000	
		6	0,10	CLT	0,13	500	1300	
CLT WALL (EPS)		1	0,03	Wood cladding	0,13	700	1200	0,391
		2	0,015	Air gap	-	-	-	
		3	0,0001	Vapour retarder	2,3	130	2300	
		4	0,05	EPS	0,40	16	1400	
		5	0,0001	Water İnsulation material	0,23	1,3	1000	
		6	0,10	CLT	0,13	500	1300	

The U-values and thickness of wall sections vary according to the formation and application detail of section. For the model, the value of infiltration occurring from external environment to indoor is established as 0.8 ach-1. The user profile identifies a single-child family of three people. It was assumed that the period during when the family stayed in the house was between 08.00 and 17:00 on weekdays and whole day at weekends. The heating-cooling values determined for the usage of building and spaces are shown in Table 5. Spaces, the heating-cooling requirement of which was similar were modelled as they were a single thermal zone while creating a thermal zoning. In the examined dwelling house, natural gas central heating boiler system for heating and air conditioner and natural ventilation for cooling was included in the program.

Table 5. Heating-Cooling Setpoint Temperatures

Heating (°C)	19	Cooling (°C)	25
Heating set back (°C)	15	Cooling set back (°C)	28

4.1. Heating - Cooling Loads of Building

Within the scope of the study, total heating and cooling load calculation for each of wall samples was performed by month and year through the DesignBuilder program using the climatic data of Istanbul as base. The results obtained from the model were used to compare all other scenarios (brick wall with rock wool / EPS (BW-R, BW-E), gas concrete block wall with rock wool / EPS (GSW-R, GSW-E), CLT wall with rock wool / EPS (CLT-R, CLT-E). In Figure 11 and 12, the heating and cooling load values for different scenarios of the model building in summer and winter are given.

According to the simulation results, the annual energy consumption by the heating load is 2912.21 kWh for the scenario 1 (BW-R), 2872.22 kWh for the scenario 2 (BW-E), 2845.65 kWh for the scenario 3 (GSW-R), 2872.223 kWh for the scenario 4 (GSW-E), 2714.737 kWh for the scenario 5 (CLT-R), and 2734.28 kWh for the scenario 6 (CLT-E). When comparing all the sce-narios with each other, we see that the scenario 5 (CLT-R) related to the rock wool-insulated CLT building delivered the best performance in terms of the heating load. The scenario 5 provided energy saving respectively by 7 % and 5 % when compared to the rock wool-insulated brick wall and the rock wool-insulated gas concrete wall. All the results are associated with the thermal conductivity and specific heat values of construction and insulation materials. The CLT walls presenting the effect of massive thermal mass enhance build-ing energy performance provided that they are insulated with materials suit-able for the climate region where they are

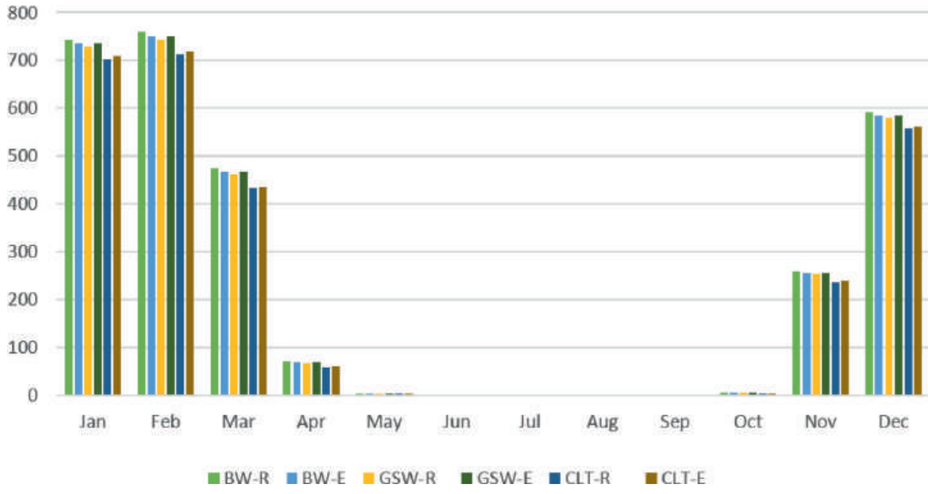


Fig. 11. Heating loads for different wall scenarios

According to the simulation results, the annual energy consumption by the cooling load is 229.6 kWh for the scenario 1 (BW-R), 229.9 kWh for the scenario 2 (BW-E), 228.5 kWh for the scenario 3 (GSW-R), 228.7 kWh for the scenario 4 (GSW-E), 262.2 kWh for the scenario 5 (CLT-R), and 263.2 kWh for the scenario 6 (CLT-E). When comparing all the scenarios with each other, we see that the scenario 5 (CLT-R) related to the rock wool-insulated CLT building delivered the least performance in terms of the heating load. The scenarios for the insulated gas concrete walls and brick walls revealed approximate values in terms of the cooling load of the model building. That CLT walls have the characteristic of high air tightness and provide insufficient natural ventilation due to their compacted formation affect cooling load per-formance negatively in the summer months.

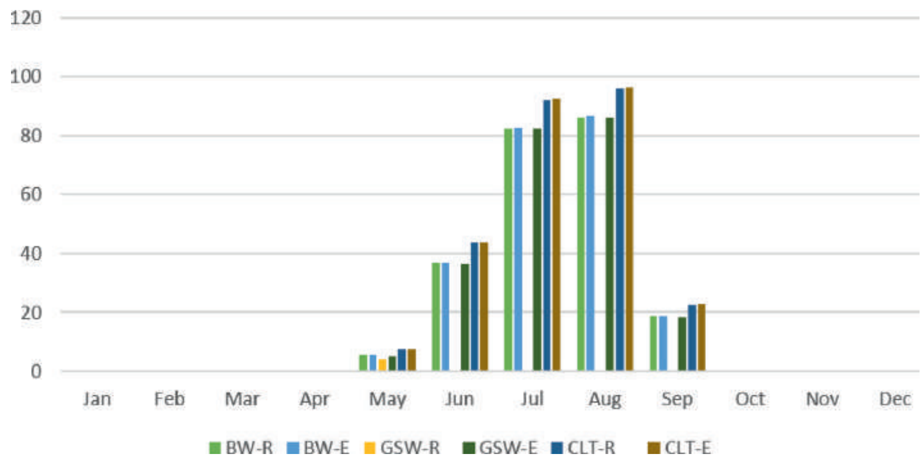


Fig. 12. Cooling loads for different wall scenarios

5. CONCLUSIONS

Low-energy building designs which have been recently constructed through passive systems in architecture sector as a solution to climate change and global environment problems by using renewable energy sources and ecological building materials have been drawing attention. In this regard, CLT, a new generation wood product, has been commonly used in construction sector around the world due to having many advantages that will make a great contribution to sustainable design. Load-bearing (being able to cover large spans) and non-load bearing construction elements can be made of CLT materials which can be used for low, medium, and high-rise buildings (taller than 8-storey). Beside this, CLT panels can be easily integrated with steel, reinforced concrete and other wood-frame systems.

As part of the study, energy efficiency of a representative building which had been constructed by using CLT was evaluated by comparing with other construction materials. Consequently, when compared to the walls which were built with other construction materials (brick, gas concrete, etc.), the insulated CLT panel walls were seen to have enhanced the energy efficiency of the building and had positive impacts on the heating load. That CLT has a high-density formation (massive timber) and very low air tightness increases energy efficiency by creating sort of the thermal mass effect. However, thermal mass effect and air tightness generate adverse effect in terms of cooling loads. The data of cooling load related to the CLT building, the simulation of which was made for the study, also corroborates the aforesaid situation. In their studies, Glass (2013) and Khavari et al. (2016) indicate that the cooling load was high in the CLT buildings which they had analyzed but the peak cooling load lower than that of the reference building was required. Moreover, the thickness of CLT panels is inversely proportional to the U-value but directly to the thermal performance, which also allows for the lower thickness of insulation. According to a general evaluation of CLT energy performance; climatic zone where a building is located, building usage purpose, size, CLT panel properties, heating-cooling-ventilating type, and indoor thermal load are the parameters which are the points to take into consideration in order to provide low energy consumption.

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