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Abstract
In order to reduce the environmental impact of the construction industry, the case of natural material (such as timber) is pursued. However, is the use of low-impact materials sufficient to decrease the overall environmental impact of a building? The answer is not trivial, because there are many parameters that affect sustainability, in addition to the unitary environmental impact of the building materials. Through this article, an evaluation of the total CO_2 emission in buildings made of reinforced concrete and CLT panels is carried out. The entire life cycle (LCA) of the materials is considered, as well as the CO_2 emissions derived from heating and chilling. The relationship between CO_2 emissions and building height is also taken into account along with weather conditions.
The structures and envelopes of a three – storey family house and of a multi-storey residential building are designed from a structural and thermal point of view, respectively. In order to consider the climatic effects, three locations with very different weather conditions are assumed (i.e. Catania, Turin, Oslo). The carbon footprint of three different structures is considered, namely RC frame made with cast–in–situ structural elements, precast RC panels and timber CLT structure.
The quantification of the carbon footprint allows to notice how the overall structural and thermal performances, including the thermal mass, affect the environment performance.

Keywords: LCA, FEM analysis, reinforced concrete structures, timber structures, thermal analysis

1. Introduction

1.1 State of the art
The use and sustainability of cement in housing construction is a concern due to the considerable amount of carbon dioxide generated in the manufacturing process [1]. Recent reports indicate that clinker burning accounts for approximately 4% of all global CO_2 emissions [2].
In response to this problem, the use of more ecologically sound alternatives, such as wood, is increasing [3]. However, the determining factors and efficacy of such materials on environmental impact is still an open problem. Further generalized environmental impact assessment (E.I.A.) of these building materials is therefore necessary.

1.2 Research significance
In this regard, the goals of this work are to answer to the following questions:
- To what extent is the sustainability of a construction influenced by the construction techniques, and by location?
- What are the results obtained by Life Cycle Assessment (LCA) when only the materials are taken into consideration?
- How the results are influenced by the use of the building?

Fig. 1a: EMA Haus,
Arch. Bernardo Bader [4].

Fig.1b: Borgo dei lavandai, Cristiano Picco [5].

To answer these questions, it was decided to carry out two studies on two different types of building: a single-family house and a condominium. The first case focuses on a small 3-story building with a total area of about 120 m^2 (Fig. 1a). The second is related to a 5-story building with a total area of about 1200 m^2 (Fig 1.b). The same criteria and steps were followed to perform the analysis for both the buildings.
The structure of these two buildings consists of:

- Reinforced concrete frame with cast-in-situ beams, columns and one-way slabs;
- Precast reinforced concrete vertical panels and horizontal one-way slabs.
- Timber CLT structure.

The climatic influence on the use of the building was taken in account by analyzing three different scenarios: buildings located in in Catania, Turin and Oslo. Therefore, both the family house and the condominium were assessed 9 times.

2. Materials and methods

As two existing buildings (Fig. 1a-b) are investigated, the shape and the geometrical dimensions of the structures are fixed. Only the thickness of the panels and the size of the frames cross-sections were modified, to satisfy all the requirements. All structural analysis and design were performed using CDM Dolmen [6], which is a Finite Element software.
The stratigraphy of the envelope was chosen according to the construction technology. Thus, each type of construction is characterized by a specific stratigraphy, which remains the same in the three locations. Only the thickness of the insulating layer changes according to the required thermal performances of the specific location.

2.1 RC frame, Precast RC Panels and CLT panels structures.

- **Reinforced Concrete structures**

As mentioned above, the design of the structure was made in accordance with current shape and dimension of the building. Pre-dimensioning was conducted by referring to ACI code [7] and Eurocode 2 [8], which establish the minimum size of the structural elements. An appropriate stratigraphy was provided for the envelope elements and internal partitions (i.e. external and internal walls, slabs, and roof). For instance, the external walls are composed by plaster layer, bricks, mineral wool isolating panels, and another plaster layer (internal to external ordering).

- **CLT Structures**

Cross Laminated Timber structure, also known as C.L.T., consists of three to nine cross laminated softwood board plies with different orientation, which form precast panels. The layers are composed of wooden slats which are crossed and glued by a specific type of glue. In this project, CLT Dolomiti was chosen [9].
CLT has good structural, thermal and fire resistance properties and is made with sustainable material having a low carbon footprint, because it is derived from re-planted trees. The ecological issue resulting from C.L.T. is the adhesive glue its effect on the environment.
The structures of the two buildings were made up of precast panels whereas the element in direct contact with the soil, such as foundations and slab on grade, are made with cast-in-situ concrete.

Only the bigger building has the ground floor with reinforced concrete frame, because, this existing building is actually made with CLT panels and provides this type of structural arrangement.

- **Precast RC panels structures**

The use of Precast RC Structures allows the combination of concrete with industrial fabrication. Hence, versatile and fire-resistant structures can be obtained with structural elements that are precast in a plant under controlled boundary conditions and then assembled on site. The construction of the building with precast RC panels is faster than traditional cast-in-situ frame structures. Precast elements can be beams, columns and panels. In this project, sandwich precast exterior wall panels were employed with respect to time efficiency and to improve the thermal insulation. These panels consist of an insulation core, in XPS, between two layers of normal-weight concrete. The thickness of insulation layer is in accordance with the local thermal requirements.

2.2 Structural assessment

CDM Dolmen is the software used for the finite element analysis [6]. Through this software, dead-load and live loads were computed and combined in accordance with Eurocode 2 [8].
In the case of RC frame structures, two phases of computation were introduced. A pre-dimensioning of the structural elements was conducted in the first phase, then the software computed the necessary reinforcement according to the stresses provided by the static and dynamic analyses. For instance, Fig. 2a shows the 3D model created in CDM Dolmen in the case of reinforced concrete structure.
When a building is composed by CLT panels or Precast RC panels, the structures were modeled with shell elements (Fig.2b). In CLT structure, the thickness and the number of layers of which the timber panel is composed were chosen in reference to similar cases. The performance of the panels provided by the producers [9] was compared with the stress values computed by CDM Dolmen.
Finally, in the RC Precast structure, the panels and the insulation layer thicknesses were established in accordance with both thermal and mechanical requirements. The amount of the reinforcement within the panel was determined from literature [10]. Whereas, in the case of CLT structures, structural check is based on the comparison between calculated stresses and the mechanical strength of the materials.

3. LCA

LCA (Life Cycle Assessment) is an environmental impact evaluation tool. It considers the complete life cycle “from cradle to grave”, namely from materials production to the end-of-life and management of waste disposal.
LCA analysis may be performed at the product level, according to EN 15804 [11], and at the building level, according to EN 15978 [12].
EN 15978 considers in the following LCA process

- Material production (Modules A1 to A3).
- Construction stage (Modules A4 and A5).
- Use stage (Modules B1 to B7).
- End – of – life stage (Modules C1 to C4).
- Benefits and loads due to recycling, recover or reuse of materials (Module D).

3.1 Assumptions

In this study the life cycle of the buildings was considered by the phases of production (modules A1 to A3), transportation (modules A4 and A5) and End of Life (modules C1 to C4 and D) of materials. The use phase will be assessed through the thermal analysis, as illustrate in section 4.
The assessment is mainly based on secondary data from literature and from available Life Cycle

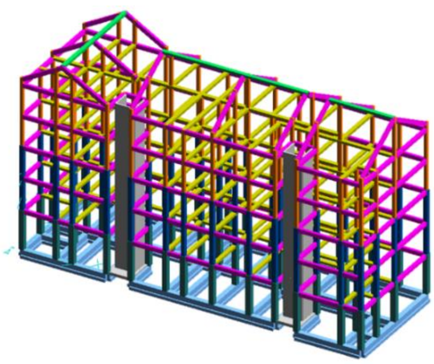

Fig. 2a: Structural model of RC frame of the condominium.

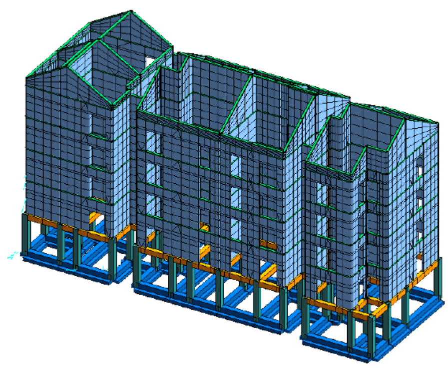

Fig. 2b: Model with shell elements valid both for the CLT and precast RC structures of the condominium.

databases, which are evaluated in relation to some necessary estimates and assumptions. These include:

- The distance between material production plants and the construction site, which has been estimated of 50 km for all the cases;
- The material End of Life (EoL), which has been assumed as follows:
  - Steel rebars: 70% recycled and 30% landfilled
  - Concrete, cementitious materials: 70% recycled and 30% landfill.
  - Wood of CLT panels: 100% recycled.
  - Other materials (such as plastic materials): 100% landfill.

The percentages of the EoL scenarios for Steel rebars and concrete were based on JRC Technical Report [13].
These assumptions are consistent with the goal of this LCA study, which is to provide a first general assessment of the building environmental impacts. For a more specific assessment, further primary data collection would be needed.

3.2 Sustainability of materials

- **Timber**

Timber is generally considered a material with low environmental impact. Mainly, this is due to the renewability of the resource, but also to the capacity of trees (across their growth) to uptake carbon dioxide and to the recyclability and reusability of wood [14], [15]. However, CLT panels are composite materials including glue. Therefore, the environmental performance of the panels depends not only on the wood material, but also on the other non-organic components.
Since no primary data were available for the timber panel production, a secondary data from an Environmental Product Declaration (EPD) [16], supplied by a CLT panels producer, has been used in the Life Cycle model.

- **Concrete**

Different environmental impacts correspond to different concrete types. Mainly, the impact per unit volume of concrete depends on the following two factors:

- the type and quantity of concrete components. In fact, most of carbon dioxide emission derives from the chemical reactions that occur during the cooking of raw materials [17] [18]. Through the replacement of these materials with others, coming from industrial waste (for instance, the blast-furnace slag and the fly ash), it is possible to reach two results. On one hand, part of emissions due to the cooking of materials are avoided [19] [20], and on the other hand, a reuse of waste materials is obtained. The latter also leads to a waste disposal reduction.
- the specific production chain of the concrete (involving the use of energy, the use of resources, emissions and waste production).

According to Habert and Roussel relationship [21], there is an empirical relationship between the CO_2 - eq. emissions of concrete and its compressive:

$$f_c \approx \left(CO_2^{m^3}\right)^2 \tag{1}$$

In other words, the compressive strength is proportional to the square of the CO_2 emitted during the production of concrete. Nevertheless, the total CO_2 decreases also when compressive strength increases, because high performance concrete leads to a reduction of the concrete volume. In the case of the family house, this strategy is not effective, because the dimensions of cross sections of the structural element are close to the minimum obtained with Normal-Strength Concrete [8].
In both the buildings, C25/30 concrete class composed by only Portland Cement (Cem I), was used.
A secondary data from Ecoinvent 3.1 [22] database has been considered for the cement assessment. Specifically, the dataset “concrete production 25 MPa, RNA only” has been taken into account. This data set covers the production of North American 25 MPa ready-mix concrete:

- Density: 2'409 kg/m³.
- Ingredients (for 1 m³):
  - Cement: 206 kg;
  - Water: 123 kg;
  - Gravel: 1100 kg;
  - Sand: 910 kg;
  - Fly ash: 69 kg;
  - Admixtures (air-entrainers and superplasticizers): 1,2kg.

The dataset includes the whole manufacturing processes to produce ready-mixed concrete, internal processes (material handling and mixing) and infrastructure. This cement has an impact of 0,808 kg CO_2 - equivalent per kg of product.
In addition to the concrete, cement - based materials, mortar and plaster, are included

3.3 Carbonation
The carbonation is a chemical process during which concrete adsorbs CO_2 from the atmosphere, according to the following chemical reaction:

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O \tag{2}$$

It is the reverse reaction that occurs during the cooking of the raw materials to produce clinker. It covers the entire life of almost all cement-based materials. Indeed, it begins when the construction is finished, passing through the life cycle of the structure, and continues during the demolition process. However, this phenomenon has advantages and disadvantages.

- Advantages: the CO_2 uptaken allows to balance part of CO_2 released during the concrete productive process. From this point of view, the chemical reaction makes the concrete more sustainable. Furthermore, in the cases of un-reinforced concrete, the product of the carbonating reaction ($CaCO_3$) has larger volume than $Ca(OH)_2$, leading to filling of the concrete pores and, thus, increasing its strength.
- Disadvantages: Carbonation contributes to the degradation of reinforced concrete, because the chemical reaction leads to a de-passivation of the reinforcement due to the reduction of pH. The steel is susceptible to corrosion and the spalling concrete occurs.

The amount of the uptaken CO_2 was evaluated in accordance with EN 16757: 2017 [23], which provides the compute of the CO_2 in kg per m^2 of concrete structure:

$$CO_2\ uptake = k \cdot \left(\sqrt{t}/1000\right) \cdot U \cdot C \cdot D_c \tag{3}$$

Where:

k = factor given in the Table BB.1 by EN 16757: 2017 [23].

U = is the maximum theoretical uptake in kg CO_2 per kg of cement (0.49 is the value for Portland cement CEM I).

C = is cement content in kg per m^3 of concrete. In this report, the value is 300 kg / m^3.

DC = factor given by the Table BB.1

t= exposure time of the concrete's surface. It coincides with the life expectancy of the building, which is 50 years in the buildings considered in this study.

This approach has been used to calculate the carbonation of the structural and non-structural element containing cement.

3.4 Unit values of emissions
Table 1 shows the unit values of CO_2 - equivalent emitted (positive values) and uptaken (negative values) by all the material used in the three buildings. The so-called "CO_2 -equivalent" derives from the conversion of each polluting emission in terms of CO_2 emissions through specific conversion coefficients. All the values are derived from the OpenLCA [24] database, except in the cases of the CLT panels [16] and of the steel rebar [14]. OpenLCA is the software used to perform the LCA of the family house and the condominium evaluated in this study.
In the cases of reinforced concrete structures, the negative values of the uptaken CO_2 for carbonation is due to EoL scenarios, whereas the uptaken CO_2 for carbonation that occurs during the use has not been considered, because this assess is reported in the section 5.
Instead, in the CLT panels structures, the negative value is due to the biogenetic CO_2, which is the capacity of wood to absorb carbon dioxide during the growth of the tree.
A total recycling of the panels is hypothesized as End of Life stage of the CLT panels.
It is important to underline that the results of the analysis derive from the input data taken from Ecoinvent 3.1 [22] database or literature (as in the case of CLT [16] panels and steel rebars [13]). These data often refer to average situations but cannot be not strictly related to specific case.

4. Thermal analysis
The aim of the thermal analysis is to compute the energy consumption for heating or cooling of the two construction typologies in according to the weather conditions and the structural typologies. Particular attention was paid to the greater contribution of the thermal inertia that concrete offers, compared to timber panels. DesignBuilder [25] is the software used to carry out this evaluation, which is an interface of the EnergyPlus calculation engine.

Table 1: Global Warming Potential (GWP) impacts of building materials related to the main phases considered in the life cycle of buildings.

Material	U.o.M.	Production stage A1, A2, A3	Construction stage A4, A5	EoL stage (C1, C2, C3, C4, D)	Total
Brick	kg -CO_2 eq./kg	0.2315	0.0078	0.0042	0.2434
Thermal isolation - Rockwool	kg -CO_2 eq./kg	1.1746	0.0102	0.0042	1.1890
Plaster	kg -CO_2 eq./kg	0.2257	0.0078	0.0042	0.2376
Mortar	kg -CO_2 eq./kg	0.2032	0.0244	0.0042	0.2318
Paint	kg -CO_2 eq./kg	1.9414	0.0244	0.0042	1.9699
Tiled roof	kg -CO_2 eq./kg	0.3449	0.0078	0.0042	0.3568
Waterproof membrane	kg -CO_2 eq./kg	0.7375	0.0244	0.0042	0.7660
Vapour barrier	kg -CO_2 eq./kg	2.5171	0.0244	0.0042	2.5456
Ceramic tiles	kg -CO_2 eq./kg	0.5465	0.0078	0.0042	0.5585
Adhesive mortar	kg -CO_2 eq./kg	1.1040	0.0005	0.0042	1.1086
Screed - Portland	kg -CO_2 eq./kg	0.8269	0.0078	0.0042	0.8389
Thermal insulation - XPS	kg -CO_2 eq./kg	3.7577	0.0244	0.0042	3.7862
Crawl space	kg -CO_2 eq./kg	1.9114	0.0244	0.0042	1.9400
Acoustic pad	kg -CO_2 eq./kg	1.8899	0.0244	0.0042	1.9184
Gypsum Plasterboard	kg -CO_2 eq./kg	0.1618	0.0102	0.0042	0.1762
Reinforcing-Steel	kg -CO_2 eq./kg	1.9624	0.0078	-0.5860	1.3842
Concrete	kg -CO_2 eq./m^3	237.94	19.48	-44.7700	212.65
CLT	kg -CO_2 eq./m^3	-685.53	55.21	810.23	179.91

The thermal transmittance of the building envelope elements of the two buildings, for each of the nine combinations between location and structural type, was taken into account by including information on the relative stratigraphy. The openings were modeled as timber profile and double glazing filled with argon gas, in order to obtain high-performance thermal doors and windows. To reduce the solar loads during the warmer seasons, external window shading systems were provided, which also provide solar heat gains during the cold season. The weather conditions were considered using the internal database of DesignBuilder.

The family house was divided into two thermal zones. In the first, all of the living space was embedded. In the second, the ground floor was considered as an un-heated zone. Similar criterion was used in the larger building, where the garages on the ground floor and the stairwells are considered to be un-heated. All other spaces are considered heated. According to the standards on thermal comfort [26], heating setpoint temperature is 20 °C, whereas the cooling setpoint temperature is 26°C. Regarding the HVAC (Heating, ventilation and air conditioning) system, an ideal system (CoP=1) powered with electricity was provided for both heating and cooling needs. Since no mechanical ventilation system is present in both a family house and in a condominium, only natural ventilation has been provided.

5. Results and discussions

The total amount of CO_2 – equivalent is determined by multiplying the amount of each material, deriving from the design, by the unit emission of CO_2 – equivalent (Table 1).

The total amounts of CO_2 emissions per square meters of usable area are shown in Table 2. In the first section of this table, the global CO_2 emissions that occur during the production phase, the transportation and the EoL of the building materials are reported. The second section contains the values of CO_2 uptaken by cement-based materials through the carbonation reactions. These amounts are the same among different cities because no change of geometry of the structures occurs. The incidences in percentages of the CO_2 absorbed, with respect to the emissions reported in the first section, are on the right. The overall balance of CO_2 derived by the subtraction of the CO_2 uptaken by the emissions contained in the first part of the table is evaluated on the last section.

The histogram depicted in Fig. 3 shows the comparison between the global values of the CO_2 – equivalent emissions per square meter (section 3 of Table 2) for each building type, structural type and location.

In all the cases, the condominiums are affected by a larger unitary environmental impact in terms of CO_2. These buildings emit about 25% to 30% more CO_2, due to the larger size of cast-in-situ RC elements (columns and beams), which are also present in the grand floor of the buildings made with RC and CLT precast panel. In addition, the larger CO_2 emissions always occurs in the RC frame type, which produce up to 37% more greenhouse gases than CLT structures, namely the structures that show the lower values.

Table 2: Summary table of the unitary amount of CO_2 -eq emissions related to materials [kg CO_2 – eq/m^2]

Phase	Building type	Structural type		Location		
				Catania	Turin	Oslo
Production transport and EoL of materials	Family House	RC frame		312.64	321.64	325.98
		Precast RC		233.73	240.04	244.01
		CLT		186.22	189.67	193.67
	Condominium	RC frame		434.68	442.38	444.07
		Precast RC		329.57	337.17	338.87
		CLT		261.81	269.07	270.62
			Amount	Reduction		
Carbonation of cement-based materials during their lifespan	Family House	RC frame	18.26	5.84%	5.68%	5.60%
		Precast RC	13.79	5.90%	5.75%	5.65%
		CLT	7.79	4.18%	4.11%	4.02%
	Condominium	RC frame	30.11	6.93%	6.81%	6.78%
		Precast RC	26.43	8.02%	7.84%	7.80%
		CLT	6.14	2.34%	2.28%	2.27%
Total	Family House	RC frame		294.38	303.38	307.72
		Precast RC		219.93	226.24	230.22
		CLT		178.43	181.88	185.88
	Condominium	RC frame		404.57	412.27	413.97
		Precast RC		303.14	310.74	312.43
		CLT		255.68	262.94	264.48

Conversely, no differences can be observed among the emission values in the different cities for each structural and building type. This due to the arrangement of stratigraphy which is the same in all the cities. Only the thickness of the insulation layer increases moving toward colder climate conditions, which, however, has a little influence on the environmental impact of the building.
Regarding to the carbonation, the amounts of the CO_2 uptake are quite low, as they vary between 2% and 9% of greenhouse emissions. Besides, there are only slight differences between the three locations. Nevertheless, the structures made of CLT panels show the lower amounts of CO_2 uptake. On the other hand, there is a slightly different trend between the small and the large building. In the case of the family house, the CO_2 values absorbed by the frame structure and the concrete panel

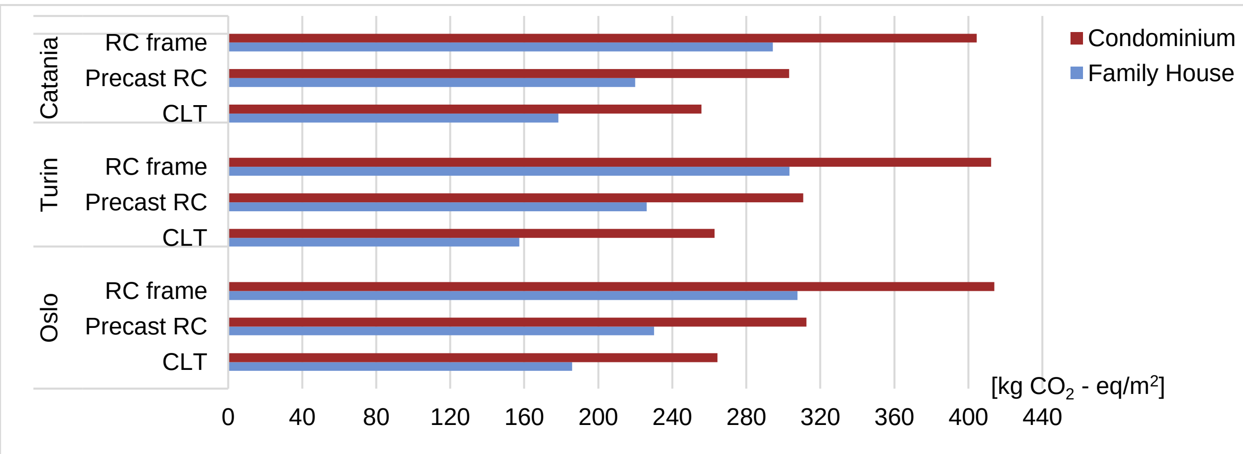

Fig. 3: Comparison among Global CO_2 -equivalent emissions of materials.

structure are very similar. On the contrary, in the second case the CO_2 uptakes by the RC panel structure is slightly higher the RC frame. Since the CO_2 absorbed by carbonation is closely linked to the exposed surface of the concrete elements, the shape of the building affects this result. In fact, the condominium building has a larger surface to volume ratio because one side of the base is greater than the other, unlike the smaller building which has almost square base. As the overall area of the panel elements is more influenced by the surface area of the building envelope than the elements of a frame, the buildings in precast RC elements entail a greater unitary CO_2 uptake.

Concerning the thermal analysis, the goal is to estimate the energy consumption (for cooling and heating) of the buildings during their life (here in established in 50 years). These energy values were converted into kg of CO_2 equivalent through the conversion factor [27]. This factor takes into account the type of energy source. In this case the electricity was assumed as the energy source, to which corresponds a conversion factor k = 0.43 kg CO_2 / kWh. Finally, this amount of CO_2 due to the energy was added to the CO_2 related to construction materials. Table 3 shows the total emissions and those due to heating and cooling per square meter of the useful surface area. In the histogram of Fig. 4 these results are compared. Firstly, in contrast to the result of the LCA of the materials, the family houses always produce more unitary carbon dioxide than condominium buildings owing to energy consumption. Besides, emissions related to the energy consumption have a greater incidence than those related to materials, especially in the small buildings. As a result, the smaller buildings turn out to be those with the greatest global impact, emitting between 20% and 45% more than the condominiums.

Table 3: Unitary global emissions and unitary emissions due to energy needs of CO2 -eq [kg CO_2 – eq/m^2]

Emission type	Building type	Structural type	Location		
			Catania	Turin	Oslo
Total CO_2 emissions related to heating and cooling needs	Family House	RC frame	894.53	1112.95	1423.39
		Precast RC	875.80	1072.55	1370.46
		CLT	979.07	1185.65	1519.55
	Condominium	RC frame	577.27	604.86	837.70
		Precast RC	556.25	586.77	827.09
		CLT	621.58	663.01	906.23
Global CO_2 emissions	Family House	RC frame	1188.58	1416.33	1731.11
		Precast RC	1095.73	1298.80	1600.68
		CLT	1157.50	1343.03	1705.43
	Condominium	RC frame	981.84	1017.13	1251.67
		Precast RC	859.39	897.50	1139.52
		CLT	877.26	925.94	1170.72

Moreover, the precast of RC is the structural type with less unitary impact for both the building and for all the locations. With respect to the other two structural types, its unitary emission is 12% lower, for the condominium building, and 6% lower for the smaller building. As well as in the case of the LCA of

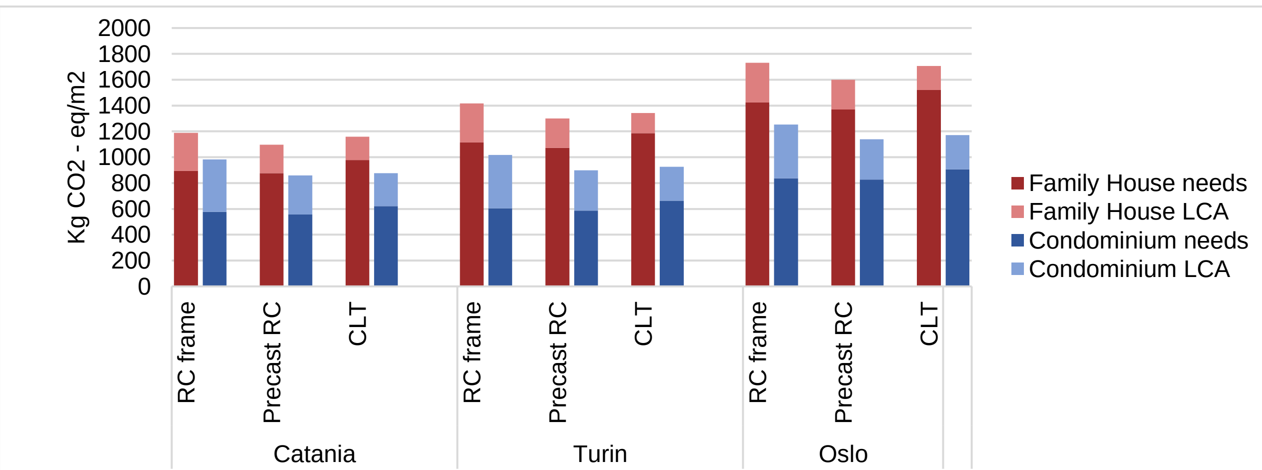

Fig. 4: Comparison of global unitary CO2 - eq. emissions

the materials, an increase of environmental impact con be noted moving from Catania to Oslo, in particular in the smaller buildings. In these cases, the differences are beyond 30% for all structure types.

6. Conclusions

The analysis performed in this paper, allow to understand how the environmental impact of residential buildings vary according to its size, structural materials and climatic conditions. Through this study, both the LCA of construction materials and the thermal analysis are considered. The main results are the following:

- if only the environmental impact due to the materials production is taken into account, the condominium building always has a higher carbon footprint. This is because the larger size of the structural elements, which leads to an increase of the unit volume of the construction materials. Vice versa, if an adequately life expectancy of buildings is supposed (50 years for residential buildings), the smaller building shows a higher emission of greenhouse gases. As a matter of fact, keeping the thermal performances of the envelope fixed, the heating and cooling needs of a single-family building involve greater energy demands per square meter than a condominium building. Hence, the lifespan of a building is a parameter that has a considerable influence on the assessment of the environmental impact.
- In general, higher CO_2 emissions, which correspond to harsher climates, depend on a greater volume of insulating material and a greater energy need for heating. This applies in particular to timber houses.
- In reverse than expected, no stark lower emissions were obtained in the case of CLT panel. Actually, in the case of the condominium building, the CO_2 produced is slightly higher than the precast RC building for all the cities. Indeed, if on the one hand the timber building ensures larger sustainability of materials, on the other hand it has greater energy needs. This is partly owing to the limited thermal inertia of this type of structure.

Consequently, when an environmental impact analysis is pursued, it is crucial to define the initial parameters and boundary conditions. Particularly, the environmental sustainability of a building is not trivially linked only to the sustainability of its materials. For instance, as argued, the lifespan of a building plays a marked role in the calculation of CO_2 – equivalent emissions. In fact, it could make the thermal performances of the different structures more relevant than the carbon footprint of the materials.

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