Environment, Climate Change and Low Carbon Economy Programme

'Environment Programme'

European Economic Area (EEA) Financial Mechanism 2014-2021

Final Report

31/03/2023

07_Call#2_CircularBuild - Development and Validation of the Concept of Circularity Applied to Modular Prefabricated Construction

Accordingly, with the Articles 25.2.j) and 29.4 of the 'Applicants Guide for Financing of Projects Supported by Environment, Climate Change and Low Carbon Economy Programme'

https://www.eeagrants.gov.pt/media/2994/applicants-guide-for-financing-eea-grants_environment-projects_28112019.pdf

I. Detailed description

The CircularBuild Project, led by ***CONCEXEC*** and Developed together with 3 partners, ***LNEC – Laboratório Nacional de Engenharia Civil de Lisboa***, ***Rise Fire Research AS*** and the ***Cluster Habitat Sustentável***, was developed between October 2020 and March 2023.

Although the project was defined for 24 month execution, ending in September 2022, due to the various constraints encountered, such as access and the price of critical raw materials for the normal development of the CircularBuild project negatively impacting its Schedule and forcing the postponement of several tasks that were correlated.

In good time and after several informal interactions between CONCEXEC (as project promoter) and the Secretaria-Geral do Ambiente e Ação Climática (as operator of the Environment program), on the need to carry out a budget adjustment of the project, aiming at it's suitability in the view of the substantial increase in raw material prices, in September 2022, CONCEXEC and the 3 project development partners signed na addendum to the Grant Agreement, establishing the extension and conclusion of the CircularBuild Project, for a period of 6 months, ending on March 31 of 2023, reflecting the various adjustments, optimizing budget distribution (namely, delays resulting from access to the acquisition of some equipment; savings in transport, travel and accommodation), it was possible to redirect some resources financial resources available to strengthen other critical investments, such as human resources and the acquisition of raw materials, making it possible to carry out test specimens leading to critical tests for the development of the project.

With the signing of the aforementioned addendum, it was possible to formalize the strategies adopted, in line with the work in progress enabling the acceleration of work in the timely execution of all tasks. Specifically, the adjustments adopted and formalized allowed the completion of the project in the subsequent 6 months (mitigating the impacts arising from the constraints encountered), optimizing budget distribution and allowing the acquisition of the new fundamental elements to speed up the work, such as laboratory validation tests (provided in LNEC and RISE), and the execution/completion of the pilot construction, as recommended in the project objectives.

Thus, we present below a brief description of the work carried out in the 6 structuring activities planned for the development of the project:

Activity 1 – Study and definition of the functional requirements of the alternative materials.

A "Activity 1 – Study and definition of the functional requirements of the alternative materials", aimed to enhance the UNU House prefabricated modular constructive system, through the substitution/introduction of sustainable materials, more environmentally friendly and subject to separation, recycling/reuse at the end of its life, under the assumptions of the environment program, and the objectives and results defined for the development of the CircularBuild Project.

Having as a starting point the definition of the goals to be achieved with the development of the CircularBuild Project, it was necessary to carry out an extended analysis of the existing materials and their respective mechanical and functional characteristics, capable of integrating the CircularBuild constructive solution, with more environmentally friendly materials, environment promoters of circularity, efficiency of material and human resources, without compromising the mechanical and functional capacity of a construction system designed to provide its users with safety, Comfort and well-being, whether from a structural, thermal or acoustic point of view.

In order for the materials and alterations made to the basic construction system, considering the new materials and respective composition of the construction panels, to fit in with the assumptions, rules and regulations of construction, it was necessary to carry out tests, developed under the activity "A3 – Functional Validation Assys – Laboratory", composed by the tasks "T3.1 – Study of the Durability of the Panel Cladding Plate", "T3.2 – Characterization of the Panel and Connections", T3.3 – Mechanical and Functional Performance", "T3.4 – Acoustic, Thermal and Seismic Performance" and "T3.5 – Behavior to Fire", where the results will presented succinctly in the Activity 3, and complete in *deliverables* "D3.2 – Reports of performed tests".

From the basic constructive solution, composed of XPS (inherent in thermal insulation), mineral wool (inherent in acoustic insulation), aluminum (inherent in the structural component), and GLASROC X (inherent in the resistant outer layer) intended for the reception of exterior finishes, 3 new solutions were studied:

The first alternative aimed at replacing the outer plates in GLASROC X, with Corotech plates, resulting from waste from the automotive industry, however, through the contacts made, difficulties were encountered inherent in the delivery of the material in the desired quantities, resulting from the lack of capacity of production and respective delivery, within the deadlines established by the project works.

The second alternative, aimed at studying the composition of the panel, with only 3 different structuring materials, such as aluminum in the structural component, the various layers of the composition of the panel in AGEPAN, by using AGEPAN DWD 16mm (resistant layer), AGEPAN TDT Static 40mm and AGEPAN TDT Static 60mm (Acoustic and thermal insulation), and the use of agglomerated cork on the outsider (reinforcing/improving the thermal behavior of the built solutions), through the ETIC system, completely eliminating potential thermal bridges and contributing to the improvement of the acoustic behavior of the solution. In this way, the AGEPAN resulting from wood fibers would have a significant weight in this solution, maximizing the integration of more environmentally friendly materials, and enhancing its recycling/reuse at the end of its life. However, it was not possible to proceed with this solution in its entirety, due to the logistical difficulty in ordering and the respective transport f the raw material, but above all due to the high cost that it would entail, in view of the basic solution, and recommended for the development of the project, in application seat.

The third solution, which would become the final solution, developed and optimized throughout the project, incorporated aluminum in the structural component, 50mm XPS and 100mm in the thermal component, AGEPAN DWD 16mm, as a resistant outer layer of the panels and the 40mm agglomerated cork, apply on the outside, as ETIC's system apply on the outsider of the panel.

The development of this activity was fundamental to the development and elaboration of the deliverables "D1.1 – Study Report on Alternative Materials and Application Requirements", "D1.2 – Report Whit the Life Cycle Analysis – LCA" e "D1.3 – Datasheet for New Panels", sent as an attachment to this final report.

Activity 2 – Adaptation of the Productive Process and Industrial Validation

The "Activity 2 -Adaptation of the productive process and industrial Validation" consists of 3 tasks, "T2.1 – Adaptations of the Process to new Material/Components" the task "T2.2 – Preparation of Samples" and the task "T2.3 – Study Integration of Technical Infrastructures".

In the task T2.1, the work carried out focused on adapting the production process, adapting it to the new constitution of the construction system, namely with regard to the defined thicknesses for the materials and procedures from the reception of materials, machining and assembly of the panels, until they are shipped to the site. Thus, this work allowed the study and definition of the factory floor, optimizing procedures and spaces, in this sense of a more functional conscious and safe production, safeguarding the stored product, produced, but above all its actors.

The task T2.2 was intended for the preparation, study, definition and production of the specimens defined to be tested at LNEC – Laboratório Nacional de Engenharia Civil de Lisboa, and also at RISE Fire Research AS. The specimens were executed in accordance with the established regulations and standards, necessary for the validation of the construction system, and defined in the application, with a view to carrying out durability tests on the cladding plate, connections, mechanical performance, acoustic performance, thermal and seismic and fire behavior tests carried out under the activity "A3 – Functional Validation assays – Laboratory".

The task T2.3, aimed at studying the integration of electrical, ITED, home automation and hydraulic infrastructures in the CircularBuild constructive system, by measuring the dimensions of the negatives (with a section of 40x100mm), machined in the 100mm XPS layer, existing in the interior composition of the panel, where in its final version, each wall panel has, as standard, two horizontal negatives, 1 next to the floor, at the level of the electrical sockets line and 1 next to the ceiling aligned with the junction boxes, and two vertical allowing the connection of horizontally distributed infrastructures in space and between spaces, next to the floor and ceiling, as well as the connection of infrastructures between floors.

The main constraints found were not due to the development of the constructive solution, overcome with the improvement of the solution, but above all and as previously mentioned, due to the change in the constructive solution from the second solution to the third solution, due to the high cost of acquisition of AGEPAN, the difficulty in acquiring raw materials (due to the increase in the cost of raw materials and their scarcity, resulting in the constant delay in the delivery of materials and consequent execution work on the test specimens. The delay in the delivery of raw materials, change in acquisition costs, constant throughout the development of the project, as mentioned in previous reports and presented in the justification for the addendum to the project, resulting from the socio-economic impact in which the entire development of the project.

The development of this activity was fundamental to the development and elaboration of the deliverables "D2.1 – Report with the adaptations to the Production Process for new Materials", "D2.2 – New Report Samples" and "D2.3 – Register of Building Panels".

Activity 3 – Functional Validation Assays - Laboratory

The "Activity 3 – Functional Validation assays – Laboratory", aimed at the development of the task "T3.1 - Study of the Durability of the Panel Cladding Plate", the task "T3.2 – Characterization of the Panel and Connections", the task "T3.3 – Mechanical, and Functional Performance" the task "T3.4 – Acoustic Thermal

and Seismic Performance" and the task "T3.5 – Behaviour to Fire", under the validation of the CircularBuild constructive system and respective constitution of the developed panels.

The tests carried out allowed, throughout the project, to assess the constructive solution, from the structural and compositional point of view, especially in the connections and positioning of the aluminum profiles in the panel.

With the work carried out, it was possible to measure the following:

T3.1 – Study of the Durability of the Panel Cladding Plate:

Assessment method – Water considered as a relevant factor in promoting biodeterioration.

The characterization tests of the susceptibility to biodeterioration – allowed to define the possible conditions of application in work without protection, to moulds, fungi of cubic and fibrous rot, fungi or rot and subterranean termites, in addition to the aforementioned tests, swelling tests were carried out.ls

Test - Swelling (EN 317: 1993)

SAMPLE	1	2	3	4	5	6	7	8	9	10	AVERAGE	ST DEV.
SWELLING (24H) (%)	6.81	6.86	7.02	6.96	6.91	6.81	6.78	7.10	6.99	7.09	**6.93**	**0.12**
MASS VARIATION (%)	22.32	22.74	21.32	21.56	22.76	22.27	22.28	22.34	23.22	23.16	**22.40**	**0.62**

Table 1. Table with the achieved results

According to the Declaration of Performance of the product (Koerner, 2017) the expected maximum percentage of swelling should be 8.50%. The average percentage of swelling in thickness obtained in this test was below that value (6.93%±0.12%) thus confirming the improved surface performance.

Test - Rotting Molds and Fungi

Figure 1. Molds – Exposure in saturated atmosphere, with maritime pine control (n=3), with the duration of 4 weeks of exposure and 9 replicates – **Result - Susceptible**

Figure 2. Rot fungi – 3 fungi – Maritime pine control, with 6 weeks of exposure and 10 replicated (with and without washout test) – **Resust – Very Susceptible.**

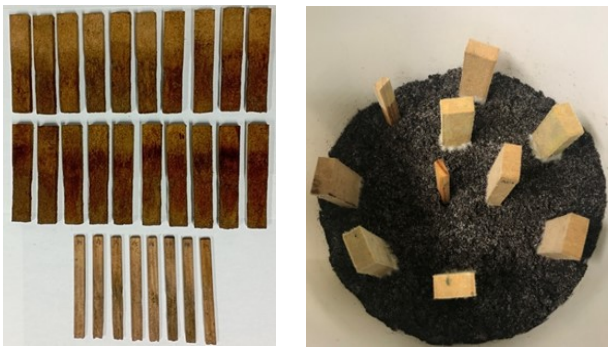

Figure 3. Soft Rot Fungi – Maritime pine control, with 12 and 24 weeks of exposure and 5+10 replicated (with and without washout test) – **Result – Very Susceptible.**

Test – Subterranean Termites

Figure 4. Reticulitermes Grassei – EN118 e EN118 + wash test (EN84) – Maritime pine control (n=3) – 8 weeks of exposure – 8 replicates – **Result – Very Susceptible.**

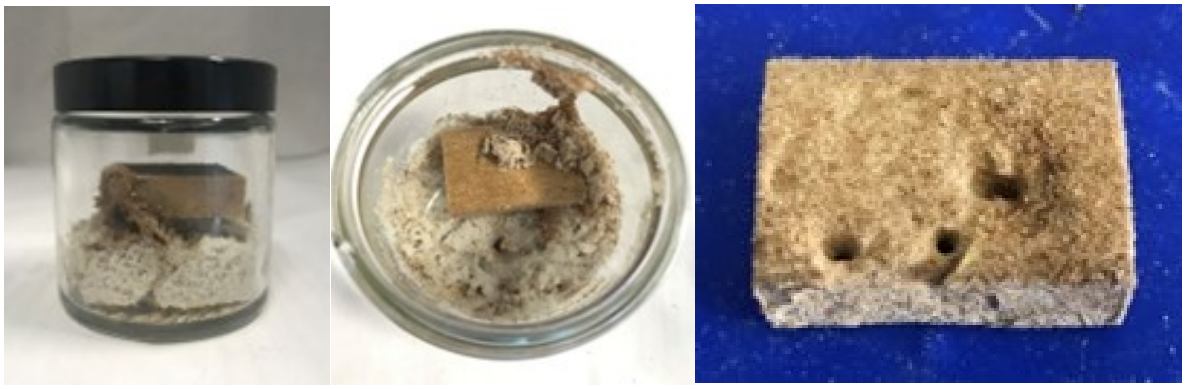

Figure 5. Adapted EN117 and adapted #N117 + weashing test (EN84) – Maritime pine control (n=3) – 4 weeks of exposure – 10 replicates – **Resust – Very Susceptible.**

Appreciation

Considering the durability characteristics agains biological agents and the water absorption capacity of the wood-based board:

- **Avoid applications in permanent contact with water (risk class 4);**
- **Carefully consider** applications where there may be occasional contact with water **(risk class 3);**
- **Satisfactory performance** for CircularBuild use **(risk class 2);**

Use class	General service situation	Exposure to wetting in service (MC [%])	Occurrence of biologic agents
UC 1	Interior, covered.	Dry MC ≤ 20%	Beetles Termites
UC 2	Interior, or under cover, without weather exposition. Possibility of water condensation.	Occasionally wet MC > 20%	Beetles Termites Disfiguring fungi Brown rot
UC 3	Exterior, above ground, exposed to the weather. 3.1 Limited wetting conditions 3.2 Prolonged wetting conditions	Occasionally or frequently wet MC > 20%	Beetles Termites Blue stain fungi Brown rot White rot
UC 4	Exterior in ground and/or fresh water.	Predominantly or permanently wet MC > 20%	Beetles Termites Blue stain fungi Brown rot White rot Soft rot
UC 5	In salt water	Permanently wet MC > 20%	Marine borers (or UC 4 for elements outside the water)

Figura 6. Classes de risco EN335 (Verbist et.al. 2018).

Hydrothermal behavior:

- 80 cycles of heat and rain -70ºC (~3h), rain (~1h), drain 2h
- 5 heat and cool cycles -50ºC ~8h, -20ºC ~16h
- Evaluated cracking and adherence
- Satisfactory Result

Shock test: Category III

T3.2 – Characterization of the Panel and Connections

Regulatory Requirements for Residual Buildings

Floors

- User Overload (bending) = 2kN/m² (housing) / 3 kN/m² (offices).

Roofs

- Snow action (bending) = Sk (characteristic value of snow load at ground level).
- In the vast majority of European countries Ski s below 3.5 kN/m2, normally being less than 2.5 kN/m².

Walls and connections

- Blocking to horizontal actions – wind and earthquake (cut in the plane) – determines the geometry/compartmentation of the buildings.
- Wind action (bending) -it is not conditioning, compared to snow and overload of use.

Walls

- Support of vertical loads transmitted by the roof and/or upper floors (axial compression) – determines the geometry/compartmentation of buildings.
- Bonding between panels (traction, cutting, tearing) – must allow exploiting the resistance of the panels.

CONSTRUCTIO ELEMENT	TEST	RESISTANCE (AVERAGE VALUE)
FLOOR / WALL / ROOF	FLEXION (RESISTANT BENDING MOMENT)	FLECHA=L/300: 5,9 KN.M FLECHA= L/200: 7,1 KN.M
WALL	AXIAL COMPRESSION	117 KN
WALL	FLAT CUTTING (2 PANELS)	16 KN

Table 2. Table with the achieved results.

Comments

- The mechanical strength values obtained allow the panels to be used on walls, floors and roofs.
- Typology of the constructions to be verified according to the mechanical characteristics and imposed actions.

T3.3 – Mechanical and Functional Performance

In the task "T3.3 – Mechanical and Functional Performance", tests were carried out subjecting the CircularBuild constructive system, to air permeability, water tightness, wind resistance, soft body impact, hard body impact and the simulation of eccentric vertical load, from which we highlight the result presented below.

Prototype wind resistance vs panel bending test.

In the wind resistance test (prototype) i tis verified that the connections between Wall and floor/ceiling panels contribute to the rigidity of the deformation measured in the wind test being situated between the deformation obtained by calculation with the rigidity resulting from bending testa 4 points and considering:

- Bending with panel simply supported on the end;
- Bending with recessed panel at the tops.

The panels stiffness in the system proved to be superior to the simply supported panel stiffness.

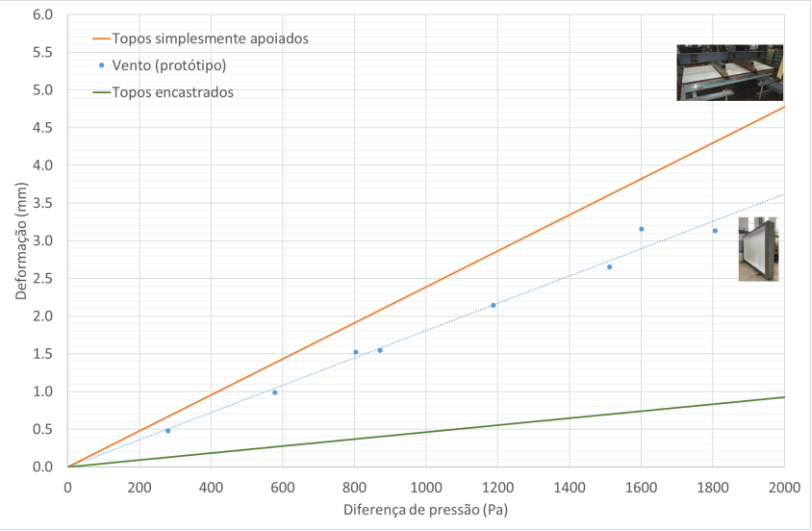

Figure 7. Comparative graph of the results obtained, with the panel on the simply supported ends, the action of the wind and with the recessed ends.

T3.4 – Mechanical and Functional Performance

The two-storay prototype, under task T3.4 – Mechanical and functional Performance, was subjected to a sequence of tests with seismic actions of increasing intensity, associated with increasing return periods, during which the seismic performance, considered the basic objective applicable to residential buildings, according to the brief data presented below:

- The shake table tests were carried out with motions imposed along three orthogonal axes (transverse, longitudinal and vertical);
- A series of artificial records were used simulating a magnitude 7.5 earthquake from a short distance;
- The time histories were imposed with increasing scaling factors of 0.2, 0.5, 1.0 and 1.5 (corresponding response spectra in the images to the right);
- Dynamic identification tests were carried out in between seismic tests in order to track the evolution of the modal parameters and detect eventual damage;
- A total of 41 seismic tests and 18 dynamic identification tests were carried out.

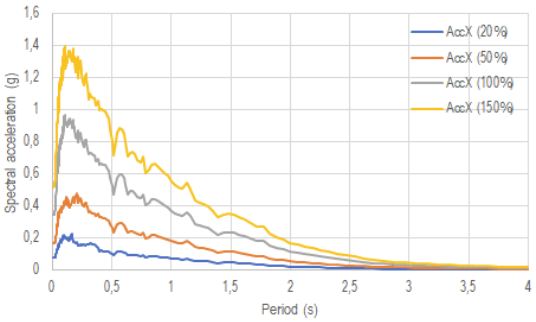

Figure 8. Transverse direction.

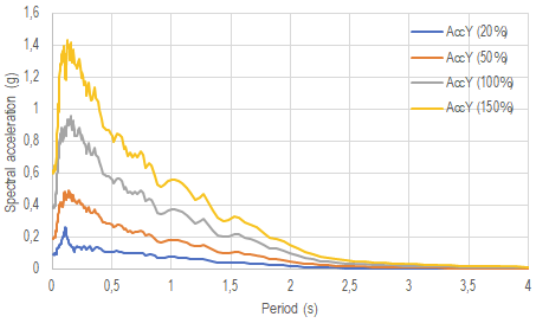

Figure 9. Longitudinal direction.

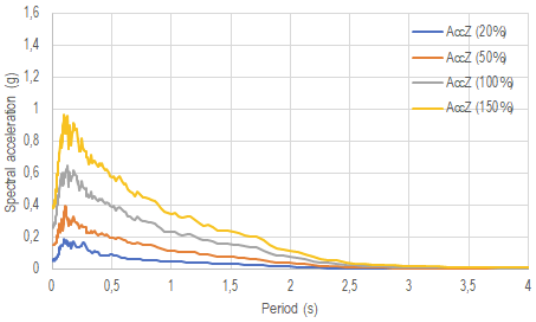

Figure 10. Vertical direction

Results for the seismic test with scale factor of 1.0

With the execution of the test, the following results were obtained:

- Accelerations and displacements were measured during the tests in several points of the test specimen;
- Inertia forces were estimated based on the accelerations;
- Sliding motions measured at the base of the ground floor panels in both transverse and longitudinal directions reached approximately 3mm maximum on the wall (without permanent deformation);
- Uplift motions measured on both sides of individual panels, up to 6mm, reveal an overturning at the base of the panels;

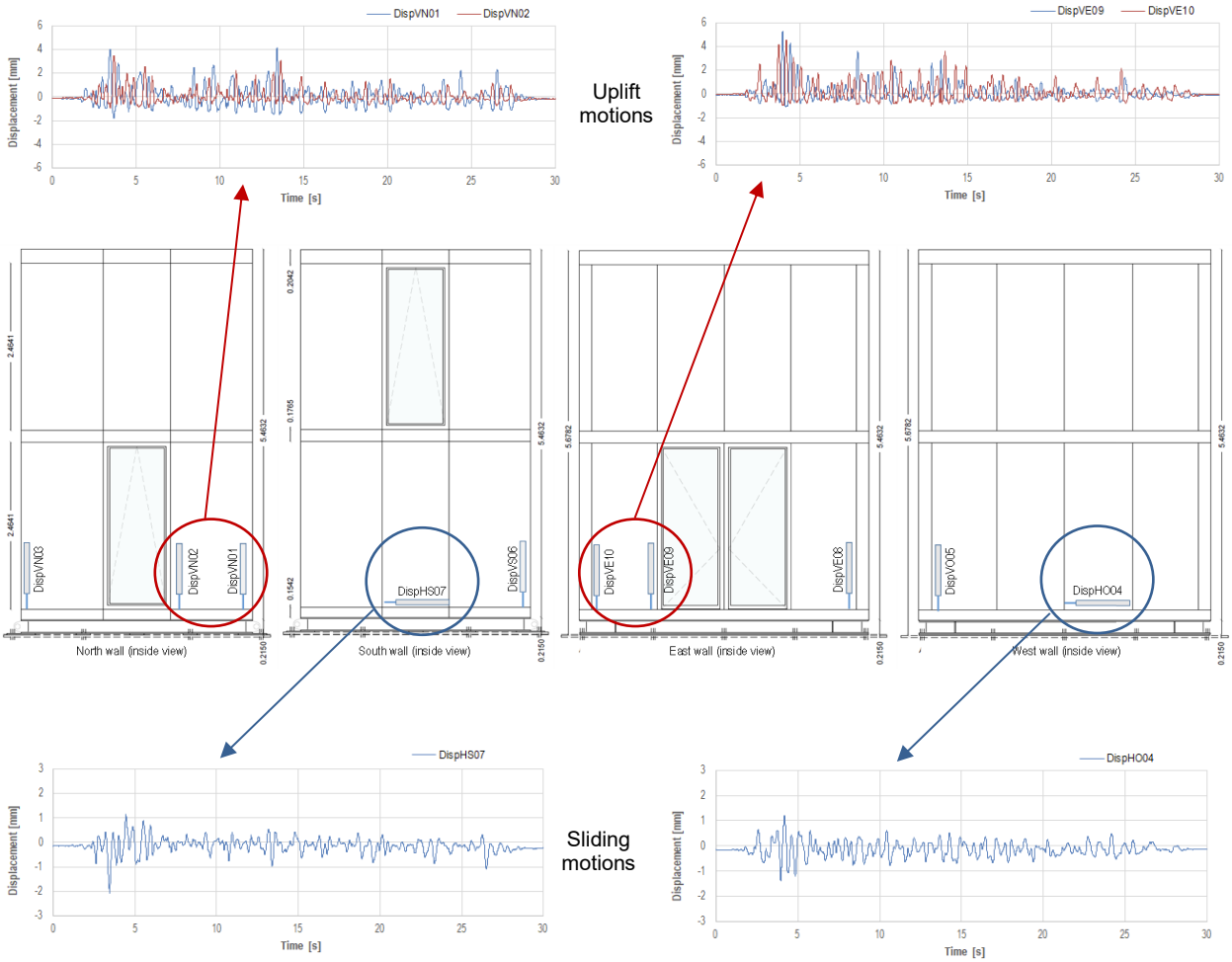

Figure 11. Graphics demonstrating actions on the prototype.

Results

- Global damage was tracked through the evolution of the modal parameters of the test specimen;
- MAC coefficients computed relative to the initial dynamic identification test, carried out before the seismic tests, reveal a change in the vibration mode shapes;
- The computation of the global damage index (DiPasquale and Çakmak, 1988), ranging from 0 (no damage) to 1 (collapse), reveals;
    - No damage up to the 0.5 scale factor (35 seismic tests);
    - 10% accumulated damage in the 1.0 scale factor (35+3 tests);
    - almost 30% accumulated damage in the 1.5 scale factor (35+3+3 tests);

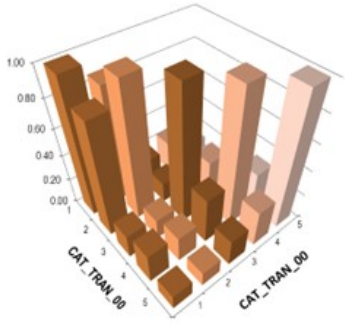

Figura 12. Initial MAC coefficients.

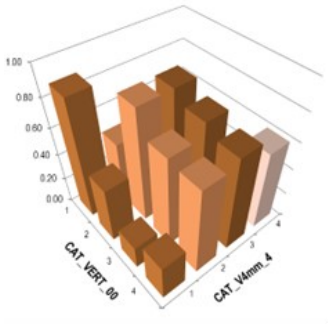

Figura 13. Final MAC coefficients

Acoustic Performance

The tests aimed at acoustic performance, carried out corresponded to the requirements of the regulations for residential buildings in accordance with the following:

- Sound insulation to aerial sounds from façades: D2m,nT,w≥ 33 dB(*)
- Airborne sound insulation between autonomous fractions: DnT,w ≥ 50 dB
- Sound insulation to percussion sounds between autonomous fractions: LnT,w ≤ 60 dB
- Sound insulation to percussion sounds between autonomous fractions: LnT,w ≤ 60 dB

(*) This value is required for mixed zones, a more unfavorable situation; if, for sensitive zones the value is 28 dB.

Laboratory Test Results

CONSTRUCTION ELEMENTS	*SOUND INSULATION*	*INDEX*
FAÇADE	AERIAL SOUNDS	RW = 35 (0; -3) DB
BETWEEN FRACTIONS (MULTIFAMILY)	AERIAL SOUNDS	RW = 46 DB
FLOORING (BETWEEN FRACTIONS)	AERIAL SOUNDS	RW= 28 DB
FLOORING (BETWEEN FRACTIONS)	PERCURSSION SOUNDS (*)	LN,W = 83 DB

Table 3. Table with the achieved results.

Comments

- The sound insulation obtained for the façade system complies with regulatory provisions, as long as sound bridges are eliminated.
- The sound insulation obtained for the separation system of autonomous, adjacent, horizontal fractions, does not in itself meet the required regulatory value.

- The sound insulation to percussion sounds obtained, between autonomous fractions, vertically adjacent, does not in itself meet the required regulatory value. However, this situation is common in most solutions, and the complementarity must be done with an adequate floor covering.
- The sound insulation obtained for the separation system between autonomous, adjacent, vertical fractions (floors), does not meet the required regulatory value. This will be possible with the application of high-density viscoelastic fabric, on both sides of the panel, and with the inclusion of an eventual false ceiling.

Thermal Performance

Regarding the thermal performance achieved by the CircularBuild constructive solution, we highlight the following aspects:

Thermal insulation (U, Ψ)

- The CircularBuild presents a satisfactory thermal transmission coefficient for any climate zone in Portugal;
- The solution's linear thermal bridges provide superior insulation compared to reference solutions.

PANELS	CIRCULARBUILD	REFERENCE VALUES (SCE 2021)		
		ZONE I1	ZONE I2	ZONE I3
STANDERD EXTERIOR WALL	0.195	0.50	0.40	0.35
STANDARD FLOORING	0.240	0.40	0.35	0.30
STANDARD COVERAGE	0.193	0.40	0.35	0.30

Table 4. Comparative table of results achieved, compared to regulatoryr equirements.

The pilot buildings has overall heat transfer coefficient 60% lower than that of a new SCE reference building (Zone I1) Cell Au =20 m²

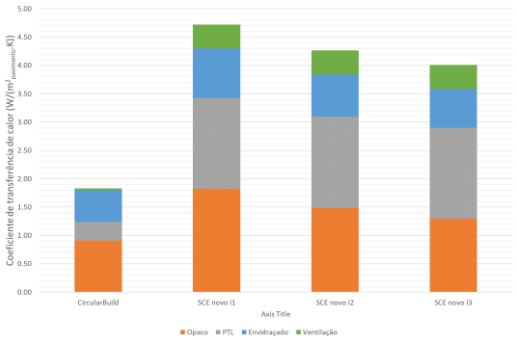

Figure 14. Comparative graph of characteristics of the Pilot Construction, in view of the needs in the diferent zones.

T3.5 – Behavior to Fire

Task T3.5 – Behavior to Fire, intended for testing the CircularBuild constructive solution, included carrying out fire reaction and fire resistance test, of which we highlight the results below:

Fire Resistance Test

The fire resistance test carried out at the Norwegian laboratory RISE Fire Research AS, was carried out based on EN 1365-1:2012, intended for fire resistance tests, for bearing structural elements, on na exterior Wall specimen 3x3m (AxW), through the EN 1363-1 standard time/temperature curve, with the action of a total axial load of 24kN, approximately 8kN/m (test piece 3m wide).

Figure 15. Demonstrative image of the specimen during the rest performed.

Results of Fire Resistance Tests

The test carried out lasted 37 minutes, at the end of which the Wall collapsed, where the temperature curves outsider the Wall are presented in accordance with EN 1365-1, where the temperature curve inside of the Wall and the deflection of the Wall and the deflection of the Wall can be seen in the graph below. From the fire reaction test carried out, we highlight the following results:

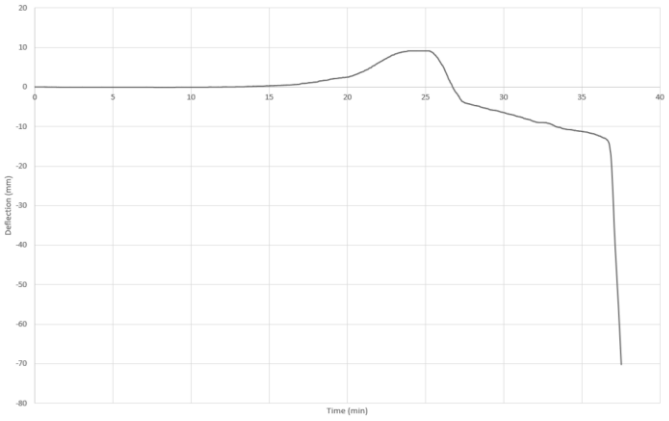

Figure 16. Deflection measured in the center of the center of the test specimen. Negative values indicate deflection away from the furnace.

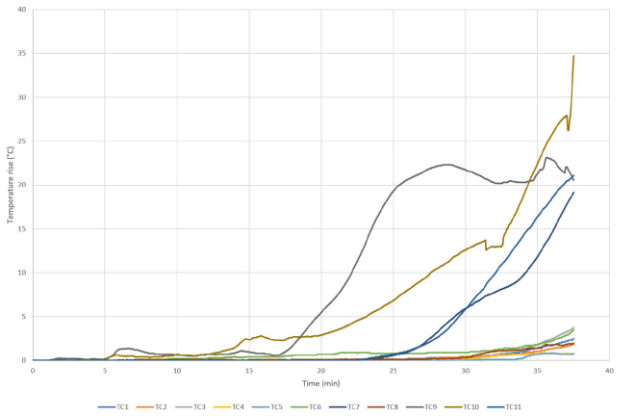

Figure 17. Temperature RISE TC 1-11.

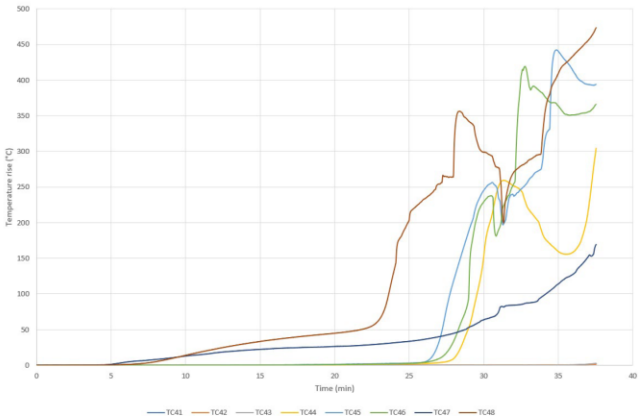

Figure 18. Temperature RISE TC 1-11.

Thus, and according to the result obtained, the test specimen will comply with the REI 30 classification parameters in accordance with EN 130501-2.

Fire Reaction Tests

Carrying out fire reaction tests on CircularBuild solution specimens, under fire safety regulations and standards, aims to assess the contribution of materials in the initial stages and development of fire, through parameters of ease of ignition development the combustion of the product (with or without flame, speed and extent of surface propagation or perforation…), release of heat, release of fumes or volatile products (such as opacity, toxicity and possibly corrosiveness), and release of fire droplets or particles.

Results of fire Reaction Tests – Walls and ceilings (EN 13823) / Floors (EN ISO 9239-1)

Walls and Roofs – Exterior Face

The preliminary results obtained on the tested specimen meet the requirements established for the cal B-s1,d0.

Walls and Roofs – Interior Face

The preliminary results obtained on the tested specimen meet the requirements established for the class B-s1, d0.

Floors – Interior Face

The preliminary results obtained on the tested specimen meet the requirements established for the class Bfl-s1.

COMPOSITE SYSTEMS FOR EXTERIOR THERMAL INSULATION		REQUIREMENT	RESULT	ASSESSMENT
SMALL BUILDINGS	COMPLETE SYSTEM	C-S3, D0	B-S1, D0	SATISFY
	THERMAL INSULATION	E	E	SATISFY
HORIZONTAL EVACUATION ROUTES COATINGS				
OUTDOOR ON FLOORS UP TO 9 M HEIGHT	WALLS AND CEILINGS	C-S3 D1	B-S1, D0	SATISFY
	FLOORS	DFL-S3	BFL-S1	SATISFY
FLOORING IN RISK A LOCATIONS (PLACES WITH LESS THAN 50 PEOPLE, I.E. OFFICE, MEETING ROOM)				
	WALLS AND CEILING	D-S2 D2	B-S1, D0	SATISFY
	FLOORS	EFL-S2	BFL-S1	SATISFY

Table 5. Comparative table of results achieved, compared to regulatory requirements.

In view of the above, we emphasize the efforts of all partners, in the development of activity 3, in order to

overcome the various constraints, already mentioned, in the acquisition of raw materials, which resulted in the delay in the execution of the specimens to be tested, but also the logistical constraints, which made it impossible to speed up the earthquake behavior tests, due to the unavailability of the seismic table, as well as the "special" transport f the large-scale specimen to the facilities of the Norwegian laboratory RISE.

The development of this activity was fundamental to the development and elaboration of deliverables "D3.1 – Document with the characterization of the panels at functional and mechanic level" and "D3.2 – Report of test performed", attached to this report.

Activity 4 – "CircularBuild" Construction

Activity 4 – "CircularBuild" Construction included the execution of work inherent to tasks "t4.1 – Project Elaboration with BIM Methodology", task "T4.2 – "CircularBuild" Pilot Manufacturing and Installation", task "T4.3 – Demonstration and Validation, of Circularity "CircularBuild" – reconfiguration", the task "T4.4 – Realization of Tests Under Real Conditions of Use" and the task "T4.5 – LCA Elaboration and Validation of Results (environmental, economic and social)".

In this way, the development of task T4.1, aimed at the elaboration of the project of the CircularBuild Construction, in the BIM methodology, initially elaborated in 2D and 3D, in different platforms. Thus, during the course of the task, detailing work on the Pilot Construction was carried out, the preparation of the planning of the constituent layers of the prototype for production and the elaboration of the specialties, as if it were a real project.

Also in this context, a 2D project was carried out, with the integration of the CircularBuild solution, elements that, together with those mentioned above, will integrate the deliverables "D4.1 – Design with BIM", attached to this report.

Within the scope of task "D4.2 – Pilot Construction", work was carried out to execute part of the prototype taken to the testo n the seismic table, all preparatory work and execution of all assembly and finishing work of the pilot construction simultaneously with task T4.3, intended for the demonstration and validation of circularity, by dismantling the earthquake prototype.

Task T4.3, as mentioned above, with a parallel execution with task T4.2, allowed to demonstrate by disassembling the earthquake prototype, and reassembling the panels together with other complementary elements necessary for the Pilot Construction, to validate the disassembly capacity of the panels used in a CircularBuild construction, and the ability to reuse them in another construction, promoting the circularity

of the construction and the respective materials used, giving them a longer useful life, eliminating the need for demolition and the respective waste.

Figure 19. Pilot Construction – LNEC Campus – Reassembly of the Prototype taken to test on the seismic table.

Task T4.4, aimed at monitoring the interior of the Pilot Construction, in a real situation of use, with the aim of assessing the behavior of a CircularBuild construction, integrated in an outdoor space and at the mercy of various atmospheric agents, namely, with regard to its thermal behavior, directly linked to the needs of energy use.

Figure 20. Pilot Construction – LNEC Campus.

The tests carried out made it possible to verify that the CircularBuild constructive solution reached a Class A energy classification, without the use of DHW, and a Class A+ classification with the use of DHW, safely reaching the NZEB20 construction designation, since it is positively above the requirements for an NZEB designation.

Elemento	CircularBuild		Requisito (SCE, 2021)
	Sem AQS	Com AQS	Zona I1
Conforto térmico, necessidades de aquecimento	N_{ic}/N_i=0,14	N_{ic}/N_i=0,14	$N_{ic}/N_i \leq 0,75$
Conforto térmico, necessidades de arrefecimento	N_{vc}/N_v=0,99	N_{vc}/N_v=0,99	$N_{vc}/N_v \leq 1,00$
Desempenho energético	Classe A	Classe A+	classe A ou melhor
Energia primária total	R_{NT} = 0,45	R_{NT} = 0,16	$R_{NT} \leq 0,50$
Energia primária renovável	*Não aplicável*	*51%*	*$Ren_{Hab} \geq 0,50$*
NZEB20	*Não aplicável*	*Sim*	$R_{NT} \leq 0,40$

Table 6. Table demonstrating the results achieved, in view of regulatory requirements.

Task T4.5, based on all the work developed and demonstrated retrospectively in this report, aimed at preparing the LCA and validating the results achieved, under the objectives initially proposed in the application phase, for the development, and goal from the project. In this way, and succinctly, we present below the elements resulting from the work carried out:

Circular Pilot Construction Build:

- Construction phase emissions of **112 $kgCO_2/m_2$** of floor area, traditional construction variable ~400 $kgCO_2/m_2$.
- To suppress the test cell's electricity needs for heating at 20ºC, cooling at 25ºC, ventilation (0.8 h-1) and DHW (electrical support of the solar thermal system), annual emissions of **203$kgCO_2/m^2$** / (energy 5,6 €/m^2).
- 4 m^2 (0,2 m^2PV/m^2 floor) of photovoltaic system would be enough to meet these electricity needs and ensure zero emissions.
- Construction A+, NZEB20 (R_{NT} de 0,16).
- **Levels** Requires 50-65 kWh_{ep}/m^2, CircularBuild depends on heat pump and PV system. Whithout PV 65 kWh_{ep}/m^2, com PV < 50 kWh_{ep}/m^2.
- CENSUS annual emissions of 475$kgCO_2$/accommodation* (includes other energy uses, but comfort is not guaranteed in many of the accommodations), energy cost 1080 €.

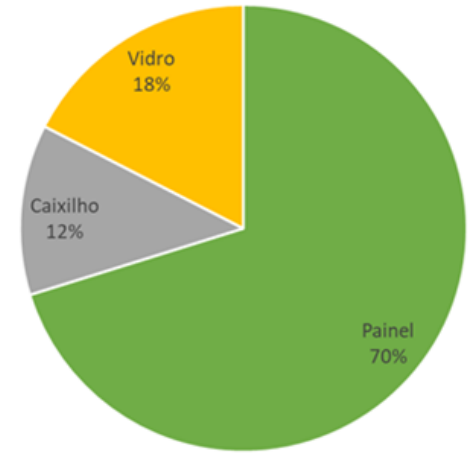

Figure 21. CO2 emissions 112 kg/m² pav (construction phase).

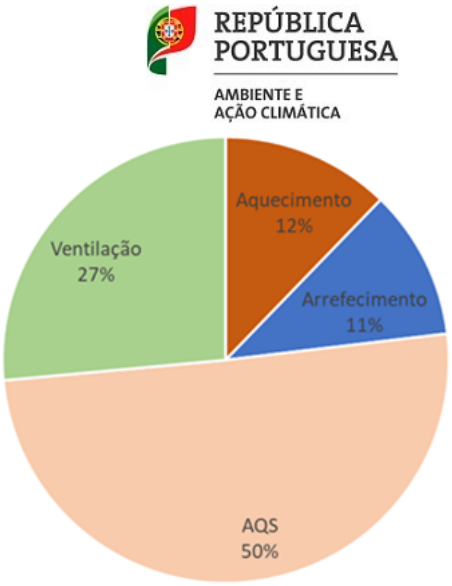

Figure 22. Annual CO2 emissions 203 kg/m² pav.

The development of this activity was fundamental to the development and elaboration of deliverables, "D4.1 – design with BIM", "D4.2 – Pilot construction", "D4.3 – Actual performance evaluation and calculation of new panels based on reused materials", "D4.5 – Construction of new module made of panels only", "D4.6 – Absence of waste from the construction process" and "D4.7 – Results of AVC and LEVELS evaluation", attached to this report.

Activity 5 – Promotion and Dissemination of Results

In "Activity 5 – Promotion and Dissemination of Results", the consortium ensured the wide dissemination of the CircularBuild project and its results. Within the scope of this activity, led by the partner Cluster Habitat Sustentável with the support of the promoter of the project - Concexec, many communication actions were promoted, meeting all expectations. As a starting point for the project, a corporate image was designed, which later served as a reference for other images and specific templates for the various communication actions.

With the launch of the website and the profiles on social networks (Facebook, Instagram and Linkedin), digital communication began, later complemented by the sending of regular newsletters (7 newsletters sent - 718 recipients reached). Additionally, information campaigns were launched to meet specific communication needs.

Throughout the project, 3 public sessions were organised enabling the presentation of the CircularBuild project to stakeholders at different implementation levels (launch event, demonstrator event and final

event). Furthermore, these events enabled the collection of answers to surveys that would help partners to evaluate the project's impact and social acceptance. The CircularBuild project, represented by its leader - Concexec, also participated in some events relevant to the project theme.

In terms of presence in the press, we highlight the three publications made in specialised technical magazines (Smart Cities Magazine - 2, Construction Magazine - 1) and the emission of regular press releases (9 in total).

For the last reporting period, a Communication Report (Annex - Activity 5 I Promotion and Dissemination of Results) was prepared, including detailed information about the actions taken under this activity.

Lastly, the communication team compiled all the elements relating to said actions, which are available for consultation in the project's communication dossier, including the "project media monitoring" file, and the 3 deliverables associated with this activity, such as "D5.1 – design of Corporate Image", "D5.2 -Attendance sheet of the 3 events" and "D5.3 – Number of recipients of Newsletter sent under the project", attached to this report.

Activity 6 – Technical Management of the Project

Last, but not least, within Activity 6 – Project Management the project teams – and, more specifically, its leader, Concexec, - made all the efforts to monitor the project's material and financial execution, as well as the interactions and interdependencies between the work carried out by all the 4 participants. In that sense, several online and face-to-face meetings were held, as well as other contacts via e-mail and telephone in order to ensure a seamless communication between all participants and together surpass all the challenges identified during the project's execution. It was during these meetings and moments of discussion that all the 4 partners discussed the need of presenting to the National Environment Secretariat all the constraints that were, at that time, jeopardizing the project execution and, together, study and define alternative solutions to carry on with the project and achieve the established goals.

The following table presents the status of all the activities within the project, showing that all of them are fully completed and all the envisaged deliverables and milestones are also achieved.

Table 1 – Summary of the technical activity's execution *(in compliance with project's updated gantt chart, which can be found on Annex 1 – Updated Gantt Chart)*

ID	Activity	Status	Observations/Justification
Activity 1 – Study and definition of the functional requirements of the alternative materials			
T1.1	Study of alternative materials to the existingsolution.	Concluded	
T1.2	Identification of regulatoryrequirements applicable tothe construction system under study.	Concluded	
T1.3	Evaluation of the life cycle of the production process of the panel against alternative materials.	Concluded	In the current reporting period, task T1.3 and T1.4 reached the execution rate of 100% as mentioned in the 9th Interim Report, due to the completion of activities A.3 and A.4, directly related.
T1.4	Elaboration of a declaration of environmental performance of the modular construction system.	Concluded	
Activity 2 - Sample Preparation and Industrial Validation			
T2.1	Adaption of the productionprocess to new materials / components	Concluded	
T2.2	Preparation of samples.	Concluded	In the current reporting period, task T2.2 obtained a 100% execution rate, resulting from the completion of the tests that took place from January 1 to March 31, 2023.
T2.3	Study integration of technical infrastructures (electricity, water, ventilation, air conditioningand renewable energy).	Concluded	In the current reporting period, task T2.3 obtained a 100% execution rate, resulting from the completion of the associated jobs.
Activity 3 - Functional validation testing - laboratory scope			
T3.1	Study of the durability of thepanel cladding plate.	Concluded	
T3.2	Characterization of the paneland connections.	Concluded	In the current reporting period, task T3.2 obtained an execution rate of 100%, with the completion of the test reports sent in the deliverable "D3.2 – Report of tests performed".
T3.3	Mechanical and FunctionalPerformance.	Concluded	
T3.4	Acoustic, thermal and seismic performance.	Concluded	
T3.5	Behavior to fire.	Concluded	In the current reporting period, task T3.5 obtained an execution rate of 100%, with the execution of the fire resistance test and respective report, sent as an attachment in the deliverable "D3.2 – Report of tests performed".
Activity 4 - "CircularBuild" Construction			
T4.1	Project elaboration with BIM methodology.	Concluded	Concluded In the current reporting period, task T4.1 obtained a 100% execution rate, with the completion of the development work for the Pilot Construction using the BIM methodology, sent as an attachment in the deliverable "D4.1 – Design with BIM".
T4.2	'"CircularBuild" PilotManufacturing and Installation.	Concluded	In the current reporting period, task T4.2 obtained an execution rate of 100%, due to the assembly and execution of the finishing works of the "Pilot

ID	Activity	Status	Observations/Justification
			Construction", installed on the campus of LNEC - Laboratório Nacional de Engenharia Civil de Lisboa, demonstrated and visited during the CircularBuild Closing Event, demonstrated in annex, in the deliverable "D4.2 – Pilot Construction".
T4.3	Demonstration and validation of circularity"CircularBuild" - reconfiguration.	Concluded	In the current reporting period, task T4.3 achieved a 100% execution rate, resulting from the disassembly and reassembly work on the earthquake prototype, in the "Pilot Construction", shown in the annex, in the deliverables "D4.4 – Construction of new panels based on reused materials", "D4.5 – Construction of a new module made of panels only" and "D4.6 – Absence of waste from the construction process".
T4.4	Realization of tests underreal conditions of use.	Concluded	In the current reporting period, task T4.4 Obtained na execution rate of 100%, resulting from the monitoring work, of the "Pilot Construction" in a real situation of use, shown in the annex, in the deliverable "D4.3 – Actual performance evaluation".
T4.5	LCA elaboration and validation of results (environmental, economic,and social).	Concluded	In the current reporting period, task T4.5 obtained a 100% execution rate, resulting from the work on the preparation of the AVC and LEVELS evaluation, demonstrated in the deliverable "D4.7 – Results of AVC and LEVELS evaluation".
Activity 5 - Program Promotion and Dissemination			
T5.1	Conception of corporateimage and promotional material.	Concluded	The task has a 100% completion rate. During the reporting period, some images were prepared by Cluster Habitat Sustentável, in line with the visual identity developed for the project. Moreover, the project presentation video and brochure were finished.
T5.2	Digital Communication.	Concluded	The task has a 100% completion rate. In this reporting period, Cluster Habitat Sustentável updated the pages/profiles on social networks and the project media monitoring. Also, the 7th and final Newsletter was sent, including the project results, the promotional material created in task 5.1, among other content.
T5.3	Events Organization andDissemination.	Concluded	The task has a 100% completion rate. During the reporting period, the Closing Event of the CircularBuild Project took place in Lisbon, at LNEC premises (16th March 2023).
T5.4	Presence in the Press.	Concluded	The task has a 100% completion rate. During the current reporting period, three press releases were delivered and the 3rd and final inquiry was applied.
Activity 6 - Project management			
T6.1	Activity 6 – Project Management.	Concluded	This activity was transversal to the project, with its execution fully accompanying the execution of the same, including the 6 month postpone.

II. Results Achieved

The following table presents, in a very intuitive and fluid way, all the results achieved within the scope of the Project during its execution. However, the consortium would like to highlight some results due to its voice in the project defined under the Environment Programme, for the construction sector and for the state of the art, such as:

From the total development of the CircularBuild Project, we highlight the Integration of more environmentally friendly materials - eco-friendly, such as wood derivatives and the replacement of some aluminum elements with wood, this without interfering with the mechanical and functional characteristics of the construction system, improving it, and promoting a more sustainable construction, which combined with the thermal characteristics of solution, allow the construction of buildings with Energy Class A+, and an energy performance NZEB20.

The Structural performance of the CircularBuild constructive solution, during the course of the earthquake behavior test, carried out on the 2-floor prototype with a 3x4 module model, surpassed all the most favorable expectations, having even been interrupted after the simulation in a real situation of an earthquake of magnitude 7.5 on the Richter scale, as its continuity is not justified, although the prototype does not show damage that would make its continuity impossible.

We also highlight the results obtained, namely in the fire reaction tests, where we achieved a B-s1,d0 classification on the inside of the panel and the outside of the panel, and the fire resistance test with results framed with a classification of fire resistance, REI30.

In this way and taking into account only some of the most significant aspects, mentioned above, we conclude that the CircularBuild constructive solution, developed in the CircularBuild Project, under the Environment Programme, obtained a transversal improvement compared to the base solution, as presented in the activity 3, standing out in the sustainable, efficient and environmentally friendly construction sector.

Table 2 – Summary of the results indicators

Activity ID	Name of Activity	Indicator	Target	Results (cumulative)	Material execution rate (%)	Means of verification
1	Study and definition of the functional requirements of the alternative materials	Substituted materials by other more energetically efficient and with a higher circular potential in the panel's construction (%)	65	0	80%	Technical sheet of the new panels -D4.7 – Results of AVC and LEVELS evalution (The UnusHouse base system has a mass per unit area of 30.5 kg/m2, with plasterboard, mineral wool and aluminum profiles (84% of the mass) having been replaced by wood fiber boards and recycled aluminum).
2	Adaptation of the productive process and industrial validation	Substituted materials by other more energetically efficient and with a higher circular potential in the panel's construction (%)	75	0	100%	Registration of Built Panels (D2.3 – Register of Building Panels)
3	Functional validation assays – Laboratory	Panels built with recycled materials that present industrial viability (%)	100	0	100%	Report of the essays performed (D3.2 – Report of test performed)
4	"CircularBuild" Construction	Number of innovative pilot solutions to increase resource use efficiency (Nr)	1	1	100%	Pilot Construction (D4.2 – Pilot construction)
		Energy efficiency increase comparing to regulatory values (%)	75	0	60%	Real performance evaluation and calculation - D4.3 - Actual Performance evalution and Calculation (The energy efficiency of the constructive solution (evaluated as the global coefficient of thermal losses of the construction) CircularBuild is 60% of the reference value of a new building, surpassing the value of 75% initially recommended).
		Increased use of secondary raw materials resulting from the separation of materials (%)	100	0	100%	Construction of new panels with separate / reused materials (D2.2 - New Panel Samples)
		Panels reused after disassembly of a pilot from a pilot module, for the construction of a new module (%).	1	1	100%	Building a new module using only panels (D4.5 – Construction of new module made of panels only)
		Construction and demolition waste avoided	0	0	0.35%	Absence of waste from the construction process (D4.6 –

Activity ID	Name of Activity	Indicator	Target	Results (cumulative)	Material execution rate (%)	Means of verification
		in the pilot construction (%).				Absence of waste from the construction process)
		Improved environmental performance comparative to the solution base (%).	55	0	77%	Report on LCA and LEVELs assessment - D4.7 - Results of AVC and LEVELS Evaluation (In the UnusHouse base system, gypsum boards, mineral wool and aluminum profiles were replaced by wood fiber boards, XPS and recycled aluminum, reducing CO2 equivalent emissions by 77%, from 110.5 kgCO2/m2 for 25 kgCO2/m2).
		Improved economic performance comparative to the base solution (%)	55	0	62%	Report on LCA and LEVELs assessment - D4.7 - Results of AVC and LEVELS Evaluation (The basic solution presents a reduction of the thermal transmission coefficient, in the reference zone I1, compared to a new traditional construction (0.50 - Ud.s), of 55%, 0.22 (Ud.s). The CircularBuild constructive solution presents a thermal transmission coefficient of 0.19 (Ud.s) for the reference zone, corresponding to a 62% reduction compared to a traditional new construction. In this way, the CircularBuild Constructive solution, presents an energy efficiency superior to the traditional construction of 62%, and of the base solution of 7%, resulting from the reduction of thermal bridges due to the insulation superior to the reference solutions).
5	Promotion and Dissemination of Results	People who had direct contact with the project results and heard about the competitive advantages of the CircularBuild solution (Nr)	65	208	320%	Attendance list of the 3 events (D5.2 -Attendance sheet of the 3 events)
		People who received information about the EEA Grants Program and its relevance to the project (Nr).	200	718	359%	Number of recipients of newsletters sent related to the project

Activity ID	Name of Activity	Indicator	Target	Results (cumulative)	Material execution rate (%)	Means of verification
						(D5.3 – Number of recipientes of Newsletter sent under the project)
6	Project Management	Project physical execution degree (%)	100	100%	100%	Full implementation of all tasks envisaged in the project
		Project financial execution degree (%).	100	94,34%	94,34%	Final Financial Report / Payment request
		Number of jobs created (Nr)	1	1	100	Social Balance / Single Report
		Number of SMEs supported (Nr)	1	1	100	Grant Agreement signed by Concexec

III. Promotion and Dissemination of Results

As shown in the following table – and widely described in the previous interim reports – the CircularBuild project has been widely promoted and disseminated through various communication channels during the entire project execution. The majority of communication actions foreseen in the project communication plan were already fully implemented / executed even before the project completion, which demonstrates the hard efforts that were made to spread abroad the CircularBuild interim – and more recently, final – results of the project and its relevance and innovation towards the evolution of the current state of the art.

Moreover, all the communication actions prepared under the project followed the guidelines of the "Communication and Graphic Standards Manual EEA Grants Portugal 2014-2021" and the elements related to those actions are included in the communication dossier.

Table 3 – Summary of the Communication Plan results.

TYPOLOGY OF ACTION FOR THE PROMOTION AND DISSEMINATION OF RESULTS	CUMULATIVE NUMBER OF ACTIONS IMPLEMENTED	VERIFICATIONSOURCE	EXECUTION	TARGET
Corporate Image Conception	1	Corporative image	100%	1
Website	1	Project Website	100%	1
Digital Communication Dossier Development	1	Dossier	100%	1
Newsletters	7	Newsletters delivery	117%	6
Social Network Pages	3	Online pages	100%	3
Launch Event Organization	1	Event attendancesheet	100%	1
Demonstration Event Organization	1	Event attendancesheet	100%	1
Project Closing EventOrganization	1	Event attendancesheet	100%	1
Presence in Scientific Events	5	Photographic record and programme (when applicable)	100%	5

Evaluation of the Product Impact and Social Acceptance	3	Created surveys	150%	3
Magazines Advertising	3	Magazines	150%	2
Press Releases	9	Press Releases delivery	100%	9

IV. Description Of Costs And Financial Impact Assessment

As previously mentioned, during the project's execution Concexec faced several constraints in accessing critical raw materials as a result of the significant increase on its price in the market (which, in its turn, was directly related to its scarcity worldwide). Those constraints negatively impacted the normal execution of the project, causing various delays in different activities and tasks and making it mandatory, not only to require for a postpone of the project's conclusion, as well as for relevant adjustments in the project's budget, allowing an optimization of the financial execution of some items and the reinforcement of others that, due to the circumstances, significantly increased their investment value.

The following tables present the financial execution of each participant during the entire project:

Projeto/ Atividades	Despesa (com custos indiretos)				Taxa de execução financeira (%) (face ao custo total)	
	no período de reporte	Cumulativa	Apresentada a PP	A apresentar no próximo PP	no período de reporte	Cumulativa
Gestão	19 430,93 €	63 654,05 €	63 654,05 €	0,00 €	27,82%	91,14%
A1	4 750,78 €	83 126,63 €	83 126,63 €	0,00 €	5,86%	102,57%
A2	3 295,85 €	80 768,73 €	80 768,73 €	0,00 €	2,02%	49,56%
A3	21 401,35 €	126 465,53 €	126 465,53 €	0,00 €	15,26%	90,15%
A4	66 802,89 €	149 138,59 €	149 138,59 €	0,00 €	75,70%	169,00%
A5	49 055,69 €	98 656,70 €	98 656,70 €	0,00 €	192,63%	387,40%
Total	164 737,48 €	601 810,24 €	601 810,24 €	0,00 €	29,01%	105,98%

Entidades/ Atividades	Despesa (com custos indiretos)				Taxa de execução financeira (%) (face ao custo total)	
	no período de reporte	Cumulativa	Apresentada a PP	A apresentar no próximo PP	no período de reporte	Cumulativa
Gestão						
CONCEXEC	4 019,09 €	16 826,09 €	16 826,09 €	0,00 €	23,78%	99,57%
LNEC	573,92 €	1 720,28 €	1 720,28 €	0,00 €	30,21%	90,54%
ClusterHabitat	205,30 €	3 262,00 €	3 262,00 €	0,00 €	6,24%	99,23%
RISE	14 632,62 €	41 845,68 €	41 845,68 €	0,00 €	433,02%	1238,33%
Total Gestão	19 430,93 €	63 654,05 €	63 654,05 €	0,00 €	76,30%	249,95%
A1						
CONCEXEC	1 545,34 €	18 094,58 €	18 094,58 €	0,00 €	8,79%	102,97%
LNEC	3 205,44 €	37 532,96 €	37 532,96 €	0,00 €	8,52%	99,73%
ClusterHabitat	0,00 €	5 419,03 €	5 419,03 €	0,00 €	0,00%	100,00%
RISE	0,00 €	22 080,05 €	22 080,05 €	0,00 €	0,00%	239,58%
Total A1	4 750,78 €	83 126,63 €	83 126,63 €	0,00 €	6,80%	119,02%
A2						
CONCEXEC	3 295,85 €	71 609,65 €	71 609,65 €	0,00 €	4,59%	99,63%
LNEC	0,00 €	9 159,08 €	9 159,08 €	0,00 €	0,00%	99,94%
ClusterHabitat	0,00 €	0,00 €	0,00 €	0,00 €	0,00%	0,00%
RISE	0,00 €	0,00 €	0,00 €	0,00 €	0,00%	0,00%
Total A2	3 295,85 €	80 768,73 €	80 768,73 €	0,00 €	4,07%	49,56%
A3						
CONCEXEC	3 525,28 €	41 110,27 €	41 110,27 €	0,00 €	7,70%	89,77%
LNEC	6 399,64 €	72 336,52 €	72 336,52 €	0,00 €	8,64%	97,60%
ClusterHabitat	0,00 €	0,00 €	0,00 €	0,00 €	0,00%	0,00%
RISE	11 476,44 €	13 018,74 €	13 018,74 €	0,00 €	26,65%	30,24%
Total A3	21 401,35 €	126 465,53 €	126 465,53 €	0,00 €	13,13%	90,15%
A4						
CONCEXEC	40 024,00 €	97 922,29 €	97 922,29 €	0,00 €	38,73%	94,76%
LNEC	18 560,42 €	36 067,37 €	36 067,37 €	0,00 €	50,24%	97,63%
ClusterHabitat	0,00 €	0,00 €	0,00 €	0,00 €	0,00%	0,00%
RISE	8 218,46 €	15 148,93 €	15 148,93 €	0,00 €	(*)	(*)
Total A4	66 802,89 €	149 138,59 €	149 138,59 €	0,00 €	47,62%	106,31%
A5						
CONCEXEC	32 848,06 €	55 623,64 €	55 623,64 €	0,00 €	57,56%	97,48%
LNEC	0,00 €	7 248,52 €	7 248,52 €	0,00 €	0,00%	62,68%
ClusterHabitat	1 575,01 €	13 814,54 €	13 814,54 €	0,00 €	10,49%	92,03%
RISE	14 632,62 €	21 970,01 €	21 970,01 €	0,00 €	317,55%	476,78%
Total A5	49 055,69 €	98 656,70 €	98 656,70 €	0,00 €	55,59%	111,80%
Total	164 737,48 €	601 810,24 €	601 810,24 €	0,00 €	29,01%	105,98%

(*) There are no percentages, because in the application form, the co-promotor RISE had no expenditure planned for this activity.

Entidades/ Totais	Despesa (com custos indiretos)				Taxa de execução financeira (%) (face ao custo total do projeto/entidade)	
	no período de reporte	Cumulativa	Apresentada a PP	A apresentar no próximo PP	no período de reporte	Cumulativa
CONCEXEC	85 257,60 €	301 186,52 €	301 186,52 €	0,00 €	27,28%	96,36%
LNEC	28 739,42 €	164 064,73 €	164 064,73 €	0,00 €	16,78%	95,77%
ClusterHabitat	1 780,31 €	22 495,57 €	22 495,57 €	0,00 €	7,51%	94,85%
RISE	48 960,14 €	114 063,41 €	114 063,41 €	0,00 €	81,25%	189,29%
Total	164 737,48 €	601 810,24 €	601 810,24 €	0,00 €	29,01%	105,98%

Entidades/ Totais	Atividades						
	Gestão	A1	A2	A3	A4	A5	Total
CONCEXEC	16 899,58 €	17 573,09 €	71 876,90 €	45 797,41 €	103 338,87 €	57 063,70 €	312 549,54 €
LNEC	1 900,06 €	37 633,28 €	9 164,47 €	74 112,49 €	36 941,86 €	11 564,64 €	171 316,80 €
ClusterHabitat	3 287,42 €	5 419,04 €	0,00 €	0,00 €	0,00 €	15 010,86 €	23 717,33 €
RISE	3 379,20 €	9 216,00 €	0,00 €	43 056,00 €	0,00 €	4 608,00 €	60 259,20 €
Total	25 466,26 €	69 841,42 €	81 041,37 €	162 965,90 €	140 280,72 €	88 247,20 €	567 842,86 €

Regarding the financial execution of the CircularBuild project, the project reach a total expenditure of 548.006,03€, which corresponds to an execution rate of 96.51%, demonstrating the good execution of the project and the commitment of all the promoters. One of the reasons, and perhaps the most significant, for not having reached 100% of execution rate was the bargaining power achieved with suppliers, making it possible to purchase consumables and services at lower prices than expected. In addition, we would like to warn that de costs of RISE, are limited to, in the tables above, to the amount of the total eligible investment foreseen in the application (60.259,20 Eur). The actual costs presented by the partner, with the recalculation of the human resources costs based on the "Research Council prices" is 114.063,41 Eur.

V. Description of the Project's contribution to achieving the overall objectives of EEA Grants and the 'Environment Programme'

PA	Expected Programme results	Indicator	Baseline value	Baseline year	Target value	Project contribution to date	Related activities
PA11 Outcome 1	Increased application of circular economy principles in targeted sectors	Construction and demolition waste avoided by the supported sectors (percentage)	48,6%	2017	70,0%	**99,67%[1]**	A2, A3 and A4
		Number of jobs created (disaggregated by gender, age)	0	N/D	25	1	A1, A2, A3, A4, A5 and A6
		Tons of plastic recycled through all supported schemes/measures	0	N/D	20000	Na	Na
		Use of secondary materials increased in the supported sectors (percentage)	0,0%	N/D	15,0%	**58.05%[2]**	A2, A3, and A4
Output 1.4	Increased resource efficiency in the construction sector	Number of SMEs Supported	0	N/D	5	1	A1, A2, A3, A4, A5 and A6
		Number of demonstration buildings constructed	0	N/D	3	1	A3 and A4
		Number of Innovative solutions for increased resource efficiency piloted	0	N/D	5	1	A3 and A4

[1] The base construction solution generates waste of 50.90% (denominator). In the construction process of the CircularBuild solution, only 0.17kg/m² of RCD's are generated, as 50.73kg/m² are reused construction materials. This significantly contributes to the reduction of waste on site. In this sense, 50.73kg/m² of materials from the CircularBuild construction are reused, thus avoiding 50.73kg/m² of RCDs (numerator).

[2] Based on the mass of the constructive system per m² (reference panel), of the CircularBuild constructive solution, that is, 50.92kg/m², the mass of secondary raw materials corresponds to 29.56kg/m². Thus, it is possible to verify that the percentage of secondary raw materials corresponds to 58.05%.

Project Promotor

Name	
Date and Signature	Assinado por: **JAIME ALBERTO FERNANDES DA SILVA** Num. de Identificação: 08127080 Data: 2023.09.13 11:55:29+01'00'
Position	

Programme Operator – Secretary General for Environment

Name	Marco Rebelo
Date and Signature	
Position	Secretary General