MONOMATERIAL ECOLOGICAL BUILDINGS, WITH MOPATEL® AND ECOPIERRA® CONCRETE. CASE STUDY

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Abstract. This paper presents a case study performed on a pilot building from Gainesti, Suceava county. The constructive system used is unique in that it employs a monomaterial, namely ecological concrete of type MOPATEL® or ECOPIERRA®. These types of concrete, created by eng. Petrache Teleman, possess international patents and have received awards in Brussels, but they are not yet used in Romania. These materials can be used integrally to make all the constructive elements of a building – load-bearing elements (floors, beams, pillars, walls) as well as the secondary elements of a partly finished building, such as screeds or non-load-bearing masonry. The constructive system also uses ecological mortars which integrally ensure the interior and exterior finishing. The final result is a building practically made from a single type of material, in which the effect of thermal bridges is reduced to a maximum. The MOPATEL and ECOPIERRA types of concrete have a mechanical resistance similar to regular concrete, but they also have superior thermal insulation qualities (between 0.09 and 0.28 W/mK), they are permeable to the transfer of water vapours from the interior to the exterior of the building, and, in certain compositions, they canalso be considered waterproof.

Key words: Energy efficiency, healthy living, CO_2 adsorption, durable buildings, clean environment.

1. Introduction

As a complex policy challenge, support for eco-innovation requires a coordinated approach, most notably among innovation, research and environmental policy.

The implementation of eco-innovation measures has to be done in close collaboration between the factors involved in innovation, research and environmental policy, and the innovation policy must deliver a set of objectives and a strategy shared by all concerned stakeholders. Environmental policy agencies will have to cooperate more systematically with innovation policy-makers. Equally, dematerilising our economies requires a shift in emphasis towards innovation, inducing regulations such as setting strict environmental performance standards.

Eco-innovation encompasses novel or significantly improved solutions introduced at any stage of the product or service life ('from cradle to grave'). The so-called 'end-of pipe' or curative technologies are, however, the least efficient solutions from this point of view. Resource and energy efficiency becomes of key importance as preventive measures minimizing material inputs and decreasing levels of waste throughout the production and use process (Reid and Mieszinki, 2008; UNEP, 2010; CIOB Annual Review, 2010)

The idea of creating a building out a single material belongs to Edison, who patented it in 1917. Concrete prefabricated buildings meet the criteria of stability and resistance. However, their thermo-energetic response cannot be accepted under the new conditions imposed by the EPBD directive (2010/31/UE - recast) unless the base material is associated with other thermal insulation materials to ensure the required energy performance. Modern designers of concrete structures have been awakened to reality by NJIT (New Jersey Institute of Technology) Assistant Professor Matt Burgermaster who resurrected Edison's idea in the scientific session Science Daily (June 1st, 2011) at the 64th annual meeting of the Society of Architectural Historians (Burgermaster, 2011).

Edison invented a single-pour system for concrete construction as a novel application of this material's dynamic behaviour and speculated on its role in the development of a type of integrated building anatomy that, perhaps inadvertently, also invented the idea of a seamless architecture.

Originally motivated by the objective of providing a cost-effective prototype for the working-class home, this early experiment eventually entered mass-production.

Edison's 1917 patent proposed a building-sized mould that leveraged the intrinsically dynamic capacity of concrete to form itself into a variety of shapes and sizes, limited only by the design of its framework.

The invention's potential efficiencies resided in the distribution of this material as a continuous flow through an entire building instead of being confined to the prefabrication of its constituent parts.

By physically integrating all interior and exterior building components and their associated functions of structure, enclosure, and infrastructure within a single, monolithic concrete cast, all aspects of assembly were eliminated.

This radical proposition - a seamless architecture - was built by Edison before it was conceptualized by the European avant-garde (such as Le Corbusier and the Bauhaus) with whom it later became associated.

Edison's approach to invention remains as radical today as it was a century ago. Professor Matt Burgermaster said, "my hope is that this 'lost' chapter in the early history of concrete construction will demonstrate that Edison not only left a mark on the field of architecture right here in our back-yard, but that his unique approach to design thinking offers a model for how today's architects and designers can add value to the process of technological problem-solving."

Superadobe (sandbag and barbed wire) technology (US patent #5,934,027, #3,195,445) (Cal - Earth The California Institute of Earth Art, 2013) is a large, long adobe. It is a simple adobe, an instant and flexible line generator. Long or short sandbags are filled with on-site earth and arranged in layers or long coils (compression) with strands of barbed wire placed between them to act as both mortar and reinforcement (tension).

Fig. 1. Wall of Superadobe construction

Stabilizers such as cement, lime, or asphalt emulsion may be added. This technology is offered free to the needy of the world, and licensed for commercial use. This concept was originally presented by architect Nader Khalili to NASA for building habitats on the moon and Mars, as "Velcro-adobe". It comes from years of meditation, hands-on research and development, and searching for simple answers to build with earth. The system can be used for structural arches, domes and vaults, or conventional rectilinear shapes. The same method can build silos, clinics, schools, landscaping elements, or infrastructure like dams, cisterns, roads, bridges, and for stabilizing shorelines and watercourses. In Superadobe, the ancient earth architecture of the Middle East using sun-dried mud bricks is fused with its portable nomadic culture of fabrics and tensile elements, not just through design and pattern, but through the structure itself. Structural design uses modern engineering concepts like base-isolation and post-tensioning. The innovation of barbed wire adds the tensile element to the traditional earthen structures, creating earthquake resistance despite the earth's low shear strength. The innovation of sandbags adds flood resistance, and easy construction, while the earth itself provides insulation and fire-proofing.

This constructive system can only be applied for small buildings, but it involves the use of a support material (usually a synthetic one) in order to make the base adobe.

We may state that, until today, there are no known worldwide complete construction systems which use a single type of material. In the most part of the current systems, using different components and materials, often complementary, but sometimes opposite to the point that they must be separate by other materials, which means that the building as a whole presents itself as a set of heterogeneous materials. This often has a negative influence as much on the technical quality as on the overall construction cost. We see that the construction market is flooded by thousands of materials and **components harmful** both for the health of the population and for the natural environment and **that this already costs enormously (asbestos, for example). However, civil society does nothing to reduce the huge costs in terms of health insurance and remediation of sites.**

These costs will only increase, since we will only know the harmful effect of such and such materials after a long period of time, as was the case with asbestos.

It is noted that the same findings have been made by many actors in the construction field and that they have tried to introduce on the building market **noble materials** such as **wood** (especially), **clay**, **limestone**, and other stones.

However, their use has remained confined to the construction of individual houses, their cost of returns being more expensive than other systems.

2. Monomaterial constructive system

2.1. Description of the constructive system

This paper proposes an integrated building system, unique in the world, which is ecological and perfectly adhering to the principle of an ecologically durable building, with respect to the health of those who will live in and use the buildings erected on its basis, as well as to the environment. The conception of the ecological building system is based on using a single type of material, which is an ecological concrete and mortar composite. This composite can be made in the entire range of densities and mechanical / energy characteristics, and it can be used for all load-bearing, closing or finishing elements necessary for the construction of a wide range of buildings: homes, social and cultural objectives, offices and so on.

From a financial point of view, the proposed integrated building system saves about 85-90% of the shuttering usually needed on construction sites. **Factored into the total cost of the concrete usually cast on construction sites**, the saving of shuttering leads to a 35% drop of the final cost.

This ecological material, patented in a European Union country, Belgium (Teleman, 2006) through two inventions of engineer Petrache Teleman, mainly uses lime and natural wood residue of any kind, as well as other raw/natural materials, such as cork and clay pellets. It presents remarkable thermal and sound insulation qualities, it is ecologically durable, and it has antibacterial, permeable properties, etc. However, its most impressive and valuable quality is the capacity to absorb the polluting emissions from the atmosphere, which are represented by the carbon oxide compounds.

This material is composed entirely of noble components, ecological construction materials and possesses European patents (eng. Petrache Teleman) for 2 types of light and green concrete trademark names - MOPATEL and ECOPIERRA. MOPATEL and ECOPIERRA concrete types received gold and silver medals in the "construction materials" category at the EUREKA 2003 Inventions Exhibition in Brussels and the certificate of merit at the EXPOCONSTRUCT show in May, 2004, in Bucharest.

2.2. Technical characteristics of Mopatel® and Ecopiera® concrete

The ecological **ECOPIERRA®** and **MOPATEL®** concrete types are produced in three ranges:

- Strong, with a density of 1.400 -1.700 kg/m³, whose main characteristic is its high resistance to compression, its elasticity module being similar to that of light concrete.
- Medium, with a density of 1.100 - 1.400 kg/m³, having high mechanical resistance and great sound and thermal proofing properties.
- Light, with a density of 800 - 1.000 kg/m³, mainly used as thermal and sound insulating materials.

The MOPATEL® and ECOPIERRA® light ecological concrete with thermo-insulating properties are resistant to fire, have good plasticity, good thermal and sound insulating qualities and ensure a resistance to tensile strength similar to that of classic concrete. They are characterized by a permeability similar to that of the air, allowing the elimination of condensed vapours and toxic gas. They can be coloured in any shade, which gives a clean look to walls made from this material so that they do not require any further finishing.

Fig. 2. Fire test

Table 1. Main technical characteristics of MOPATEL and ECOPIERA concrete

Characteristic – Unit of measure	*Measured value*	*Executing Laboratory*
Density - kg/m³		
-ECOPIERRA® Strong	*1235…1480*	
-ECOPIERRA® Medium	*1200 -1400*	CSTC Belgium INCERC
- ECOPIERRA® Light	*1000-1200*	
- MOPATEL® Strong	*1100*	
-MOPATEL® Medium	*870…920*	
- MOPATEL® Light	*745…810*	
Thermal conductivity λ_{10} - W/mK		
-ECOPIERRA® Strong	*0,348*	
-ECOPIERRA® Medium	*0,22..0,25*	
- ECOPIERRA® Light	*0,17 …0,22*	INCERC
- MOPATEL® Strong	*0,271..0,331*	
-MOPATEL® Medium	*0,202.. 0,215*	
- MOPATEL® Light	*0,09 ..0,160*	
Resistance to compression - N/mm²		CSTC Belgium,
- ECOPIERRA® Strong	*11,2 …22,56*	ARGEX
- MOPATEL® Strong	*9,037 .. 12,0*	SA
-MOPATEL® Medium	*4,792..5,539*	Belgium,
- MOPATEL® Light	*0,533..1,022*	INCERC
***Water absorption** - % ECOPIERRA® Strong*	*2,73 …3,97*	ARGEX SA Belgium
***Resistance to water vapour** – MOPATEL® Strong*	16.6..17.2	CSTC Belgium

2.3. Case study – pilot building

The inventor of these materials has erected an experimental building in Gainesti, Suceava using these types of concrete. The building functions as his production workshop. It was finished in the winter of the year 2011.

Fig. 3. Eureka Exhibition - 2003

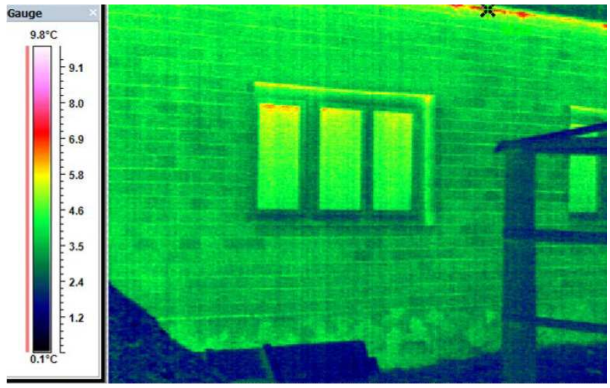

Fig. 4. Infrared image of the wall made from 40cm Mopatel masonry blocks.

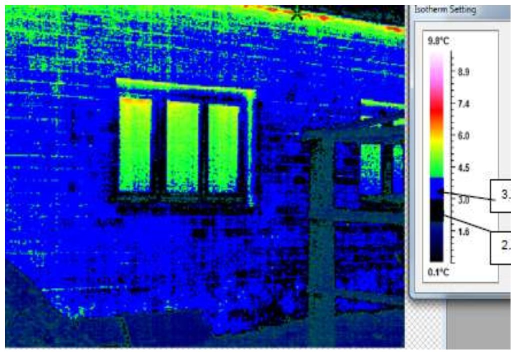

Fig. 5. Isotherms between 2.1⁰ …3 ⁰C black dots and 3,1⁰ …4⁰ C blue dots

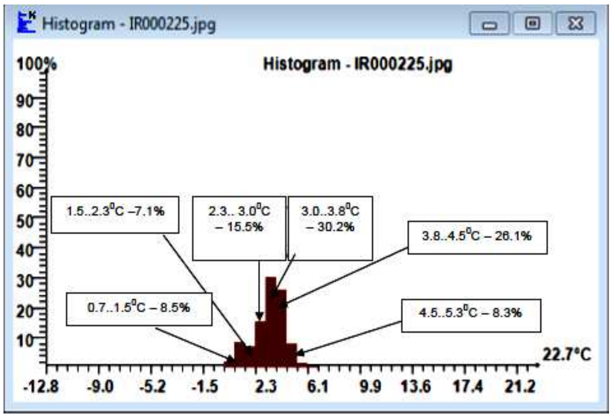

Fig. 6. Percentage distribution of temperatures on the surface of the exterior wall from 40cm Mopatel masonry blocks (Fig. 4, 5) (temperature between 1.5⁰C …4.5⁰C – 78.9% from the total surface)

The building is the subject of a monitoring study aiming to survey its behavior in time. Between December 2011 – January 2012, the first measurements of the thermal transfer were made with a thermal imaging camera.

We should mention that the measurement was conducted soon after the heating source of the building was also finalized. The homogenous quality of the building made with this constructive system is illustrated below by the thermal images captured during the study.

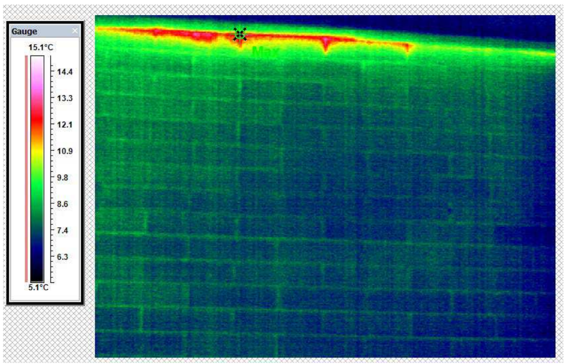

Fig. 7. Infrared image of the wall made from 20cm MOPATEL masonry blocks

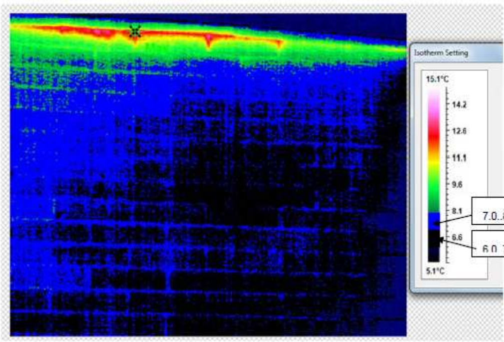

Fig. 8. Isotherms between 6^0 …7 ^{0}C black dots and 7^0 …8^0 C blue dots

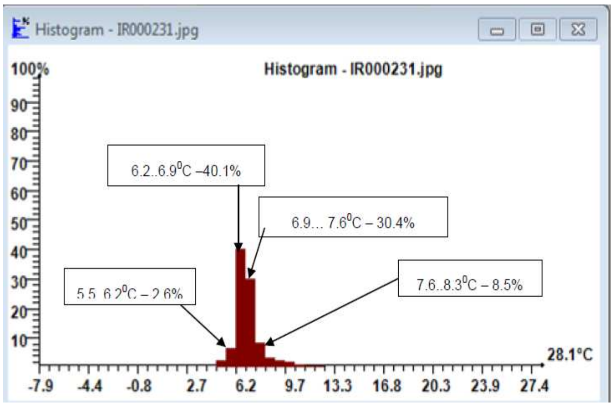

Fig. 9. Percentage distribution of temperatures on the surface of the exterior wall from 20cm Mopatel masonry blocks (Fig. 7, 8) (temperature between 5.5 ^{0}C …8.5^{0}C – 81.6% from the total surface)

As this is a pilot experimental building, the walls have been made from Mopatel Light masonry blocks with a thickness of 40cm and 20cm, using a mortar with identical composition.

3. Conclusion

In this monitoring stage, the measured values are not important as absolute values, since the measurement was made under conditions that do not involve reaching stationary regime parameters. The building continues to be monitored and the conclusions of the study will become available in the coming years. The workshop had been heated only for about a week, the average interior temperature being of circa 12 ^{0}C, while the exterior temperature was around -3^{0}C (minus three Celsius degrees). The interior of the building had freshly plastered areas. The thermal imaging measurement has only a qualitative value, aiming to show the uniformity of the temperature field on the exterior wall made from MOPATEL 40cm masonry blocks of light concrete.

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