FACTA UNIVERSITATIS
Series: **Architecture and Civil Engineering** Vol. 12, N^{o} 3, 2014, pp. 221 - 232
DOI: 10.2298/FUACE1403221D

APPLICATION OF NEW ACTIVE THERMALLY ENHANCED INSULATION MATERIAL (PCM) – STOREPET

UDC 621.315.61=111

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Abstract. *Lightweight constructions represent an economical alternative to traditional buildings, one of whose main drawbacks is the very high energy load needed to keep internal comfort conditions, as they are unable to curb rapid variations of temperature. When compared to heavier weight materials buildings, it is estimated that to maintain a thermally comfortable temperature range of 18-24°C, low weight materials use between 2 and 3 times the heating and cooling energy needed by a heavy weight material construction.*
The research concept is based upon the fact that outdoor/indoor heat exchanges (which play a significant part of lightweight buildings cooling and heating loads) can be potentially controlled by a new fiber insulation that possesses a thermally active heat storage capacity. During the day, when temperature rises, the peak loads can be largely absorbed by a PCM (Phase Change Material) - enhanced fiber insulation layer, only to be slowly discharged back to the environment later (during the night time, when outside temperature drops), without affecting the interior building energy balance, as it is aided by the presence of an standard low heat transfer fiber insulation layer. This approach will provide a much slower response of the building envelope to daily temperature fluctuations, helping in maintaining inside temperature in a comfortable range and thus avoiding the need for extra energy consumptions to accomplish it. Effective levels of indoor comfort will be also guaranteed by the well known fiber materials excellence, when it comes to reduce airborne noise transmission and its superior performance upon controlling the sound resonance in construction cavities.
Development of such material is in final phase in frame of European FP7 project STOREPET (FP7-SME-2011-2, Proposal 286730). Project participant from SEE is Construction Cluster „Dundjer” from Niš. Development and application of project results will be presented in this paper.

Key words: *building materials, thermal insulation, acoustic insulation, light building constructions, energy efficiency, sustainable building.*

Received January 9, 2014
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1. STATE OF THE ART

Nowadays builders and contractors can choose from a large variety of insulations that can vary in cost, performance, and ease of installation. Generally divided in two main categories – Bulk and Reflective, thermal insulation products are sometimes combined into one single product to be able to resist radiant heat flow (Reflective part) and to block the transfer of conducted and convected heat (Bulk part), relying on pockets of trapped air within its structure to perfom the latter function.

Lightweight timber construction

LSF construction

Traditionally, lightweight building systems involving timber and steel framing elements have relied mostly on bulk fiber materials (fiberglass or mineral wool) for its heat insulation. Due to technical and time consuming on-site building limitations, these structures are being replaced by modern and less time consuming pre-fabricated plywood Structural Insulated Panels (SIPs), or pre-fabricated composite Light Steel Framing (LSF) systems, that combines faster buildings times, easiness of installation and resources economy, with good heat insulation and superior air-tightness.

Following the overall trend to use rigid foam insulation, the choice of insulation materials for modern off-site manufacturing approach is moving from the traditional fiber materials, and is being replaced for thick insulation layers of polystyrene (PS) or polyurethane (PU) foams, sandwiched between oriented strand boards (OSB), or pre-finished skin products made of steel or light aluminium alloys, filled with polyisocyanurate (PI) or PU foams.

Although these materials generally provide better air-tightness and moisture control to the envelope structures, their heat insulation properties are not always superior and surely their abilities to reduce levels of airborne noise are considerably worse than the ones given by the majority of fiber solutions available. A balanced combination of thermal and noise insulation excellence is still only achievable by fiber materials.

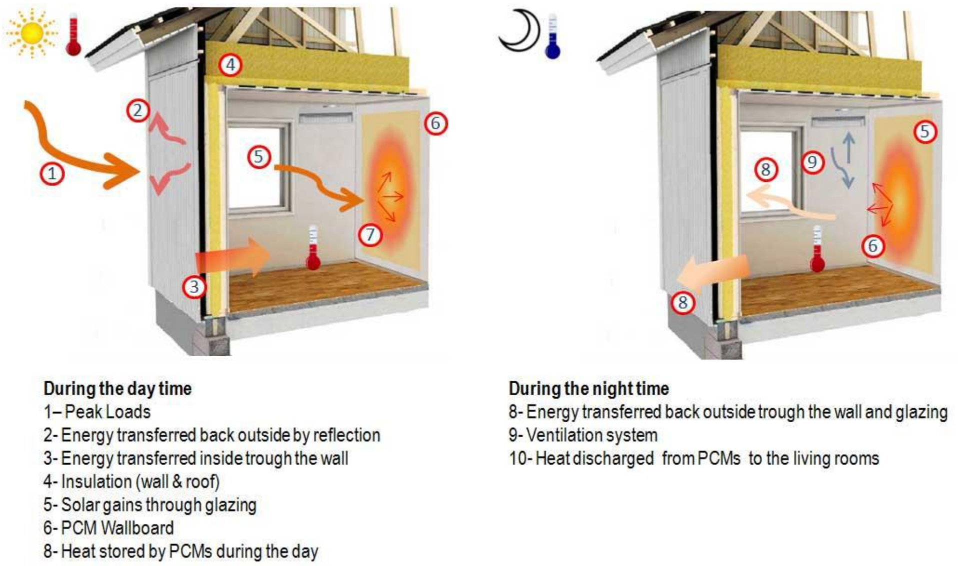
A summarized list of the most common types of bulk insulation products is to be found in references and includes bulk rigid foams, fiber blankets bats and rolls and also spray-in-place insulation options, that can even be used together to yield higher R-values (*Thermal Resistance*, that indicates the material's resistance to heat flow. The higher the R-value, the greater the insulating effectiveness.

Rigid foam insulations are made from polymer materials – such as polystyrene, PU or PI, molded into rigid boards in a variety of sizes. Lightweight and easy to install, rigid foam provides higher insulating values (typical R-values range from R-4 to R-6 per inch of thickness), but generally offers much less guarantees as the fiber insulation materials, when it comes to fire resistance and to reduce noise transmission. The most common product made out of polystyrene is Styrofoam™ produced by DOW Chemicals. Ranging from R-3.20 to 4.00, depending on its density, Styrofoam values are generally adequate for most insulation

Spray-in-place cellulose needs. Closed-cell PI foam board products are being more welcomed (especially in the US), not only because of their thermal insulation abilities but mainly due to its superior reaction to fire. Polyisocyanurate insulation is a closed-cell rigid foam board manufactured with isocyanate and polyether mixed together in the presence of a catalyst that allows the molecules to rearrange, forming closed cells. Typical R values of PIR insulation range from R-5.6 to R-8. Finally, there are a large number of commercially available products made of PU foams systems, in the form of large lightweight boards capable of achieving extremely high insulation values, or more commonly a two-component, spray-applied on site polyurethane foam that creates a seamless, monolithic barrier for protection against water vapor, heat and air in the interior of steel stud walls. Although generally regarded as good thermal insulators, these product are incapable of levelling with fiber materials (like the StorePET) when it comes to acoustic insulation, which represents their major drawback.

Fiberglass installation

"Spray-in-place" has become one of the most popular types of insulations products, especially due to the increasing number of retrofit actions. Spray-in-place cellulose, fiberglass and mineral wool are cavity insulations that are mechanically blown into the wall. R-values vary depending on installation but generally range from R-3 to R-4 per inch of thickness. This insulation technique usually costs more than blanket insulations, but is well suited to use around obstructions and irregularly shaped areas. However, it usually takes too long to be completely installed, as it must dry completely before being covered by a drywall panel and reach maximum performance. Another potential drawback to loose-fill spray-in-place insulations is that, over time, the R-values can decrease because of particle settling. Spray plastic foam usually overcomes this problem while it is usually made of polyurethane or other polymers that have no settling problems. However, special equipment is still required to meter, mix, and spray the foam into place. After application, spray foam expands and conforms to the shape of the wall cavities, helping to minimize air infiltration. The ability to conform to space makes spray foam ideal for insulating around obstructions and other hard-to-reach areas. Spray foam materials and installation usually also cost more than blanket insulation, but its effectiveness for air-tightness is sometimes its major advantage.



On the other hand, fiber blankets, batts and rolls, available in different widths and thicknesses, are the most cost-effective and widely available types of insulation. They are usually made from glass and mineral wool, but also from recycled polymers (polyester insulation) and a long list of natural materials like cotton fibers, sheep wool fibers and even recycled denim jeans, with R-values ranging between R-1 and R-5 per inch of thickness. Rolls come in long lengths that can be cut to required dimensions and batts come in pre-cut standard lengths. Blanket insulation is inexpensive, but the pieces must be hand-cut to fit snugly around obstructions, such as window frames, wires and pipes. Small aps between batts or small non covered areas of the wall are generally the most important factors that lead to a loss of efficiency of these products. Although capable of combining thermal and acoustic insulation skills, there is still no fiber product available on the market at a broadly affordable price that is sold as a standalone product and includes thermal storage abilities, thus being able to provide extra energy savings on both cooling and heating dominant loads, like the StorePET.

Worldwide there are several manufactures and suppliers of different polyester insulation products that compete with other common fiber materials in the form of soft or semi-rigid boards, batts and rolls, or even on in-situ blow applications. Primarily made out recycled plastic (PET) bottles, this technical nonwoven insulation involves the melting of the polymer materials, to then be spun to form fibres that are bound together and cut into different shapes and thickness. It is an excellent insulation product that does not release fiber dust or irritate the skin as other insulation products can (i.e. fiberglass and mineral wool), thus very easy to handle without the need of personal health safety equipment.

With R-values varying from 1 – 5.0 depending on its thickness, polyester insulation is essentially the same material used in many pillows and often manufactured by the same companies. Polyester owes its excellent heat insulation properties to its no-toxicity and outstanding acoustic blocking properties, as also high resilience and outstanding compressional resistance. Polyester is fire resistant material as it requires quite high temperature to burn. However, poor polyester installation procedures, particularly on roofs and ceilings, can be troubled if batts are not well protected or let to cover down lights & ceiling fans with overheat potential. While being easy to install, resistant to fungi and insects, insensitive by moisture, produced without formaldehyde, borates or other chemicals and none allergic or irritant, the main environmental benefit of polyester insulation is that it is manufactured out of up to 70% recycled plastic bottles, reducing landfill and contribute for carbon emission cutbacks.

Knauff Thermalcore PCM Smartboard, Maxit's Clima and CelBloc Plus

Delta Cool 24, DuPont Energain and Datum Phase Change's Racus

Apart from the most common insulation products, recently the market has been receiving some new materials and composites with very good performances and high R-value rates. 99% air-made material, Aerogel is probably the most notable one, as it can reach R-values of about R-10 per inch and is capable of insulate up to 37 times more than fiberglass (the lowest thermal conductivity yet available - 13 mW/mK, while mineral wool is 30-45 mW/mK). Its major drawback is still its mechanical fragileness and huge price. For example, fiber aerogel containing blankets with nominal conductivities of 14 mW/mK, like the Aspen's Spaceloft23 ones (capable of reaching a 10.3 R-Value/Inch), are not expected to cost less than $65 US dollars for each m2, for a 5mm thick batt24. Aerogel price has been limiting its use in regular residential constructions, although other alternatives are arising like their use inside R-30 and R-50 per inch vacuum insulation panels (VIPs)25, or instead in cheaper but still efficient solutions, like the Thermablock26 aerogel thin tape that helps eliminate thermal bridges on stud wall constructions that can be sold for about $\$21/m^2$.However none of these aerogel solutions act like phase change materials, thus incapable to overcome thermal mass issues and their price is not yet competitive for a broad adoption.

2. APPLICATION OF PHASE CHANGE MATERIAL (PCM)

Regarding the utilization of PCMs on the building sector, most studies have demonstrated that the application of thermal mass in well-insulated structures could generate heating and cooling energy savings of up to 25% in residential buildings. Considering that new PCM-enhanced building envelope components could be installed in about 10% of both new and existing U.S. homes, the potential for energy savings would be between 0.2 and 0.5 quad/year.

All the extensive scientific research work that has been made over the last 40 years in this area have allowed PCMs to hit the market by being incorporated into products such as: plasterboards or drywall systems (Knauff Thermalcore PCM Smartboard28), interior plasters with a temperature regulating effect (Maxit clima®29) or aerated concrete blocks (H+H Deutschland GmbH‘s CelBloc Plus®30), all of them based on microencapsulated paraffin waxes form BASF. BASF‘s Micronal® 23 is also the component that Datum Phase Change incorporates into a magnesium oxide-based matrix to create the Racus®31 PCM ceiling tile system. DuPont‘s Energain®32 is another PCM related product that is used in construction. It consists of paraffin-based gel core held between two sheets of conductive aluminium, designed to be sealed behind plasterboard walls or above ceiling panels, so they can act as a fire-retardant barrier to the material. The PCM is formulated to absorb heat above 22°C, storing it until the temperature drops below 18°C, when it releases it back to the room. DuPont claims that it can help reduce heat consumption by 15% and air conditioning costs by 35%. Finally, Delta-Cool 24 by Dörken33 is a packaged PCM suited to retrofit situations, that can be easily placed on top of suspended ceilings or under floors, ensuring comfortable room temperatures around 25 °C. Nevertheless, contrary to the StorePET proposal, all the current building market solutions dealing with PCMs do not have any acoustical insulation skills or the same thermal properties like the ones expected from StorePET, which combines thermal storage and thermal insulation in one single product. In traditional applications, PCMs uses the day solar gains through glazing to be able to store the heat without affecting the indoor comfort temperature, and then slowly release it, during the night and with the aid of ventilation, avoiding the need for extra artificial heating during this period. They do not block or buffer the heat exchange between the outside and inside like the StorePET solution proposes.

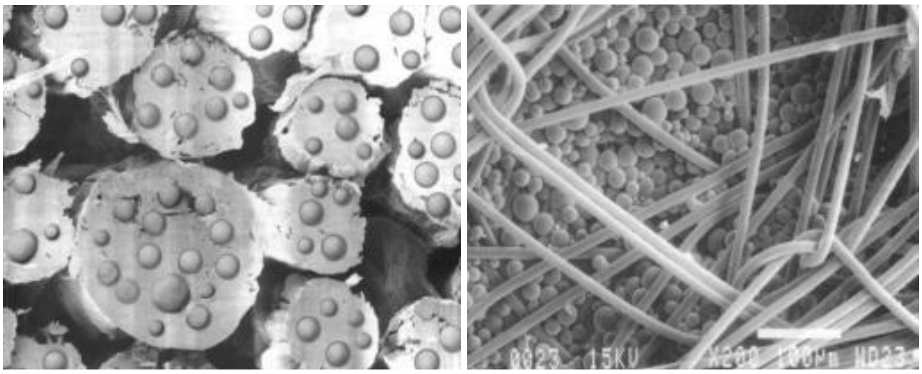
Up until now, PCMs association with fiber insulation materials has only been tested on in-situ blowing test applications, at construction sites built for academic and industrial-driven research purposes. Some US studies have proved that using loose-fill cellulose and fiberglass insulations mixed with microencapsulated paraffinic organic PCMs can be effective technique to reduce wall-generated peak-hour cooling loads on roofs and wall cavities. It was found that it was possible to reach considerable heat flow reductions values (up to 40%) and peak-hour load reductions of 30% during the summer months, depending on the construction site climate conditions.

Although indoor temperature control and energy saving abilities were confirmed by those research reports, none of the trial products tested have yet hit the market. Apart from time consuming procedures, skillful application and specific machinery needs to perform its installation, there are two major drawbacks of this on-site technique that the StorePET product and technology production will aim to overcome – The difficult and inefficient PCM-fiber mixing using a insulation blower and the tendency for the PCM content to become loose and settle on the bottom of the insulation cavity during its life-time, thus reducing its efficiency.

Alternatively, the project proposal was to produce a technical nonwoven insulation on a bulk form (blanket, batt or roll), easily to be installed on the construction site like similar standard mineral or glass wool products. Moreover, the precise layer concept and the ability to get the most out of the PCM content by insert it inside the fibers, seems to be another advantage that surely suppress what is being tested on the other side of the Atlantic. Thus its innovation beyond the state of the art is clear. Not only it will outstand the fiber insulation products presently available for having the PCM-fiber technology integration, its storage, transport, installation and usage will not limit its time-life performance.

A patent search on fiber insulation products incorporating PCM materials was also undertaken. A number of patents relating PCM integration with textile fibers were found, like the WO 0224830 (A2) regarding the using of stable PCMs in temperature regulating synthetic fibers, fabrics and textiles and the WO 9812366 (A1), concerning the PCM incorporation throughout the structure of polymer fibers, as a loose fill insulating materials for clothes or bedding articles. Directly linked with thermal control of nonwoven materials, 2003‘s patent Nº 20030551 (A), stated by Frisby Technologies Inc. [US] as applicant, have secured a method to produce fibers, where thermal control material dispersed within a binder could be blown onto a preformed fiber web, to form a bi-layered product with one layer having thermal control properties, and another one without such properties. US 2010/0264353 A1 patent assigned by Outlast Technologies INC, describes thermal regulation building materials and other constructions components containing polymeric phase change materials, which shall be taken in consideration not to collide with the StorePET manufacturing production system.

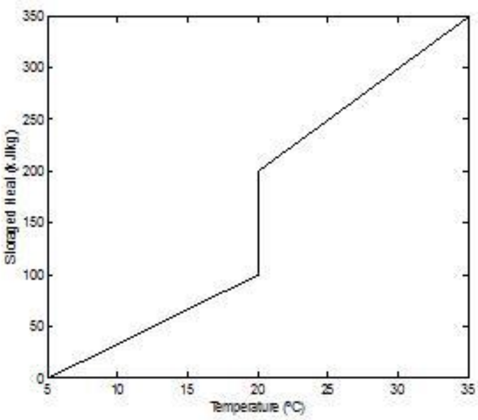
StorePET aims to offer a new solution to a large SME community by adapting already existent technologies used by the textile industry. The latest achievements dealing with the PCMs on this sector have been enormous, mainly dealing with the production of thermo-regulated fabrics (TRF). Several manufacture processes, such as impregnating hollow or non-hollow fibers with a PCM solution, wet-spinning, melt-spinning and electro-spinning are used to fabricate TRFs. Whilst the concept of using PCMs is clearly a very attractive one, there is still a number of limitations. Up to now, only a very small group of fibers are compatible with PCMs, and there is an upper limit to the amount of PCM that can be incorporated into them, before tensile properties are appreciably reduced.



PCM integration with fibers

Currently, the textile market has to offer some commercial TRF products, like the viscose fibers containing MicroPCMs manufactured by Kelheim Fibres (Germany), which provides all of the benefits of regular viscose with temperature-buffering capabilities for extreme comfort. Also, a new environmental friendly technology developed for cellulose shaping was recently accomplished by Thuringian Institute of Textile and Plastics Research (TITK). TITK introduced the Smartcell™ clima fibre - an alloy of cellulose and a phase change material made by using lyocell technology. Unlike the related viscose-based product produced by Kelheim Fibres using the Outlast™ encapsulated phase change material, the TITK process uses the PCM directly and disperses it in the dope with the aid of inorganic nanoparticles. Outlast Technologies microencapsulated PCMs (mPCMs) called “Thermocules” can then be applied as a finishing on fabrics, or infused into fibers during the manufacturing process. Presently it´s undisputable that TRF can response to ambient temperature and maintain the microclimate equilibrium and that is why worldwide researches are currently trying to explore it.

From the knowledge acquired regarding the incorporation of PCMs into fibers, it‘s clear that to produce the novel StorePET product there will be several implicit technological innovations to be undertaken and that optimization process will be needed to provide frameworks for decision-making. Thus, risk assessments mitigation procedures and contingency plans must be described by the consortium (type of PCMs and fiber integration technology amongst the most important ones).



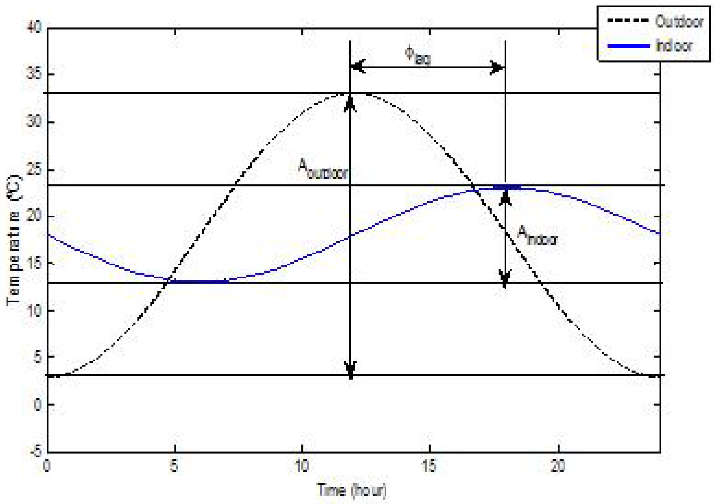
Heat storaged by a PCM with latent heat of 100 kJ/kg and transition temperature of 20 ºC

3. SIMULATION 0F PCM AND ACCOMPANIED SOFTWARE

In parallel to the development of the new PCMs products and technology it is fundamental to develop suitable thermal and acoustic simulation tools to aid in the definition of a range of fiber PCM products and system solutions to fulfil the requirements for different applications. In order to implement these tools we had first to establish the mathematical models and physical parameters that drive the heat transfer/storage and sound transmission/absorption in these materials.

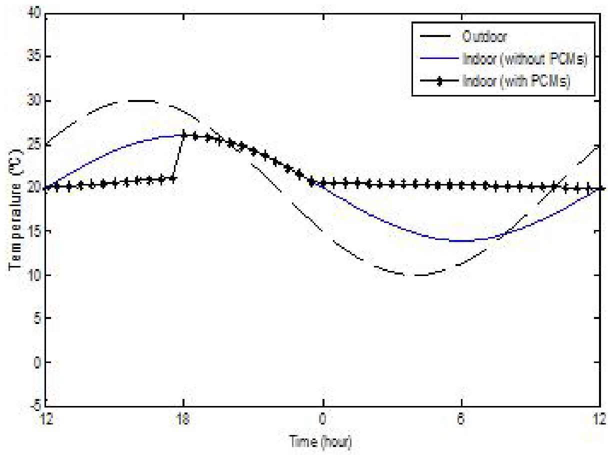
With regard to the mathematical model for the analysis of the heat transfer in layers containing PCM materials, the standard methods/algorithms for current materials/applications are based on the equivalent electric circuit with the following analogies:

Temperature – electric potential, thermal resistance – electric resistance, heat capacity – capacitance, heat flow - current. In this circumstances the thermal behaviour of a wall consisting of homogeneous layers can be characterized by the period of the outdoor thermal wave (time between temperature peaks), the thermal resistance and heat capacity of each layer.



Parameters used to characterise the effect of the thermal storage of a wall

However, the equivalent electric circuit method is not applicable to materials with PCMs because this analogy is valid only for materials with constant heat capacity (thermal mass) and thus, the effect of the fusion latent heat exchanged during the phase change cannot be taken into account by these models. Moreover, due to the non-linear behaviour of the PCMs, the standard parameters used to measure the thermal performance of the thermal mass, that is the time lag φ_{lag} (time delay between the peak temperatures in the outdoor and indoor peak temperatures) and decremental factor $f=A_{indoor}/A_{outdoor}$ which measures the ratio between outdoor and indoor temperature wave amplitudes (see figure above) , are no longer suitable and new parameters have to be defined to evaluate the enhance in the energy saving introduced by the PCMs.



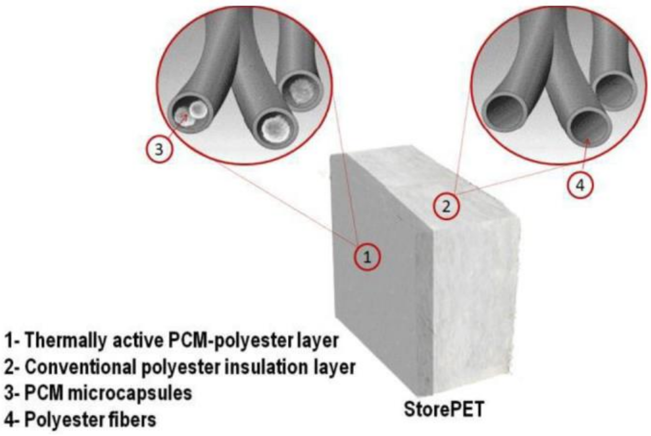
Indoor temperature profile with and without PCMs

The simulation tool will allow then to calculate the energy saving of a certain wall configuration, containing layers of the developed fiber PCMs materials, for different weather conditions represented by the corresponding outdoor thermal wave. The simulation tool should also cover situations in which the thermal mass of the PCMs is complemented with other indoor temperature control techniques such as night ventilation and/ or solar thermal storage systems. The simulation tool will allow for an optimization of the PCM layers and wall system for a wide range of applications.

On the other hand, in order to implement an acoustic tool it is necessary to fully understand first the effect on the sound transmission and absorption of the embedded PCMs in fiber materials. The mathematical equations and the physical parameters that characterize their acoustic behavior are stated and included in software module that will be employed to compute the sound reduction index of multilayer walls including PCMs. Since the sound absorption and transmission through porous materials is mainly driven by its flow resistance and matrix stiffness, it was investigated whether the PCMs change substantially these properties of the fiber matrix. The acoustic simulation tool has the following input data: number of layers, thickness of each layer, acoustic properties of each layer and computes the sound reduction of the wall.

4. CONCLUSION

The new thermally-enhanced fiber insulation is a technical nonwoven product, made mainly from polyester fibers resulting from the recycling of Polyethylene Terephthalate (PET) plastic bottles, where some of the fibers are modified/impregnated with phase change materials (PCMs), on a single or multilayer bulk design, in the form of blankets, batts or rolls that are available ready to be installed.



Based upon the excellent thermal and noise insulation properties and market acceptance for commonly glass and mineral wool materials, it was reasonable to think upon using those types of fibers to integrate the StorePET approach, instead of the polyester. However, their manufacturing process, dealing with high temperatures and other technical issues, makes it almost impossible to incorporate the PCMs within its fiber structures. Other possible option was to choose cellulose fibers as the core material for this new product. The reason to withdraw this pathway was that cellulose insulation production is still too much based on low-tech machinery and methods, making it unfeasible to re-process the shredded recycled cellulose fibers for PCM incorporation sake, and still be competitive under the same basis. Thus, polyester fiber was chosen for this approach for been currently the most promising material to be able to incorporate this novel thermal enhancement.

Thanks to the peculiarities of the polyester fiber, this type of insulation differs from other similar products, for being breathable and because it's physical and chemical features remain unvaried over time, maintaining their excellent thermal and acoustic insulation and mechanical properties. Generally able to satisfy the different needs of application and/or of technical performances by meeting the standard regulations in terms of thermal and acoustical insulation, moisture resistance and reaction to fire, furthermore not containing harmful substances for human beings, being completely recyclable, and by being manufactured with materials obtained from post consumer PET bottles recycling, it also allows consequently savings of CO_2 emissions.

Acknowledgement. *This work is supported by EU FP7 project STOREPET (FP7-SME-2011-2, Proposal 286730), with following partners (and co-authors of this paper): SGG Slovenia, Techniberia Spain, Texclubtex Italy, Dundjer Serbia, Ecoterra Spain, Rama Spain, Devan Portugal, Itav Spain, IPN Portugal, Centrocot Italy, and Acciona Spain. Part of research is supported by the Serbian Ministry of Education and Science (research projects III44006 and TR37003).*

REFERENCES

1. Tae Won Kim et al.: Impregnation of Eicosane into Polyester Fiber Using Supercritical Carbon Dioxide. Solid State Phenomena Journal, 2007, (Volumes 124 – 126), pp 1095-1098.
2. Kośny J. et al.: (2007) Thermal Performance of PCM-Enhanced Building Envelope Systems - in Thermal Performance of the Exterior Envelopes of Buildings X, Proceedings of ASHRAE THERM X, Clearwater, FL, Dec. 2007.
3. Kośny, J. : Field Testing of Cellulose Fiber Insulation Enhanced with Phase Change Material. Oak Ridge, TN, USA: Oak Ridge National Laboratory Report—ORNL/TM-2007/186, 2007.
4. Kośny, J. et al.: Development of new generation of thermally- enhanced fiber glass insulation. Oak Ridge, TN, USA: Oak Ridge National Laboratory, March 2010.
5. Kelheim Fibres GmbH. [Online] http://www.kelheim-fibres.com/home/index_de.php.
6. Advanced Phase Change Materials (PCM) Market: Global Forecast (2010-2015) Report -Marketsand Markets, June 28, 2010 - Pub ID: MKMK2717813
7. Nordic Analysis of Climate Friendly Buildings Summary Report - Nordic Innovation Centre, September 1, 2010.
8. Eurostat, Statistics in focus, 7/2010. The EU-27 Construction sector: from boom to gloom.
9. Green Outlook 2011: Green Trends Driving Growth, McGrow-Hill November 2010.
10. World Insulation Report - Freedonia Group Inc, February 1, 2009 - Pub ID: FG2703472
11. Frost&Sullivan: Strategic Developments in Construction Materials Industry- Technical Insights, Materials and Coatings, June 2010.

PRIMENA NOVOG TERMIČKI USAVRŠENOG IZOLACIONOG MATERIJALA (PCM) – STOREPET

Lake gradjevinske konstrukcije predstavljaju ekonomičnu alternative tradicionalnoj gradnji, kod koje je glavni nedostatak velika potreba energije za održavanje unutrašnjih konfornih termičkih uslova, pošto nisu u stanju da uspore brze promene spoljašnje temperature. U poredjenju sa masivnijom gradnjom, procenjuje se da je za održanje termički ugodne temperature u opsegu od 18-24°C, lakim konstrukcijama potrebno izmedju 2 i 3 puta više energije za grejanje i hladjenje.

Koncept ovog istrađivanja je baziran na činjenici da se unutrašnja/spoljašnja razmena temperature (koja igra značajnu ulogu u potrošnji energije kod lakih konstrukcija) može potencijalno kontrolisati pomoću novog vlaknastog izolacionog materijala koji sadrži aktivni termički kapacitet: tokom dana, kada temperature raste, vršno opterećenje može biti u znatnoj meri absorbovano pomoću PCM (Phase Change Material) – unapredjeni vlaknasti izolacioni sloj, da bi se ponovo oslobodilo u okolinu (tokom noći, kada spoljašnja temeratura opadne), bez uticaja na unutrašnji energetski balans, uz pomoć standardne termoizolacije. Ovo rešenje omogućava mnogo sporiji odziv omotača zgrade na dnevne promene temperature, omogućavajući održavanje unutrašnje temperature u konfornom opsegu i takoizbegavajući potrebu za dodatnom potrošnjom energije da bi se to postiglo. Efektivni nivoi unutrašnjeg konfora je takodje postignut pomoću osobine vlaknastih materijala kao odličnih zvučnih izolatora kao i za sprečavanje i kontrolu zvučne resonance u unutrašnjim prostorima.

Istraživanje i razvoj takvog izolacionog materijala je obavljeno u okviru evropskog FP7 projekta STOREPET (FP7-SME-2011-2, Proposal 286730). Učesnik na projektu iz Jugoistočne Evrope je Gradjevinski Klaster „Dundjer" iz Niša. Istraživanja i primene rezultata su okvirno dati u ovom radu.

Ključne reči: *građevinski materijali, termička izolacija, akustička izolacija, lake građevinske konstrukcije, energetska efikasnost, održiva gradnja.*