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MF-RETROFIT

Multifunctional facades of reduced thickness for fast and cost-effective retrofitting

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MF-Retrofit aims to address the numerous requirements of external façade panel retrofitting by developing a multifunctional, lightweight, durable, cost effective and high performance panel. Its layered structure enables the separate but also synergistic function providing thermal & acoustic insulation, excellent physical properties, resistance to fire and self cleaning properties, supported by a fast, easy and economic installation.

Objectives

- To optimize the incorporation of nanomaterials into building envelope components (PCMs, polymers, fire protection systems and self cleaning coatings).
- To orientate building envelope materials towards exploitation of industrial byproducts (fly ash and rice husk ash) as well as renewable sources (biopolyols).
- To integrate multiple technologies into a single multifunctional façade panel system.

Impact

- Massive reduction in CO_2 emissions during production and operation of façade panels.
- The significant reduction of overall panel thickness and weight.
- To make retrofitting considerably easier, faster and more accessible.

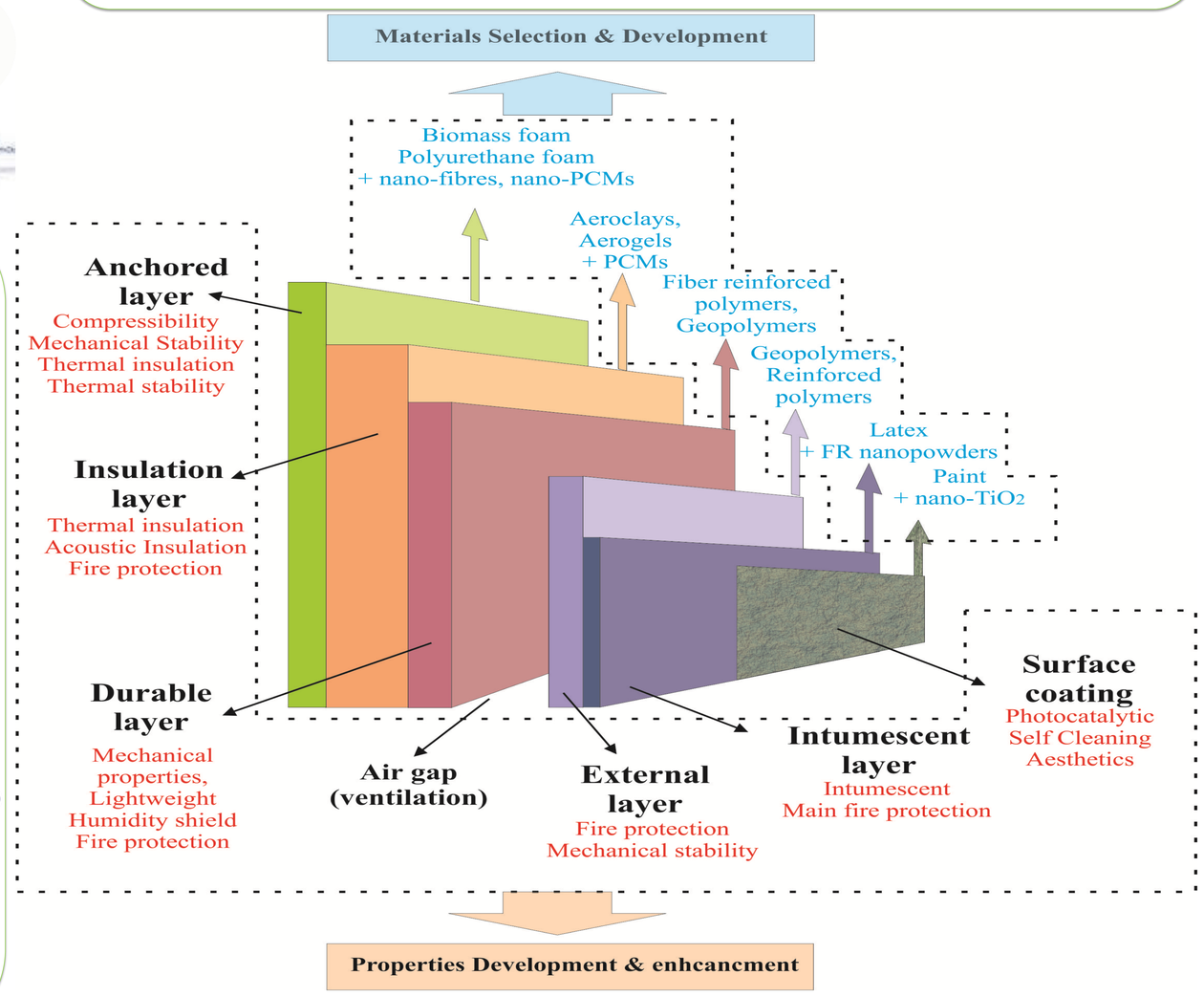


Figure 1: Concept of the MF-Retrofit project

Anchoring Layer

Development of polyurethane is accomplished using diacids and polyalcohols from renewable sources: terephthalic acid (glucose, biomass), adipic acid (sugar and red beets) and succinic acid (rhubarb, tomato). Ethanol, 1,3-propandiol and glycerin will be received from glucose and fatty acids. The integration of PCMs is also being conducted.

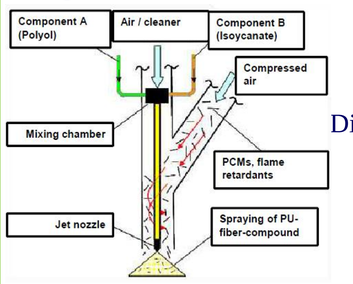


Figure 2: Process employed for the integration of PCMs and flame retardants in polyurethane.

POLYOL + (Methylene Diphenyl iisocyanate) **MDI**

Additives ⇩

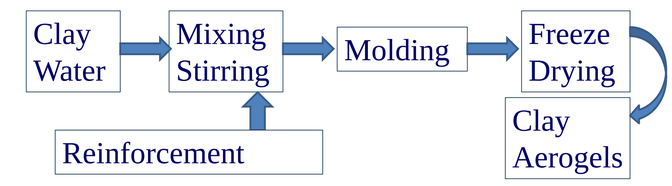
PU FOAM

Main Insulation Layer

Clay Aerogel: Na-MMT as clay source, reinforced with PVA, cellulose fibers and casein.

Silica Aerogel: Rice husk ash as raw material, with TEOS, TMCS as sililating agents and reinforced with sepiolite, and porcine gelatin.

PCMs are being mechanically incorporated.



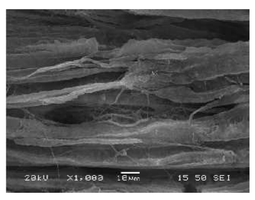
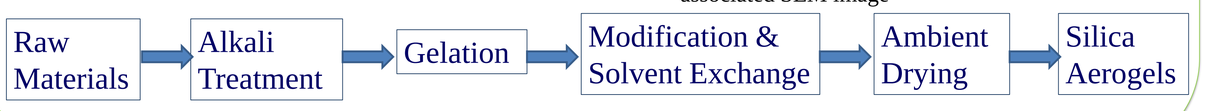


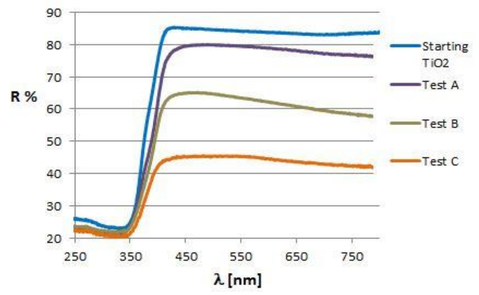
Figure 3&4: Clay Aerogel produced sample and associated SEM image



Intumescent Layer & Surface Coating

Development of intumescent layer Intumescent coating using new materials technology to enhance thermal conductivity and fire resistance.

Development of the surface coating: A clear coating containing photocatalytic agents, compatible with most color formulations.



Development of photocatalytic agents: doping of TiO2 nanostructured powder with metallic and non-metallic elements, modulating the material absorption. Commercial photocatalytic TiO2 powders used as reference.

External Layer

Fiber Reinforced Polymers: fabricated with the hand lay-up process, reinforced by glass and carbon fibers, as well as inorganic nanoparticles dispersions, mainly for fire resistance enhancement.

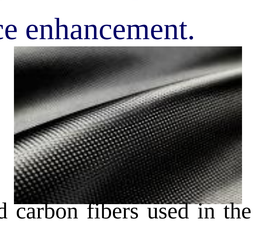
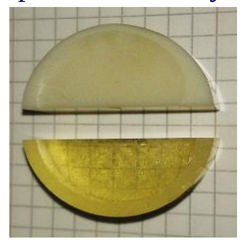
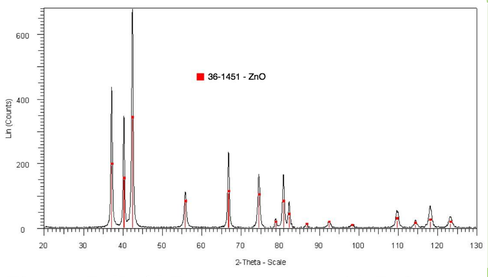


Figure 6: Glass and carbon fibers used in the reinforcement of FRPs

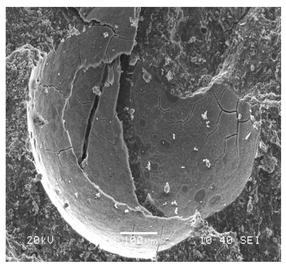




Figures 7: [Left] Epoxy precursor with ZnO (top) and raw (bottom) with crystal size of 27nm and associated XRD spectrum [Above]

Durable Layer

Geopolymers developed using fly ash as raw material, reinforced with fibers and/or grid. The reaction is activated through NaOH/KOH and H2O2-silica fume are used as pore forming agents. Silica fume is dispersed in fly ash by High Energy Ball Milling.



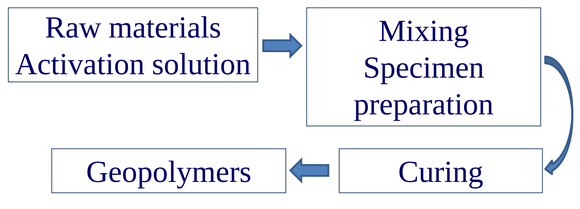
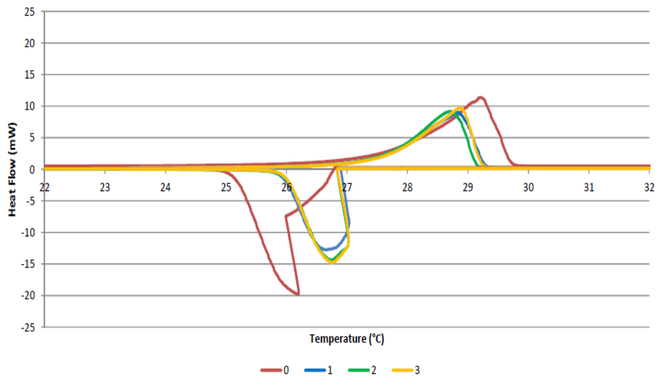


Figure 5: Fly ash during the geopolymerization reaction [Left] and effect of pore forming agents (silica fume) [Above].

Phase Change Materials

Commercial **PCMs** were reinforced with CNTs and graphene oxide.

The incorporation of PCMs is investigated in the anchoring and main insulation layers through the development of associated models.



The effect of the resulting nano – modified PCMs is investigated by structural and thermal characterization. PCM thermal conductivity increases with % loading of CNTs.

Figure 8: DSC analysis of nano-modified PCMs [Left].

LCA and modelling

The specifications and experiments will be aligned with simulation and modelling tools to maximize efficiency.

Development of thermal models: Heat-air-moisture, CFD/Fluent, Thermal & Mechanical, Theoretical calculation of U-value.

LCA/LCCA analysis performed regarding materials and processes employed

Numerical models are being developed to define and optimize PCM positioning in the panel, as well as modifying the thickness of individual panel components depending on thermo physical properties.