International Renewable Energy Storage Conference IRES

IRES 2017 Poster Exhibition
11th International Renewable Energy Storage Conference

THERMAL MASS IMPROVEMENT OF LIGHTWEIGHT CONCRETE WITH MODIFIED AGGREGATES

ARACELI GÁLVEZ*, JAIME JOSÉ CUBILLO* , SISKA L.A. VALCKE†
*Acciona Construcción S.A. Dirección de Innovación Tecnológica. (SPAIN). † TNO (The Netherlands)
Contact araceli.galvez.moreno@acciona.com, www.acciona.com

INTRODUCTION

More than 50% of the energy used in buildings is for space heating an cooling due to, mainly, the use of thin and lightweight construction elements and the decrease of the thermal resistivity and the thermal mass. A way to increase the thermal mass of these structures is using PCM but the leaks problem when it is liquid makes necessary its encapsulation .

Lightweight concrete is used frequently in precast building pieces but the decrease in the thermal properties compared with traditional concrete is the main handicap of this kind of concrete. The aim of this research is to obtain a concrete that has the necessary structural properties for a prefab façade element and is lightweight, whilst keeping the same thermal properties (thermal conductivity and buffering capacity) compared to a traditional concrete (2300 – 2500 kg/m³). The use of PCM encapsulated in the pores of the lightweight aggregates is tested here for reaching this objective.

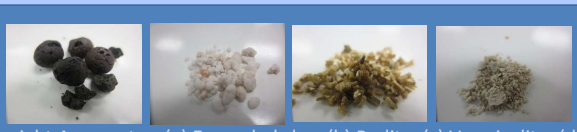
METHODS: Materials and experimental set-ups

AGGREGATES RESEARCH

- Lightweight aggregates
- PCM (organic)

} Vacuum Impregnation process [1]

- TGA & DSC analysis (impregnation capacity analysis



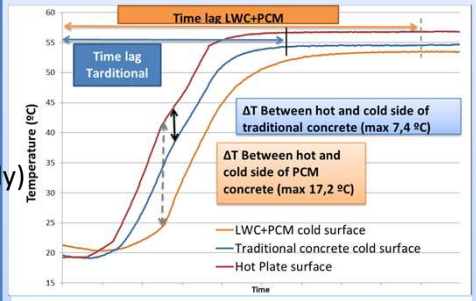
Lightweight Aggregates: (a) Expanded clay; (b) Perlite; (c) Vermiculite; (d) Sepiolite

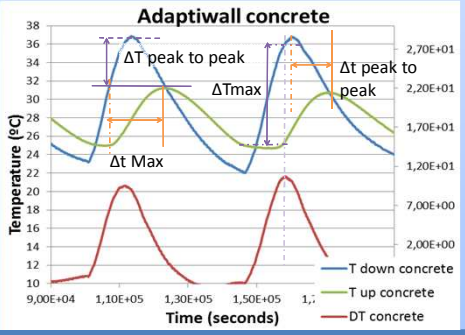
CONCRETE RESEARCH

- Cement, sand and additives for concrete production
- Hot box for thermal behaviour study (hot plate)
- Step test (thermal energy storage capacity analysis)
- Cyclic thermal test (cold and hot side of sample study)

Laboratory assembly

CONCRETE THERMAL BEHAVIOUR





	Traditional Concrete	LWC+PCM
TES (kWh/(Km³) *	0,94	3,42
ΔT peak to peak (ºC)	3,5	5,9
ΔT max (ºC)	7,1	10,3
Δt HF (min)	118,4	190,3
Δt peak to peak (min	111,6	170,3
Δt max: Heating Delay (min)	191,6	277,5
Decrement factor	0,69	0,43

45% more time to achieve the maximum temperature with PCM

45% higher difference between the temperature of both PCM concrete sides

Outcome of the aggregates & concrete research

OPTIMIZATION OF THE LIGHTWEIGHT CONCRETE RECIPE:

- Higher quantity of PCM → 0,18 kg PCM/L concrete
- Higher mechanical strength → C20/25
- Lower density → ≈ 1600 kg/m³
- Good thermal conductivity → quartzite sand + additives
- Good workability → nanosilica additive → S4

LIGHTWEIGHT AGGREGATE SELECTION in order of performance

	Impregnation capacity
Expanded clay (3-8)	454 kg PCM/m³
Perlite	358 kg PCM/m³
Vermiculite	261,3 kg PCM/m³
Pumice	158,2 kg PCM/m³

DEMONSTRATION STAGE

SCALE DEMONSTRATION

- ✓4 concrete buffers with different composition 80x80x16 cm (Acciona, Spain)
- ✓The structural and buffering part of the whole retrofitting panel designed in the project.
- ✓Thermal behaviour monitored

REAL SCALE DEMONSTRATION

- ✓PassysCells (CEA, France)
- ✓Multifunctional façade of 10 m²
- ✓Concrete surface 3 m²
- ✓Internal multisensor system
- ✓Thermal behaviour monitored

CONCLUSIONS

Expanded clay is the selected aggregate due to its structural properties and impregnation capacity (and stability) .

A concrete mix with 0,18 kg PCM/L achieves 3 times higher thermal storage capacity than traditional concrete that has 30% higher density.

[1] Dong Zhang et al. Cement and Concrete Research 34 (2004) 927–934

Coordination Project Team:
www.ADAPTIWALL.eu NMP4-SL-2013-608808
This project is funded by the 7th Framework Programme of the EC