Waste 2 Resources: Valorization of the waste generated in building retrofitting works. Eco-friendly gypsum materials

Del Río Merino. M.; Villoria Sáez. P.; Santos Jiménez. R.; San Antonio González. A.; González Cortina. M.; Santa Cruz Astorqui. J.; Rodríguez Sánchez. A.; Viñas Arrebola. C.

Universidad Politécnica de Madrid. Escuela Técnica Superior de Edificación. Grupo de investigación TEMA
Avda. Juan de Herrera. 6 28040 Madrid. Spain.
tema.edificacion@upm.es

1. INTRODUCTION

A new paradigm within the building sector is currently rising in Spain. changing from new construction activities to building rehabilitation works. This change is motivated by recent legislative requirements such as the Spanish Energy Efficiency Certification Royal Decree. which will lead to a considerable increase of building rehabilitation works. The expected increase of building retrofitting works will generate vast amounts of construction and demolition waste (CDW). which will need to be correctly managed by promoting ways for reuse or recycling in order to meet the requirements set by the European Community for 2020. Also, many initiatives and research have been found focusing on the development of new building materials and products that are less expensive, more durable, with higher quality and more environmentally friendly. In this sense, the following studies can be highlighted:

- Gutierrez-Gonzalez et al. designed a lightweight plaster material with enhanced thermal properties made with polyurethane foam wastes [1];
- Parres et al. analysed the use of fibre and microfiber obtained from shredded tires to reinforce gypsum composites [2];
- Ge et al. investigated the influence of aggregate gradation, sand-to-PET ratio and curing conditions on physical and mechanical properties of recycled PET mortar [3];
- Abdulkadir and Ramazan analysed the effects of using recycled waste expanded polystyrene foam, as a potential aggregate in lightweight concrete [4].

2. AIM

The aim of this research is to analyze the feasibility of using CDW —from building retrofitting works— as raw materials for gypsum materials manufacture. To this end. several tests (density. mechanical strength. etc.) were performed to gypsum samples containing different building retrofitting waste categories (insulation. paper. plastic. ceramic tiles. etc.).

3. MATERIALS & METHODS

Table 1 shows the different CDW materials analyzed in this study and their percentage of addition and format.
To analyze the feasibility of using these CDW as raw materials for gypsum materials manufacture the different gypsum composites containing these CDW were analyzed by elaborating prismatic specimens (160x40x40) mm^3. These composites were tested by their density in dry state. their flexural and compressive strength after 7 days and their Shore C surface hardness as specified in the European Standards EN 13279-2 [5] and UNE 102039 [6]. All results were compared with the results obtained with a reference sample made with no additives. to evaluate the advantages and disadvantages of incorporating the different CDW aggregates.

WASTE	% CDW	WASTE FORMAT
Perforated ceramic brick	25.0%	ø 1.00 - 2.00 mm
Perforated ceramic brick	25.0%	ø 1.00 - 0.50 - 0.25 - <0.25mm
Double hollow brick	25.0%	ø 1.00 - 2.00 mm
Double hollow brick	25.0%	ø 1.00 - 0.50 - 0.25 - <0.25mm
Ceramic tile	25.0%	ø 1.00 - 2.00 mm
Ceramic tile	25.0%	ø 1.00 - 0.50 - 0.25 - <0.25mm
Flexible polyethylene	0.1%	Fibers around 1.5mm
Flexible polyethylene	0.1%	Fibers around 0.5 - 1mm
Flexible polyethylene	0.1%	Dust
Expanded polystyrene	1.0%	ø 1.00 - 4.00 mm
Glass wool	4.0%	ø 0.05 mm y longitud 10 - 30 mm
Formwork panel	2.0%	ø <0.50 mm
Formwork panel	1.0%	ø >0.50 mm
Wet sheet paper	0.5%	Fibers around 0.5x5 cm
Sheet paper	0.5%	Fibers around 0.5x5 cm
Sheet paper	0.8%	Fibers around 0.4x5 cm
Newspaper	1.0%	Dust
Newspaper	1.0%	Fibers around 20x2 mm
Newspaper	1.0%	Fibers around 20x6 mm
Wet newspaper	0.5%	Fibers around 0.5x5 cm
Wet newspaper	0.5%	Fibers around 0.5x5 cm
Gypsum kraft papers sack	0.5%	Fibers around 0.5x5 cm
Gypsum kraft papers sack	0.5%	Fibers around 0.5x2.5 cm
Gypsum kraft papers sack	0.8%	Pieces around 1 x 1 cm
Plasterboard	5.0%	ø 0.32 mm
Plasterboard	5.0%	ø 1.25 mm
Plastic (fibers)	2.0%	Length >3.5 mm
Polypropylene	0.05%	Length 1 - 1.5 cm
Polypropylene	0.05%	Length 2 - 3.5 cm
Polypropylene	0.05%	Dust
PVC	3.0%	ø 8 - 15 mm
PVC	3.0%	ø 10 - 30 mm
PVC	3.0%	Dust
Cellular glass	30.0%	Irregular pieces
Extruded polystyrene	2.0%	ø 1 - 4 mm
Extruded polystyrene	2.0%	Fibers around 6 mm long
Extruded polystyrene	2.0%	Fibers around 12 mm long
Extruded polystyrene	1.0%	Dust

Table 1. Main characteristics of the analyzed samples

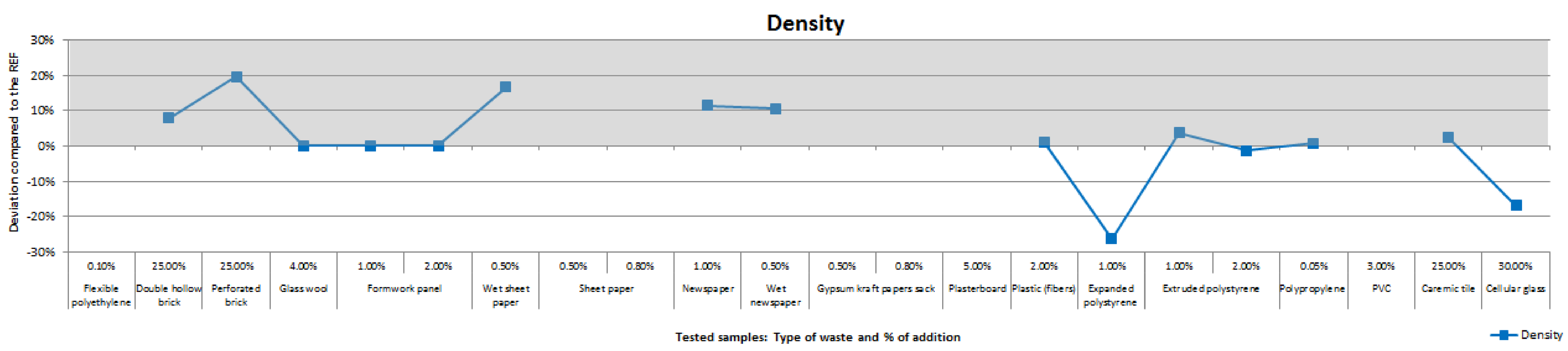
4. RESULTS

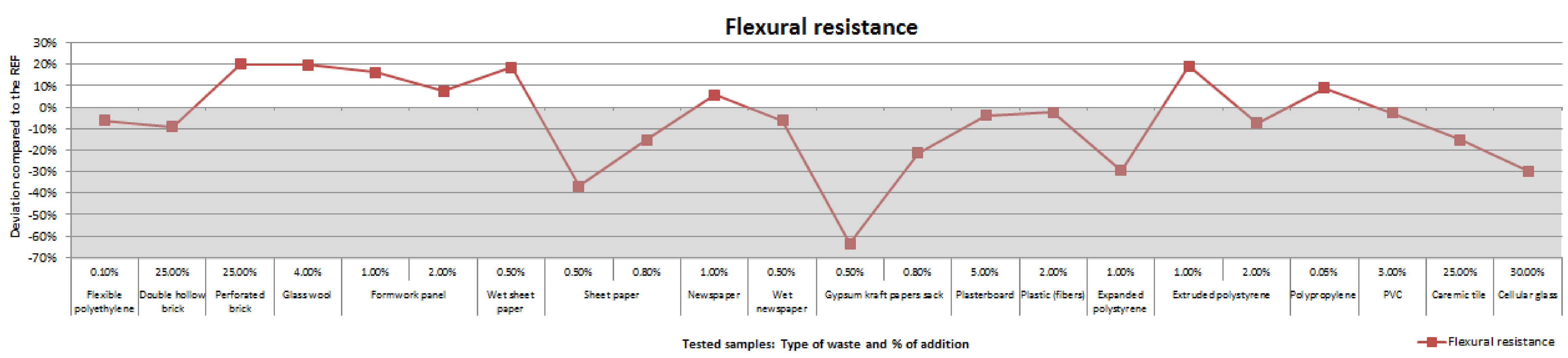
Results have been summarized in the following graphics for density. flexural strength. compressive strength and Shore C Surface Hardness.

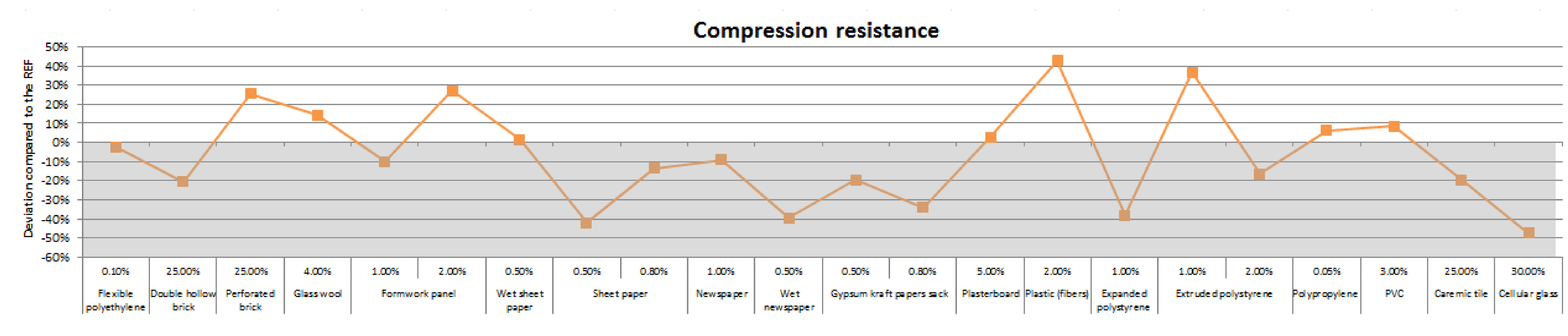
These figures show that density can be increased by adding ceramic waste and paper. while the incorporation of expanded polystyrene and cellular glass helps decreasing density up to almost 30% over the reference value.

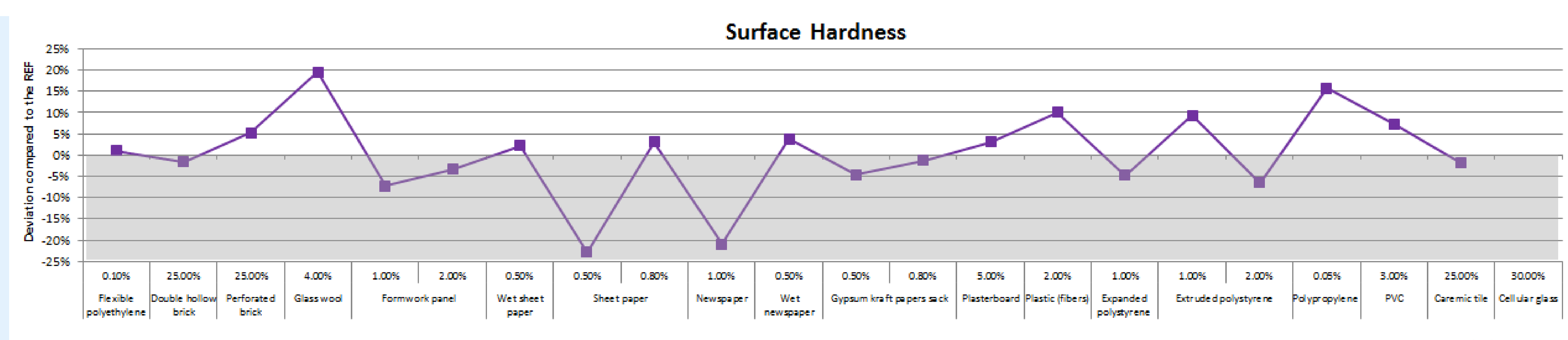
Flexural and compressive strength have a similar behaviour. Both strengths values increase when ceramic waste --from perforated bricks-- or glass wool are added. and decrease considerably with the addition of paper and expanded polystyrene.

Shore C Surface Hardness only increases significantly with the addition of glass wool. plastic fibres and polypropylene.









5. CONCLUSIONS

After analyzing all test results. it is seen that manufacturing gypsum composites with CDW has obtained positive results. In this sense. the use of ceramic waste from perforated bricks in gypsum composites improves the general properties of the gypsum material. In addition. mineral wool. plastic fibers and polypropylene can be used to reinforce gypsum and the use of expanded polystyrene helps reducing density. On the other hand. waste paper has been studied in different formats. but no significant results were obtained.

Acknowledgements: This research was supported by the Spanish State Secretariat for Research. Development and Innovation of the Ministry of Economy and Competitiveness under "Waste 2 Resources Project"(BIA2013-43061-R).

References:

[1] Gutierrez-Gonzalez, S. et al. (2012) Lightweight plaster materials with enhanced thermal properties made with polyurethane foam wastes. Constr Build Mater 28. pp. 653–658.
[2] Parres, F; Crespo-Amoros, J; Nadal-Gisbert, A. (2009) Mechanical properties analysis of plaster reinforced with fiber and microfiber obtained from shredded tires. Constr Build Mater 23. 10. pp. 3182–3188.
[3] Ge, Z; Sun, R; Zhang, K., 2013. Physical and mechanical properties of mortar using waste Polyethylene Terephthalate bottles. Constr Build Mater, Volume 44, p. 81–86.
[4] Abdulkadir, K. Ramazan, D. (2009) A novel material for lightweight concrete production. Cement Concrete Comp, Volume 31. pp. 489–495.
[5] AENOR (2014) UNE-EN 13279-2:2014 Gypsum binders and gypsum plasters. Part 2: Test methods. Madrid: AENOR.
[6] AENOR (2014) UNE 102042:2014 Gypsum plasters. Other test methods. Madrid: AENOR.