International Conference on GREEN CONSTRUCTION
Córdoba (Spain), April 8-9, 2019

Using graphene oxide as means of improvement of concrete: a brief review

Luís Evangelista [1]
Pedro Raposeiro da Silva [2]
CERIS-ICIST, Instituto Superior de Engenharia de Lisboa, ISEL-IPL, Lisbon, Portugal
[1] evangelista@dec.isel.pt;
[2] silvapm@dec.isel.pt

Keywords: *Portland cement, concrete, graphene oxide, Mechanical property*

1. Introduction

The use of nanomaterials (NM) to improve the performance of cement and concrete matrixes nowadays appears as a potential alternative to the exclusive use of Portland cement (PC). Similarly, there is currently no doubt in the construction industry (CI) about the pressing need to reduce consumption of PC. The CI represents the world's third-largest industrial energy consumer, and the component related to the production of PC alone represents 7% of the carbon dioxide (CO_2) emissions globally (OECD, 2018). PC is undoubtedly the most used material in construction in terms of its relative volume. Raw materials for PC production are generally plentiful and are available throughout the world. It is possible to state that there is, at this moment, no other material, with the same availability as the PC, that is able to fulfil the construction's technical requirements as the concrete's main component. In this sense, it is imperative that the cement industry obtains viable technical solutions that allow the reduction of PC consumption. That reduction can be achieved either by its direct replacement with another material (as for example with the use of fly ash), or by improving the cement and concrete matrix performance with the addition of new materials such as NM. This second option is quite interesting since it allows, for example, to maintain the cement and concrete matrix properties/characteristics, reducing PC consumption by adding a tiny amount of a NM.

2. Nanomaterials

The NM evolution has allowed the production of new cement-based nanocomposites with previously unimaginable properties. In general, NM can be grouped into three main types: the zero-dimensional (0D) nanoparticles, such as nanosilica; the one-dimensional (1D) nanofibres, such as carbon nanotubes and lastly the most recent two-dimensional (2D) nanosheet, ie, graphene oxide (GO) (Chuah *et al*., 2014). These materials, especially the 1D and 2D NM, have the ability to, in very small dosages, strengthen the cement and concrete matrix through the reinforcement and pore refinement. This allows for conventional cement composites to achieve higher performance levels or to maintain the same performance levels with decreasing PC consumption (Yang *et al*., 2017).

3. Graphene oxide

In the particular case of GO, we are in the presence of one of the most recent advances in materials science, with enormous potential to be used as nano-sized additive for cementitious materials (Tong *et al*., 2016). The GO shows a number of unusual properties, namely: super-high specific surface area, ultra-high strength and elastic modulus (Wang *et al*., 2017); excellent thermal, electrical and optical conductivity (Wang *et al*., 2017); easily forms composites with

polymer and ceramic materials and contains a large concentration of hydroxyl, epoxide, carboxyl and carbonyl functional groups that are compatible with water and, for this reason, is highly dispersible in polar liquids (Saafi *et al*., 2015). Its introduction in the production of cement and concrete implies a substantial improvement in the performance of these cementitious nanocomposites. There are reports that the 3 and 7 days compressive strengths of cementitious nanocomposites with 0.2 % of GO were increased by ≈36% and ≈42%, respectively when compared to the control mix (Yang *et al*., 2017). Analogously, Tong *et al*. (2016) states, in his research, that the microstructure morphology observed shows that GO can significantly reshape the microstructure of the cement paste. However, mainly associated to its high specific surface area, the GO can cause a significant loss of the workability of the cement and concrete matrixes due essentially to the increase of its viscosity (Wang *et al*., 2017).

4. Closing remarks

The need for cement mixes with increasingly higher performances and on the other hand the need to reduce the impact of the CI, through cutting of PC consumption, require industry and researchers to look for new solutions and new materials. The use of GO in the development of a new cemetitious matrix can lead to a significant improvement in the performance of the mortars and concretes used in the CI.

5. Acknowledgment

The authors acknowledge the support of the *Instituto Politécnico de Lisboa* (ISEL - IPL) through the funding of the scientific research project “Performance evaluation of self-compacting mortars with nanomaterials” (IPL/2018/ Nanomortar /ISEL)”.

6. References

OECD / Organisation for Economic Co-operation and Development (2018), *Technology Roadmap - Low-Carbon Transition in the Cement Industry*, International Energy Agency (IEA) and the World Business Council on Sustainable Development (WBCSD), France, 66 p.

Chuah S., Pan Z., Sanjayan J. G., Wang C.M., Duan W.H. (2014), *Nano reinforced cement and concrete composites and new perspective from graphene oxide*, Construction and Building Materials, Vol: 73, pp: 113-124.

Yang H., Monasterio M., Cui H., Han N. (2017), *Experimental study of the effects of graphene oxide on microstructure and properties of cement paste composite*, Composites Part A: Applied Science and Manufacturing, Vol: 102, pp: 263-272.

Tong T., Fan Z., Liu Q., Wang S., Tan S., Yu Q. (2016), *Investigation of the effects of graphene and graphene oxide nanoplatelets on the micro- and macro-properties of cementitious materials*, Construction and Building Materials, , Vol: 106, pp: 102-114.

Wang Q., Cui X., Wang J.; Li S. Lv C., Dong Y. (2017), *Effect of fly ash on rheological properties of graphene oxide cement paste*, Construction and Building Materials, Vol: 138, pp: 35-44.

Mohamed Saafi M., Tang L., Fung J., Rahman M., Liggat J. (2015), *Enhanced properties of graphene/fly ash geopolymeric composite cement*, Cement and Concrete Research, Vol: 67, pp: 292-299.