Construction and Building Materials 63 (2014) 97–107

Contents lists available at ScienceDirect

Construction and Building Materials

journal homepage: www.elsevier.com/locate/conbuildmat

Review

Fired clay bricks manufactured by adding wastes as sustainable construction material – A review

P. Muñoz Velasco [a,*], M.P. Morales Ortíz [a,b], M.A. Mendívil Giró [b], L. Muñoz Velasco [b]

[a] Autonomous University of Chile, Chile
[b] University of La Rioja, Spain

HIGHLIGHTS

- This paper consists of a review of different research, concerning bricks partially made from various waste materials.
- Clay composition was well characterized for prior researches and several types of additive have been reported on.
- Procedures for making samples have been described and compared between research and procedures followed in factories.
- Standards followed to test samples have been considered and related to those assays.
- Water absorption, compressive strength and bulk density results have been included and discussed.

ARTICLE INFO

Article history:
Received 9 January 2014
Received in revised form 27 March 2014
Accepted 27 March 2014

Keywords:
Fired clay bricks
Additives
Recycling wastes
Waste-bricks properties
Sustainable construction materials

ABSTRACT

This paper provides a review of research concerning the recycling of different types of wastes into eco-friendly fired clay bricks (FCB's). Materials and methods of researches are discussed. Several properties of bricks, made by incorporating additives are reviewed as well as procedures in accordance with international standards are highlighted. Most common results, grouped by type of additive, are shown and discussed. In conclusion, the reuse of waste in brick production might be an environmental friendly way to manage them. In some cases it even implies an enhancement of the bricks properties as well as an advantage for brick producers.

Contents

1. Introduction

Manufacturing activities produce different amounts of substances which are not wanted for the main purpose of such process. Industry, agriculture and also cities where we live, produce large amounts of these substances. The target for engineers must be developing new ways to recover waste into new products by the so called 3R system, reuse, reduce and recycling [1].

Large mass flow and high temperatures are required in order to be viable for this type of waste management. Therefore, the research has been focused on the ceramic sector. This sector meets

* Corresponding author. Tel.: +56 712345692.
E-mail address: pmunozv@uautonoma.cl (P. Muñoz Velasco).

http://dx.doi.org/10.1016/j.conbuildmat.2014.03.045
0950-0618/

both needs. Therefore this paper is only focused on fired clay bricks and does not pay attention to others types of waste bricks such as concrete or unfired blocks.

Reducing waste is not the only reason to investigate the addition of certain residues into a clay matrix, although traditionally it has been the main purpose of research on this topic. Other reasons may be considered. Wastes may save energy in the manufacturing process by increasing local temperature, in some stages of the firing process in a tunnel kiln. Their higher heating values (HHV) are added by self-combustion within the clay matrix so less energy is needed to fire the bricks. Their addition may also reduce water requirements by improving the plasticity of the blend and depending on the waste nature, some properties of FCB's may be improved.

Therefore there are more reasons for using additives in the ceramic sector than just recycling. Various researches have been conducted focusing on the enhancement of FCB's. Some authors studied the effects on manufacturing processes and in other cases research just took into account how much waste was possible to add while remaining within minimum standard requirements.

It is well known, clay deposits are formed over several centuries and indeed they contain a mixture of several minerals with different grain sizes. Due to this fact, it is necessary to note that the clay composition must be factored into the analysis of the results [2–4]. Additionally, clay undergoes several processes which have a great influence on its final properties as ceramic block [5–8], consequently production methodology must be documented in detail. Research must conclusively describe and characterize both raw materials and procedures (preparation of raw materials, shaping bricks, drying and firing).

2. Previous reviews

Several researches have been carried out since the 90s summarizing the use of different types of wastes as additives for clay. Special attention must be paid to three of them.

Dondi et al. [9,10] reported on the effects of several additives. For each additive, the HHV was compared along with the chemical composition, shaping techniques and firing temperatures. In the paper is also highlighted the effects on water absorption (WA), linear firing shrinkage (LS), bending strength (BS) and compressive strength (CS).

Raut et al. [11] studied both fired and unfired clay bricks made by adding wastes. The paper incorporates information about sample size, shaping methods drying and firing processes and it mentions all the tests carried out, for each additive. However, it only shows results for WA and CS without including the percentage of additive mixed or how the samples were made.

Table 1
Referenced reviews, type of additive, location and date of research.

Ref.	Additive and percentage added into clay matrix	Location	Date
[13]	Rice husk ash (0–50%)	Thailand	2008
[14]	Wastewater treatment plant (0–15%)	Spain	2011
[15]	Recycled paper processing residues (0–30%)	Turkey	2009
[16]	Kraft pulp production residues (0–10%)	Turkey	2004
[17]	Processed waste tea (0–5%)	Turkey	2005
[18]	Sawdust (0–10%), spent earth from oil filtration (0–50%), compost (0–30%), marble residues (0–20%)	Spain	2012
[19]	Recycled glass (15–45%)	Thailand	2009
[20]	Recycling PC (0–5%) and TV (0–5%) waste glass	Italy	2009
[21]	Cigarette butts (0–10%)	Australia	2010
[22]	Sawdust (3–9%)	Algeria	2012
[23]	Rice starch (10–50%), corn (10–50%), potato starch (10–50%)	Czech Rep.	2008
[24]	Arsenic-iron sludge wastes (3–12%)	Bangladesh	2013
[25]	Wine pomace (0–15%), paper pulp (0–30%), sawdust (0–15%), coke (0–20%)	Spain	1993
[26]	Waste marble powder (0–80%)	Turkey	2011
[27]	Sludge from wastewater (0–40%)	Taiwan	2003
[28]	Treated river sediments (0–20%)	France	2013
[29]	Waste bricks (0–30%)	Turkey	2003
[30]	Steel dust pollutants (20%)	Argentina	1996
[31]	Textile laundry sludge (0–20%)	Brazil	2011
[32]	Tobacco (0–10%), sawdust (0–10%), grass (0–10%)	Turkey	2007
[33]	Biomass gasification fly ash (15–20%)	Spain	2011
[34]	Water treatment sludge (0–20%), rice husk (5%)	Taiwan	2009
[35]	Olive pomace (0–25%)	Spain	2012
[36]	Petroleum waste (0–20%)	Brazil	2006
[37]	Ash from biomass (0–50%)	Spain	2012
[38]	Sludge from urban and industry waste water (0–15%), bagasse (5%), coffee ground (3%), olive mill waste (7%)	Spain	2011
[39]	Recycled paper process residue (0–30%)	Turkey	2010
[40]	Boron waste (5–15%)	Turkey	2005
[41]	Foundry by-products (0–50%)	Spain	2012
[42]	Biodiesel production residues, glycerine (0–20%)	Spain	2011
[43]	Oily wastes (0–5%)	Brazil	2007
[44]	Steel dust pollutants (0–90%)	Brazil	2011
[45]	Olive mill wastewater (0–19,5%)	Tunisia	2008
[46]	Polluted river sediments (0–45%)	France	2008
[47]	Orimulsion fly ash (0–6%)	Italy	2002
[48]	Fly ash (50–80%)	China	2005
[49]	Quarry residues and waste steel slag (0–40%)	Egypt	2008
[50]	Granite sawing wastes (0–60%)	Brazil	2005
[51]	Hematite tailings (77–100%)	China	2011
[52]	Fly ash and acidic process waste water (0–40%)	Turkey	2010
[53]	Sawdust (0–5%), grape seeds (8%), cherries seeds (5%), sugarcane ash (5%)	Italy	2013
[54]	Waste ferrochromium slag and zeolite (0–30%)	Turkey	2013
[55]	Textile effluent treatment plant sludge (0–30%)	India	2006
[56]	Sugarcane bagasse ash (0–20%)	Brazil	2012