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Wall Building

Bibliography

Building Advisory Service and Information Network

Bibliography on using waste in fired-clay brickmaking

Introduction

The purpose of this bibliography is to present the state of the art on research and practice in the use of waste material in fired clay brickmaking. A waste material is one which originates from an industrial or agricultural process and for which there is no other established economic use. Sometimes the need to dispose of a waste material results in additional costs, and sometimes storage or disposal of a waste material may be harmful to people's health or the environment.

Considerable research has been undertaken on making more use of waste materials in brickmaking because :

With wastes having a degree of combustibility, this offers the opportunity of saving on higher grade fossil fuels;

The high temperatures associated with brick firing can render some toxic wastes less harmful;

The addition of certain wastes can improve the characteristics of the fired brick;

Clay resources can be extended through mixing waste with the clay;

Brickmaking is a high volume industry and so offers the potential for utilisation of significant quantities of wastes.

Although research has been undertaken on a number of possible waste materials considerably fewer materials are used routinely in commercial brickmaking. The materials which are used generally have some intrinsic fuel value. It is much less common to add materials such as mining wastes which have no or very little combustibility. A critical factor to consider is the availability of the waste material and transport requirements -

Fig. 1: Sawdust being used for fuel in brickmaking in Sudan. Note: Clay and sawdust are being mixed in the background.

In this manual, covering all aspects of small-scale brickmaking, the author mentions the use of sawdust, coal ash, maize stalks or cobs, cotton bolls, and coffee and rice husks as fuels either included in brick bodies, if small in size, or added into the kiln.

2. Agro-Industrial Wastes in Brickmaking;
by Hajela, R.B., Gupta, R.G., Bhatnagar, J.M., Saxena, N.B., Goel, R.K; Building Research Practice, Vol. 18, No. 4, July/August 1985, pp. 248 to 252.

From tests carried out in India on brick bodies fired under controlled conditions it was found that :

Addition of fly ash, ground rice husks or rice husk ash helps reduce drying cracks in drying green bricks from various types of clays in the sun;

Fired bricks with optimum proportions of fly ash, coal cinder, coal washery waste, ground rice husks or rice husk ash conformed to the relevant Indian Standard on fired clay bricks;

25 to 30% less coal could be used in firing bricks containing wastes in the Bull's Trench Kiln.

Fig. 2: An Indian vertical shaft brick kiln (VSBK). Trials with rice husks as fuel have been undertaken in this kiln.

as transport costs can be critical in determining commercial viability. Much of the research has been undertaken for large-scale industrialised brickworks, often in developed countries (in the North), but there is no good reason why the smaller-scale or artisanal brickmaker in developing countries cannot also make use of wastes.

This bibliography concentrates on materials which can be incorporated within the body of the clay. Although certain waste materials such as coffee husks can also be used, added as fuel for the kiln, it is not proposed to consider these in this bibliography.

The subject of waste utilisation in brickmaking is still relatively specialized and so very little has been published that is relatively accessible in the public domain. Many of these publications are from academic research or trade journals with limited circulation. Nevertheless the papers and articles listed in this bibliography have been surveyed by the author and considered worthy of inclusion. Short abstracts are included for the most significant documents.

General

1. Basic Know-How for the Making of Burnt Bricks

3. Effects of Additives on the Burnt Properties of Clay Brick;
by Okongwu, David A.; American Ceramic Society Bulletin, Vol. 67, No. 8, 1988, pp. 1409 to 1411.

Clay bricks containing up to 8% by weight of sawdust, waste oil from garages or a mixture of sawdust and oil were fired under controlled conditions and tested in Nigeria. Addition of about 2% by weight of sawdust improves the strength and water absorption characteristics of the brick, but at higher concentrations these properties deteriorate. Waste oil generally results in no improvement and only has value due to its intrinsic fuel content. (Fig. 1 - by Lucky Lowe).

4. Recycling of Industrial and Urban Wastes in Brick Production - A Review;
by Dondi, M., Marsigli, M. & Fabbri, B.; Tile & Brick International, Volume 13, No. 3, 1997, pp. 218 to 225 (Part 1) & ; Tile & Brick International, Volume 13, No. 4, 1997, pp. 302 to 315 (Part 2).

This paper reviews literature that has been produced on trials or commercial utilisation of various types of waste materials in brickmaking. The wastes were added to brick bodies for their intrinsic fuel value, because they improved brick properties or because this would avoid a difficult waste disposal problem. Among waste materials considered were sewage sludge, fly ash, paper sludge waste, sawdust, textile fibre wastes and sludges, tanning industry wastes, coal mining wastes, waste oils, co-

and Tiles;
by Merschmeyer, Gerhard; Miserior, Aachen, Germany, November 1989, pp. 64.

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conut pith, rice hulls, ceramic wastes and sludges, and ground tyres. A very comprehensive bibliographic listing is included in Part 2.

Fig. 3: Storage of boiler ash waste at a brickworks in Zimbabwe.

Agricultural and Forestry Wastes

1. Properties of Bricks Incorporating Unground Rice Husks;
by Carter, G.W., Connor, M.A. & Mansell, D.S:; Building and Environment, Vol. 17, No. 4, 1982, pp. 285 to 291.

Generally it is advocated to use ground rice husks or rice husk ash in bricks because the husks by themselves are too large in size to mix in with the brick clay, but this increases the probability that the process becomes unviable. A series of firings, including at a commercial Hoffmann kiln, were undertaken with unground rice husk contents by volume of up to 70%. Although there is gradual deterioration in properties such as compressive strength and water absorption with increasing additions of rice husks, the authors concluded that with additions up to 50% the bricks would still remain in an acceptable condition for general use (Fig. 2 - by Theo Schilderman).

2. Use of Rice Husk in Ceramic Bricks;
by De Guiterrez, R.M. & Delvasto, S.:; in Ceramics - Charting the Future, Proceedings of the World Ceramics Congress, Florence, Italy, June 28 - July 4, 1994; Techna, Faenza, 1995 (P. Vincenzini - ed.).

Tests were undertaken in Colombia on incorporating ground also a decrease in strength with rice husk ash replacement, but this is of lower magnitude.

3. Utilisation of Bagasse in Brickmaking;
by Bairiak, J.; R & D in Sudan; Wall Building Technical Brief, BASIN at GATE-GTZ, Eschborn, Germany, 1999.

Bagasse is the solid residue remaining after extracting the molasses from sugar cane in sugar making. This technical brief reports on firing trials undertaken by ITDG in Sudan, on incorporating bagasse waste as fuel in the brick for firing. The use of well-matured (dark brown) bagasse is recommended to be incorporated into the brick to achieve fuel savings, reduce production costs and also produces a brick with an improved surface finish. Further savings on use of scarce firewood can be achieved with adding bagasse blocks as fuel into the brick kiln tunnels.

4. Utilisation of Cow Dung in Brickmaking;
by Bairiak, J.; R & D in Sudan; Wall Building Technical Brief, BASIN at GATE-GTZ, Eschborn, Germany, 1999.

Addition of dried cow dung, optimally replacing 20 to 30% of the volume of clay improves the plasticity of the clay, improves green strength, reduces cracking due to drying shrinkage and

rice husks and rice husk ash in fired clay bricks in proportions of up to 40%. There is an evident trend in decrease of compressive strength with increasing rice husk replacement and there is contributes towards the firing energy for clamp-fired bricks. However there would also be a marked decrease in strength and density and increase in water absorption.

Fig. 4: Loading dried clay bricks into clamp for firing using boiler ash waste in Zimbabwe - by H. Schreckenbach

Industrial Wastes

(A) Pulverised Fuel Ash

1. The Clamp Firing of Flyash Bricks;
by Anderson, M.; 9 pages - manuscript available from ITDG or author.

Pulverised fuel ash, or fly ash - a residue from coal burning, electricity generating power stations has been used for a number of decades in industrial-scale brick production in a number of countries. However, the potential also exists for smaller-scale artisanal brickworks, which often fire their bricks in clamps, to make use of this waste material, where available. The flyash could contribute towards providing energy for burning the bricks and would also improve the fired brick characteristics. A beneficiation process for the flyash is also proposed involving classification. The finer fraction would be more pozzolanic and could be used in cement and concrete while the coarser fraction would be more suitable for incorporation in brick bodies. The economic viability of the process has not been analysed, however.

2. The History of Pulverised Fuel Ash in Brickmaking in Britain;
by Anderson, M.; Transactions and Journal of the Institute of Britain, undertaken largely in the 1950's and 60's. These demonstrated that satisfactory and durable bricks could be produced, sometimes almost entirely from pfa, but the potential for utilising a particular ash varied widely, depending on nature of raw materials, method of manufacture and type of product.

3. Manufacture of Clay Flyash Bricks;
by Central Building Research Institute, Roorkee (U.P.) India:; Project Proposal No. 36, January 1990 (Pamphlet).

Document outlines the advantages of utilising flyash in brickmaking and presents an economic analysis of a possible manufacturing process showing that estimated investment costs and level of profitability are equivalent to production of ordinary fired clay bricks on the same scale.

4. Bricks and other structural ceramics;
by Central Electricity Generating Board (UK); PFA Data Book, September 1967.

The state of the art review of 1967 of about 30 pages on knowledge and research on "pfa" utilisation in brickmaking is presented. Much of this would still be relevant today.

(B) Tannery Sludge

Ceramics (UK), Vol. 86 (4) 99 - 135 (1987).

A report is presented of trials on using pfa in brickmaking in

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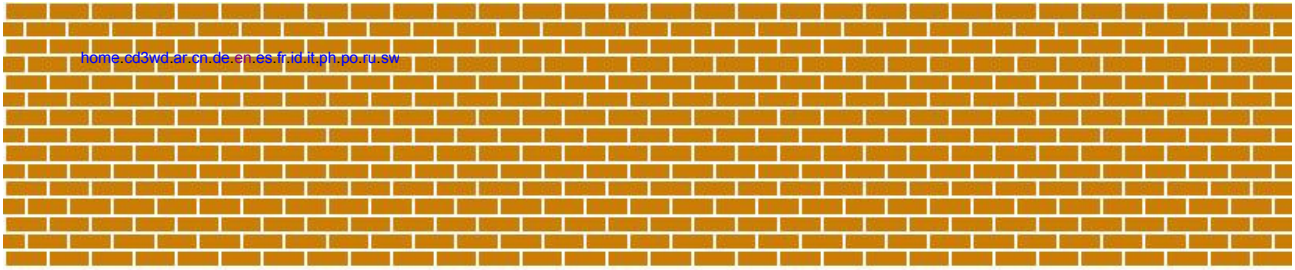
1. Use of Tannery Sludge in Brick Production;
by Giugliano, M. & Paggi, A.; Waste Management & Research (1985) No. 3, pp. 361 to 368.



Pilot plant studies in Italy indicate it would be viable to incorporate up to 10% of tannery sludges of the dry weight of bricks. There would not be a significant change in brick properties and some savings in use of the clay raw materials and fuel would result. It is also likely that European standards on emission of pollutants would be met, but further tests would be needed to ascertain this. The main disadvantages would be the need for sludge collection, storage feeding and mixing, increasing the equipment requirement for a brickworks and adding to the cost (Note: no mention was made of whether there might be any health risks of manual handling of the sludge).

(C) Brewery Wastes

1. Application of Brewery Wastes in the Production of Bricks;
by Knirsch, M., et al.; Tile and Brick International, Volume 14, No. 2, 1998, pp. 93 to 101.

Trials undertaken in Germany with spent grains from beermak-

Coal tailings, which mostly contain clay shale and carbon, can be used for brickmaking and are especially useful for insulating and high temperature bricks. Because the bricks are made predominantly from the tailings, with addition of relatively small amounts of clay, fluxes and other materials to improve characteristics, preparation techniques and final properties are somewhat different from normal common bricks. The tailings would require coarse grinding, then thermal pre-treatment to remove low temperature volatiles before blending with the clay and other additives and firing. The experiments described in the paper relate to firing in a tunnel kiln in Russia. The use of desulphurisation techniques to reduce emissions is recommended. Coal tailings vary in characteristics with different locations, so thorough testing and pilot trials are recommended for tailings from a particular source to determine optimum quantities of additives and manufacturing process. In particular the carbon content would vary, so additional fuel may be required in the kiln, or no other fuel needed, or air cooling introduced in the kiln because there is an excess of fuel.

ing, diatomite sludge from beer filtering and used paper labels indicated promising results. Spent grains can be used in place of sawdust, at the suggested replacement level of the clay of 3.5% by weight, for fuel saving or pore forming. Diatomite sludge added to the clay can improve plasticity and increase strength, and old labels can be used as fuel replacement or pore forming but need shredding and reshaping.

(D) Papermaking Waste

1. Re-use of Papermaking Sludge in Brick Production;
by Zani, A., Tenaglia, A. & Panigada, A.; Ziegelindustrie International No. 12, (1990), pp. 682 to 690 (Part 1) & Ziegelindustrie International No. 1, (1991), pp. 13 to 16 (Part 2) - in English and German.

Sludge from an Italian papermaking plant, after treatment contained 50 to 55% water, 20% organic paper fibres and 25% inorganic substances, mainly kaolin. Brickmaking trials were undertaken with sludge proportions equivalent to 5% and 7.5% of the weight of dry material (corresponding to organic material contents of 1.03 and 1.76% respectively). No significant problems were reported with moulding (by extrusion) or firing of the bricks. Slight decreases in strength and density were noted with the fired bricks. Energy savings of up to 20% in an industrial tunnel kiln were reported and emission of pollutants was generally acceptable, although emission of soot and ash exceeded European standards slightly.

(E) Coal Tailings

1. Production of Ceramic Building Materials

(F) Boiler Ash

1. Using Waste Material as an Alternative Fuel for Firing Bricks in Zimbabwe;
by Tawodzera, P.; BASIN News, No. 7, January 1994, pp. 6 to 8.

In Zimbabwe there are a number of industrial plants manufacturing products as diverse as soap, sugar and chemicals which use coal mined in the country for firing processes. Many of the coal-fired boilers used are not efficient and the ash produced still has a substantial amount of residual carbon content, perhaps as much as 80%. A project by the Intermediate Technology Development Group has found that it has been possible to produce a better quality brick when boiler ash waste is used in place of other fuel. The ash is sieved, with the fine material being incorporated into the body of the brick and the coarse material dispersed within the clamp kiln used for firing the bricks (Fig.3 - by Theo Schilderman, Fig. 4 - by Hannah Schreckenbach).

Municipal, Institutional and Household Wastes

1. Aspects of Sewage Sludge Utilisation and Its Impact on Brickmaking;
by Churchill, W.M.; British Ceramic Transactions, Vol. 93, No. 4, 1994, pp. 161 to 164.

Evidence exists to suggest that sewage additions to clay would save energy and reduce costs but further investigation is needed

in Russia from Coal Tailings;
by Siefke, C.; Tile & Brick International, Vol. 13, No. 2, 1997, pp. 116 to 131.

to assess possible health and safety risks to operators and pollution risks from emissions. Full-scale production trials are, however, recommended.

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2. The Utilisation of Sewage Sludge in the Manufacture of Clay Bricks;
by Slim, J.A. & Wakefield, R.W.; Water SA (ISSN 0378-4738), Vol. 17, No. 3, July 1991, pp. 197 to 201.

The dewatered sewage sludge produced at the Fishwater Flats Water Reclamation Works in Port Elizabeth in South Africa has for a number of years been successfully used in the manufacture of clay bricks on a commercial scale (one of only very few locations worldwide where this has been undertaken). Dewatered sludge at 30% volume to 70% clay is recommended for stock (common) bricks, and 5 to 8% sludge for facing bricks. Bricks are produced by extrusion and fired in tunnel kilns. Brick strength, shrinkage and absorption characteristics are acceptable, though the bricks are somewhat lighter than those without additive. The installation of an afterburner in the chimney stack reduces the risk of undesirable emissions.

3. Full Scale Application of Manufacturing Bricks from Sewage;
by Okuno, N. & Takahashi, S.; Water Science Technology, Vol. 36, No. 11, pp 243 to 250, 1997.

In Japan sewage sludge is normally incinerated for disposal, and a process has been developed to make bricks and tiles using only the sewage sludge ash. Several commercial plants are now producing fired products in this way. The process is somewhat complex and involves high pressure compaction and controlled firing. Details are given on the properties of the sewage sludge ash bricks, potential problems and how to avoid these problems.

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Sources of Further Information	(iv) Central Building Research Institute (CBRI)	The building advisory service and information

The following institutions have additional knowledge and experience on waste utilisation in brickmaking and might be able to provide further information and advice :

(i) BASIN at GATE/GTZ
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