Developments in brick manufacture and use

Ritchie, T.

Publisher's version / Version de l'éditeur:

Canadian Clay and Ceramics, 51, 1, pp. 8,10-12,52, 1978-01

National Research Council of Canada

Conseil national de recherche du Canada

DEVELOPMENTS IN BRICK MANUFACTURE AND USE

by T. Ritchie

Reprinted from
Canadian Clay and Ceramics
Vol.51, No. 1, January/February 1978
p. 8, 10-12 and 52

DBR Paper No. 765
Division of Building Research

Price 10 cents 03103 OTTAWA NRCC 16580

The stiff-mud method of forming bricks and the tunnel kiln for burning them, now account for a large proportion of the output of the Canadian industry. The historical development of these methods of making and firing bricks is traced, along with other developments that have influenced brickmaking, such as demands for colour and texture, and for the use of brickwork as an engineering material.

Une grande partie des briques au Canada sont maintenant fabriquées par moulage en pâte dure et par cuisson dans des fours tunnels. L'article trace l'évolution de ces méthodes de fabrication et de cuisson et traite des changements tels la couleur et la texture, qui ont influencé l'industrie des briques, ainsi que de l'utilisation de la brique comme matériau de construction.

Developments in brick manufacture and use

by T. Ritchie

In the long history of brickmaking in Canada, which began when the first settlers arrived in this country over three and a half centuries ago, many changes have taken place in the manufacture of bricks, as well as in their use in building. Machines have been developed for processing clay and forming bricks; new methods have been devised for drying bricks and new kilns have been invented for burning them. While many changes have been made for reasons of economy and efficiency in brick manufacture, others have resulted from the demands of architects and builders for decorative qualities of brickwork, particularly in regard to colour and texture.

This paper discusses the developments in the manufacture and use of bricks that have had an important influence on the brick industry. They are the development of the stiff-mud method of forming bricks and the use of the tunnel kiln for firing bricks, which now account for a large proportion of the industry's output, the demands for colour and texture, and the application of bricks and brickwork to structural uses in Canadian building.

Mr. T. Ritchie is with the Building Materials Section, Division of Building Research at the National Research Council in Ottawa.

Stiff-Mud Extrusion

Since 1890, when the production of bricks by the dry-press method was started in Canada, three brick-forming processes have been used by the brick industry: soft-mud moulding, stiff-mud extrusion, and dry-pressing. Soft-mud machines had been developed in Canada by the middle of the last century, about the same time that machines were devised to form bricks by forcing plastic clay through a rectangular die and cutting the extruded column. This extrusion, or stiff-mud method, may possibly have been first employed in Canada by John Charnock of Hamilton, who patented a machine in 1854 (1) that applied "the principle of moulding all descriptions of tiles, pipes, bricks and other articles for drainage, sewerage, building and other purposes, from clay or other plastic substances, by exuding the material, by pressure, through dies or orifices of the several required forms, having pendant cores of corresponding or other forms fixed in the centre of each die or orifice". In Charnock's machine, the clay was forced through the die or orifice by the movement of a piston or plunger; the extruded material was then cut off, producing "a perfectly rectangular and vertical severance". Charnock claimed that his machine moulded "all descriptions of perforated and hollow bricks, and other building materials, such perforations being of any shape and number".

How extensively Charnock's machine was used is not known, but another machine working on the same principle of extrusion by means of the force of a plunger was employed by Canadian brickmakers. This machine was made by Joseph Close of Woodstock, Ontario, who received an extension (2) in 1876 to a previous patent for a machine that extruded clay by means of a plunger. Details of the Close machine are not known except that an unusual feature was a cloth lining to its die to provide easier extrusion, but at some plants where the machine was used the clay was so gritty that the frequent renewal of worn cloth was necessary (3).

A different method of extruding clay, which provided continuous extrusion by means of a screw of auger, was employed in a machine designed by Philip, Abram and Jacob Kells of Michigan, who received a Canadian patent (4) in 1882. Production of the Kells machine was started by H. C. Baird of Parkhill, Ontario, in 1884 (5) and many Kells machines were soon being used in Canadian brickyards. By 1906, more than 30 yards in Ontario were equipped with Kells machines (3).

In the early use of the stiff-mud process, the die was usually arranged to produce a column of clay of dimensions equal either to the width and height of a brick, or to its length and width. In the first case, the column had to be cut into pieces as long as a brick, and in the second, the column had to be cut at intervals equal to the height of a brick, with allowances made for drying and firing shrinkage. In early machines, the cutting was done by means of a thin-bladed knife, but a better method was found in the use of tensioned wires. Automatic cutters were devised that travelled with the extruded column at its rate of speed so that the wires passing through the column formed bricks with square corners. An automatic cutter patented by Byron E. Bechtel of Waterloo, Ontario, a brickmaker who manufactured various brickmaking machinery, was extensively used by Ontario manufacturers (3).

Attempts to overcome the effects of the friction that developed between the die surfaces and the clay led to various methods of lubrication, including the heating of the die by steam and feeding oil to the die surfaces. A further important development in the stiff-mud process took place in the 1930's when de-airing, or extrusion under vacuum, came into use; the clay was subjected to a partial vacuum before it was forced

through the die. The result was that air entrapped by working the clay was removed, thus eliminating a cause of several difficulties, including poor plasticity, blistering on the surface, and lamination cracks.

The benefits of de-airing appeared to be so great that by 1934, only a few years after equipment for the process became available, 150 installations had been made by American brickmakers and several were made in Canada (6). Experiments on de-airing carried out at several Canadian plants showed that it increased the strength of the product, decreased its absorption and had other favourable effects (7, 8, 9).

Two features of the stiff-mud process were particularly useful to brickmakers. It was easy to apply texture to the surface of bricks by scratching, scraping, indenting or otherwise treating the column of clay, and texture appealed to many architects and builders. The other feature of the process was that it produced bricks continuously and at a relatively high rate of production. A stiff-mud machine used by the Don Valley Brick Company in Toronto in 1906 could turn out 8,000 bricks per hour (3), and in 1930, the capacity of the machine of the Crang-Booth plant near Toronto was over 11,000 bricks per hour (5). In 1967, most machines in Ontario brick plants could produce between 15,000 and 20,000 bricks per hour (10).

The increasing advantages to the brickmaker of using the stiff-mud process are reflected in statistics on the production of bricks by the various methods of forming, plotted in Figure 1. In the 1930's about 55 per cent of the bricks made in Canada were formed by stiff-mud extrusion, about 25 per cent by the soft-mud method, and the remainder by dry-pressing. The stiff-mud process subsequently became more extensively used to the extent that in recent years it has accounted for about 80 per cent of the total brick production in Canada, an increase made mostly at the expense of the soft-mud process that now accounts for only about 5 per cent of brick production.

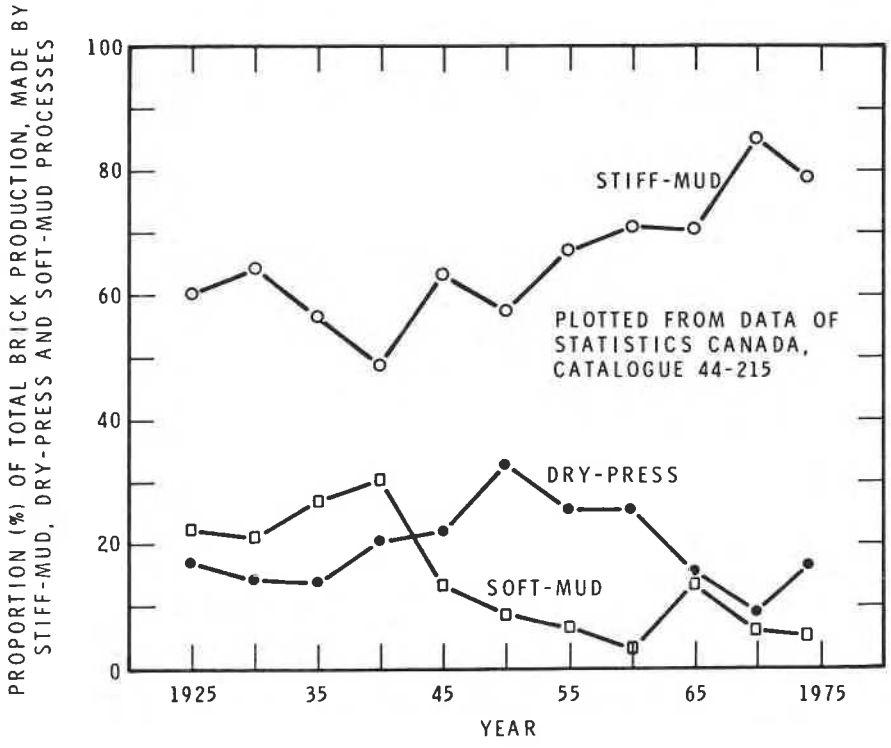

FIGURE 1

CANADIAN BRICK PRODUCTION, PROPORTIONED ACCORDING TO METHOD OF FORMING BRICKS, 1925-1974

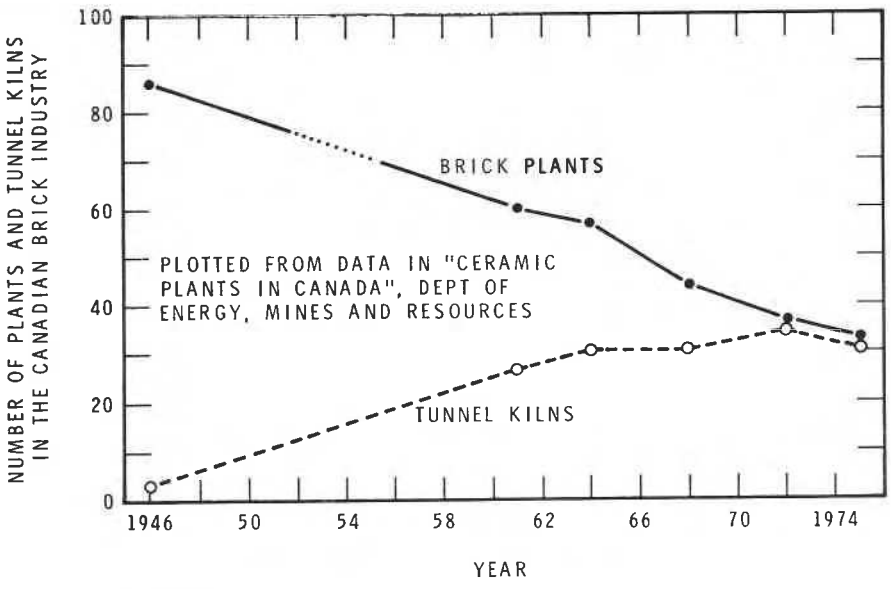

FIGURE 2

TUNNEL KILNS AND BRICK PLANTS, 1946-1975

The Tunnel Kiln

Tunnel kilns, originally called "Continuous car tunnel kilns" or "Railroad tunnel kilns", are not a recent development but have been extensively employed by the Canadian brick industry only within the last few decades, replacing various types of periodic and continuous kilns, and even replacing the primitive scove kiln, one of which was still in use in Canada as recently as 1964.

One of the first tunnel kilns was that designed in England by William Cliff, which he patented in 1869 (11). It consisted of a 90-foot tunnel, slightly inclined from the horizontal, with tracks laid along it for the trucks that carried the bricks through the kiln. The slope of the kiln assisted in the passage of the trucks. The bottom of a truck was protected from the heat of the kiln by means of a fire-brick deck, and by means of curtain plates along each side which travelled in a sand-filled groove.

In principle, the tunnel was designed to serve as a flue, with air entering the lower end and leaving through the opposite end. Midway along the kiln, producer gas entered through flues in the kiln walls and passed through flues in the truck decks, which had openings at the top to allow it to flow among the

bricks stacked on the deck where the gas burned. The operation of the kiln was such that the bricks passing down the kiln gave up their heat to the air flowing up the tunnel, thus pre-heating the air before it reached the combustion zone. Similarly, the hot gases of combustion, as they flowed to the upper end of the tunnel, gave up their heat to the on-coming bricks, pre-heating them before they reached the hot zone of the kiln.

While, in theory, Cliff's kiln offered substantial fuel savings over other kilns, it probably suffered from the practical operating difficulties that affected later tunnel kilns, such as those of Otto Bock, a German, who built about 60 tunnel kilns to a design he patented in 1877; most of them, however, were failures (12). Failure was also the fate of the first tunnel kiln used for firing bricks in the United States. Built in Chicago in 1889, this kiln, and another built by the same designer, did not operate for long. In spite of many failures, the considerable potential fuel savings of the tunnel kiln, which theoretically used between 15 and 30 per cent of the fuel required for a periodic kiln, maintained interest in this type to the extent that in 1919 there were 63 U.S. patents in force for tunnel kilns and as many more than had expired. The first U.S. tunnel kiln considered to be a success was built in 1910 and was still operating in 1922 (12).

The tunnel kiln was introduced to the Canadian brick industry in 1917 by George W. Booth, an inventive brick-maker who, after having assisted in the operation of his father's yard, established his own plant near Toronto (13). Booth received a patent (14) for his tunnel kiln in 1920, built a second kiln at his plant in 1923, a third for a plant he started in 1925 near Buffalo, N.Y., and a fourth tunnel kiln at another plant he established in 1928.

Booth experienced difficulty in the firing of his first tunnel kiln, a structure 250 feet long that originally had been fired with producer gas made on the site. He converted it to oil, and finally to coal, supplied by hand-firing. His second kiln, almost 100 feet longer than the first, was designed for coal-firing by means of stokers, but since this was not successful, hand-firing was employed.

An unusual feature of Booth's fourth kiln, which was 400 feet long, was the installation of tunnel dryers at the top to use waste heat. The brick machine was located at the plant's second floor level, where the bricks were loaded on cars for passage through the dryers. The cars were then lowered by an elevator to the ground floor, the bricks were transferred to kiln cars for passage through the kiln, and the dryer cars returned to the machine. The capacity of this kiln was 60,000 bricks per day.

In 1930 it was speculated that the Booth kiln "may be the beginning of a movement to use more railway tunnel-kilns for the burning of clay products" (5), but it was not until many years later that additional tunnel kilns to those built by Booth were constructed in Canada. The number of tunnel kilns then increased rapidly, from three in 1946, to 31 in 1964, as shown in Figure 2, which also presents another feature of the development of the modern Canadian brick industry — a steady decline in the number of plants. The decrease in the number of tunnel kilns from 1972 to 1975 may be accounted for by the closing of the plants housing the Booth kilns.

The tunnel kiln is now used for a large proportion of the bricks made in Canada because of its advantages over other means of burning bricks; it not only operates continuously but fires bricks much more rapidly than other kilns. By one estimation, tunnel kilns burned 80 per cent of the total Canadian brick production of recent years.

Colour and Texture

Changes in architectural fashions and styles, particularly those demanding new colours and textures, have long affected the brick industry. An interest in providing a new colour led Thomas Clark, an Ottawa brickmaker, to mix marl with his red-burning clay to produce a white brick, for which he received a patent in 1876 (15). This brick was used to provide the popular architectural fashion of the time of white trim in the arches and at the corners of red brick buildings. Later, other brick manufacturers used the now common practice of adding lime or limestone dust to clay to obtain a buff colour, a method employed by the National Brick Co. of Laprairie, Quebec, in 1915 (16). At a few plants, enameled or glazed bricks were produced, and at many plants the natural colours of the bricks were modified by flashing.

The architectural fashion of using smooth-surfaced, uniformly coloured brick walls with thin mortar joints promoted the establishment of dry-press brick plants in Canada because this process produced bricks of relatively close dimensional tolerances, but a change in fashion took place about 1910 when architects began to call for rough-textured bricks of blended colours laid with wide joints. Such brickwork, made of "tapestry" and "rug" textured bricks, became very popular in the 1920's and continues to be in demand. Since texture could be easily produced by scraping, scoring or scratching the column of clay coming from a stiff-mud machine, the demand for it was an important incentive for brickmakers to use the stiff-mud process.

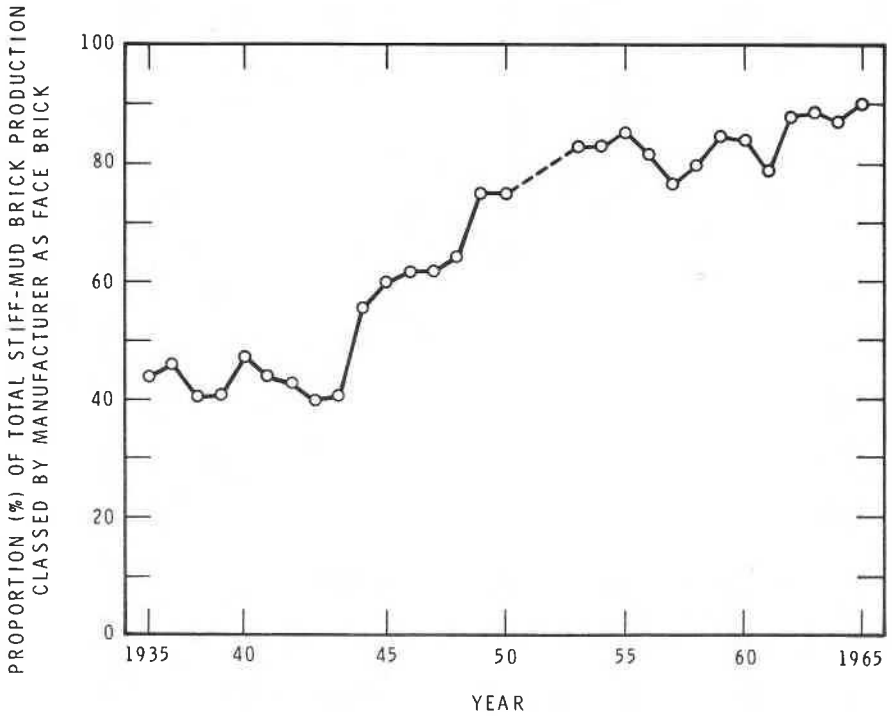

FIGURE 3

PROPORTION OF TOTAL STIFF-MUD BRICK PRODUCTION CLASSED AS FACE BRICK, 1935-1965

An important result of market demands for bricks of greater aesthetic value has been that an increasing proportion of the total number of bricks produced have been classed as face brick. This situation is shown in Figure 3, drawn from statistics of the Canadian production of stiff-mud brick. In 1935, about 45 per cent of the production of stiff-mud bricks was classed as face brick, whereas in 1965 the proportion had increased to about 90 per cent.

Changes in Building Techniques

Changes in building technology and techniques have had an important influence on the brick industry, especially with the development of skeleton frame construction in which a structural frame of steel or reinforced concrete is used to support a building, instead of the masonry walls that once had this load-bearing function. When the era of the tall building began late in the 19th century, before the introduction of the structural frame, loadbearing masonry walls of great thickness were required to provide adequate wall strength and stability, because of the low strength of the bricks and mortars then in use. The use of relatively thin walls, as shown, for example, in the building regulations of Toronto for 1904 (17), which required that the walls of a ten-storey brick building be at least three feet thick at the base. But if the designer of the building used a structural frame of steel, the walls at all levels had to be only 14 inches thick. Because massive loadbearing brick walls were costly to build and greatly reduced the floor area of the building, structural frame construction was preferred for tall buildings. It was used extensively for low buildings as well.

The use of the structural frame promoted the development of lightweight materials for reasons of economy; the lighter the loads on the frame the smaller its members could be. It also promoted the use of fireproof materials because structural members had to be encased in such a material to protect them from fire. The brick industry provided a material to meet these needs in the form of hollow estruded units, such as the hollow tiles that were extensively used in the early days on structural frame construction for arched floor construction, and in the fireproofing units made to fit around steel columns and beams. Hollow partition and furring units were also made, as well as a very light, porous material produced by adding sawdust to clay. The sawdust burned out in the firing to give a highly porous material that could be nailed and sawed, appropriately called "terra cotta lumber".

An important effect of the structural frame building was the developing interest of engineers and architects in the structural qualities of brickwork. One study of the effects of brick and mortar properties on the compressive strength of brickwork was carried out at the University of Toronto in 1895 (18). It was not until 70 years later, however, that a system of engineered brickwork for high-rise, thin-walled construction had been developed and applied to Canadian building. When this occurred in 1965 it marked a significant development in the history of the brick industry of this country.

Conclusions

The Canadian brick industry has undergone many changes in its long history, affecting all aspects of the manufacture of bricks and many aspects of their use in building. Some developments that have shaped the present industry have been described, including the stiff-mud method of forming bricks, which has now largely displaced other methods. A second major development has been the extensive use of the tunnel kiln for firing bricks, which now accounts for a large proportion of Canadian brick production. Changes in architectural fashion and style have considerably affected the brick industry, as has the recent structual application of brickwork to building, by which thin-walled, high-rise brick structures have been built economically.

This paper is a contribution from the Division of Building Research, National Research Council of Canada and is published with the approval of the Director of the Division.

REFERENCES

[1] *Charnock, J. H., "A New and Useful Machine for Moulding all Descriptions of Tiles, Pipes and Bricks, for Drainage, Sewerage, Building or other Purposes, from Clay or other Plastic Substances," Canada, Patent No. 451 [April 1854] in Patents of Canada from 1849 to 1855. Toronto, Lovell and Gibson, 1865, Vol. 2, p. 401.*

[2] *Close, J., "Brick Machine," Canada, Patent No. 5795 [March 1876]. Canadian Patent Office Record, Vol. 4, No. 4, April 1876, p. 48.*

[3] *Baker, M. B., "Clay and the Clay Industry of Ontario," Report of the [Ontario] Bureau of Mines, Vol. XV, Part II, 1906, 127p.*

[4] *Kells, P. H., Kells, A. K., and Kells, J. M., "Improvements in Brick," U.S., Patent No. 15,091 [July 1882]. Canadian Patent Office Record, Vol. 10, No. 8, August 1882, p. 235.*

[5] *Montgomery, R. J., "The Ceramic Industry of Ontario," Ontario Department of Mines, Annual Report, Vol. XXXIX, Part IV, 1930, 196 p.*

[6] *Phillips, J. G., "Outstanding Developments in Ceramics in 1934," Canadian Ceramic Society Journal, Vol. 4, 1935, p. 3.*

[7] *Akam, J. W., "The Effect of De-airing Stiff-mud Clay Bodies by Evacuation," Journal of the Canadian Ceramic Siciety, Vol. 2, 1933, p. 18.*

[8] *Dingledine, H. F., "A Practical Application of De-airing in Canada," Journal of the Canadian Ceramic Society, Vol. 4, 1935, p. 26.*

[9] *Shaw, L. E., "De-airing," Journal of the Canadian Ceramic Society, Vol. 4, 1935, p. 28.*

[10] *Guillet, G. R., "The Clay Products Industry of Ontario," Ontario Department of Mines, Industrial Mineral Report No. 22, Toronto, 1967, 206p.*

[11] *"Cliff's Brick Kilns," Engineering, Vol. VII, 1869, p. 67.*

[12] *"Preliminary Report of the Committee on Fuel Conservation on the Railroad Tunnel Kiln," Journal of the American Ceramic Society, Vol. 5, 1922, p. 602.*

[13] *Smith, J. C., "Brick, a Four Generation Story," Clay Products News and Ceramic Record, Vol. 37, No. 12, 1964, p. 9*

[14] *Booth, G. W., "Tunnel Kiln," Canada, Patent No. 198,889 [september 1919]. Canadian Patent Office Record, Vol. 48, No. 14, April 1920, p. 974.*

[15] *Clark, T. M., "Manufacture of White Bricks, &c," Canada, Patent No. 6689 [October 1876]. Canadian Patent Office Record, Vol. 4, No. 11, November 1876, p. 177.*

[16] *Keele, J., "Preliminary Report on the Clay and Shale Deposits of the Province of Quebec," Department of Mines, Ottawa, Memoir No. 64, 1915, 280p.*

[17] *"New Building Regulations for Toronto," Canadian Architect and Builder, Vol. XVII, No. 197, 1904, p. 84.*

[18] *Keele, J., "Brickwork Masonry," Engineering Society, University of Toronto, Paper No. 9, 1895, p. 153.*