HERITAGE CONSERVATION

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EARLY BRICKS AND BRICKWORK IN SOUTH AUSTRALIA

DENR

City of Adelaide

DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

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INTRODUCTION

Bricks are a very common building material. They are made by forming ordinary clay into regular blocks of a convenient size to hold (usually a little over one-and-a-half litres in volume), allowing any excess moisture to evaporate, then heating them to high temperature, typically about 1,000°C. The clay undergoes a permanent chemical alteration, becoming ceramic: no longer a soft earth, it turns into a hard stone-like substance which no longer loses its structure when wet. Well-made bricks are extremely strong and durable, resistant to impact, crushing, chemical reaction, fire, water, wind, fungus and insects, and thus requiring little maintenance. They have been in use since antiquity, and there are brick buildings which have survived for thousands of years.

There are very few historic buildings in South Australia that do not have any bricks in them. Whereas buildings can be built with no stone, no earth, no concrete, and very little metal or timber in them, almost all substantial South Australian buildings from 1836 to the present have had fireplaces and chimneys made of brick. From the 1850s to the 1920s, bricks also formed the corners (quoins) and the door and window surrounds in the majority of buildings made of stone. And of course brick was sometimes used far more extensively to form the walls of entire buildings.

This booklet gives a brief history of the manufacture of bricks and their use in South Australian buildings, with some advice on the conservation of historic brickwork today.

1 EARLY BRICKWORK IN SOUTH AUSTRALIA

Uses of bricks

There was a demand for bricks as a building material from the very earliest European settlement of South Australia; they were being carried ashore from ships within days of the arrival of the first Europeans in 1836, and manufactured on the banks of the River Torrens a few months later. However their availability did not guarantee they would be widely used, for there were both economic and aesthetic considerations which affected the choice of bricks as a building material.

Economically, the cost of brick construction was the sum of three costs: (a) manufacture, (b) transport and (c) bricklaying. As clay was abundant, and the processes of pugging and moulding were fairly simple, making the raw bricks was quite cheap, certainly cheaper than quarrying an equivalent amount of stone. However, that was only the beginning; next the bricks had to be fired, and the high cost of fuel, the time involved in drying and firing, and the multiple handling operations in loading and unloading the kiln built a steep new cost factor into the equation. Then the fired bricks were expensive to transport overland because they were so heavy (nearly 4 kg each or about 260 bricks to the tonne), so that the price rose rapidly with increased distance between brickworks and building site. There was a paradox, however, because sea transport was very cheap; the sea freight from Liverpool to Port Adelaide might cost less than the land transport from the Port to the city. A ship looking for lading would bring imported cargo at very low cost so that, amazingly, bricks from Britain competed on the local market. In some years, hundreds of thousands of bricks were imported. On the building site, bricklaying then required a lot of skilled manual labour; an expert bricklayer could lay 400 bricks in a good day. As a result a brick building was relatively expensive when all costs were considered; a brick house cost a lot more

Electric Lighting and Traction Company power station (1901- now Tandanya) (Heritage SA files)

than a stone rubble house in Adelaide's early decades. Brick tended to be most popular in places very close to brickworks or transport routes, and during times when labour was cheap.

Local aesthetic considerations further affected the pattern of brick use, because early South Australians seemed not to like brick very much. In the British Province of South Australia it was important to present a dignified, stable and prosperous face to the world, and that meant considerable social pressure to erect buildings in stone. In early Adelaide there were never whole suburbs of houses built of brick like those of Sydney, or timber like those of Brisbane. Nineteenth century South Australia had the highest proportion of stone buildings in the country, and stone was used to erect everything from metropolitan cathedrals to rural out-houses. For long periods, when brick was used in South Australia it was used sparingly and conservatively, and kept out of sight whenever possible.

Brick was used for industrial buildings: factories and their smokestacks, smelters and warehouses. Every enterprise that used a steam engine needed a boiler, and beside every boiler stood a brick chimney. Photographs of nineteenth century Adelaide show a forest of brick chimneys rising from bakeries, sawmills, breweries, potteries, tanneries, brickworks, laundries, mills and factories of every kind. Of all these the only one of substantial size left standing in the city is the smokestack of the municipal Destructor in Halifax Street (1910). Most houses had several fireplaces and chimneys - even the smallest cottages had at least one - and these were invariably built of brick. Fire resistance was one of the qualities that made bricks so useful.

Another was the ease with which they could be laid neatly and precisely. Stone blocks first had to be cut to size and shape, but bricks came from the mould in modular units which

Brick quoins on a limestone building: Old Parliament House, North Terrace

could be laid firmly, regularly and in straight lines. Internal partitions in stone cottages were often built of brick because a rubble wall had to be very thick and would take up too much space. In a cheap colonial cottage the walls between the rooms would be one 11cm brick-width in thickness.

These qualities also made them useful in forming the corners of buildings and the openings for doors and windows. In buildings with walls of stone rubble, bricks came into use for the quoins, as the corners were called, providing precise angles framing the straight panels of cheaply-built stonework, a technique adopted from the south-eastern counties of England. They were not used at first - the earliest generation of South Australian buildings had quoins of shaped stone, if they had any at all - but they were coming into use in the early 1850s. By the late 1850s and 1860s Adelaide houses were taking on the characteristic building technique of framing limestone rubble in red brick borders, a style that would persist until the 1920s.

Other ceramic products

Bricks took many diverse forms. They came in a range of qualities, from commons which were cheap and rough and intended to be hidden forever inside the finished building, to expensive face bricks which were selected for their attractive and uniform appearance as well as their good quality, and are the bricks which we see exposed on building facades today. Any brickworks would simultaneously be producing bricks of several qualities to suit a variety of uses and budgets.

Bricks could be produced in many colours, from nearly white through a variety of yellows, oranges, reds and browns to black. Matching the colours of two successive batches was a challenge to early brickmakers, given the uncertain chemistry of their clay and fuel. Bricks also came in a wide variety of shapes. Nearly all brickmakers turned out small quantities of specials or bricks moulded for specific purposes, such as coping on top of walls, or for cornices or string courses. Arched window heads were made from special tapering bricks called voussoirs. These specials had to be made from the same clay as face bricks and fired the same way, to match the colour of the surrounding brickwork. A few brickworks also produced firebricks or refractories, bricks made of very pure white clay fired to a high temperature, and designed to withstand heat. They were mostly supplied to industry for use in furnaces and smelters, and lining smokestacks, but refractory mouldings were also available for domestic fireplaces.

Bricks were only one of a wide range of ceramic products produced by brickworks and specialist potteries for a variety of industrial and domestic applications. Glazed stoneware was in enormous demand for underground drainage and sewer pipes as reticulated water supply and sewerage spread through the metropolitan area. Ceramic roofing tiles imported from France and known as Marseilles tiles became popular from the late 1880s, although they were not manufactured in

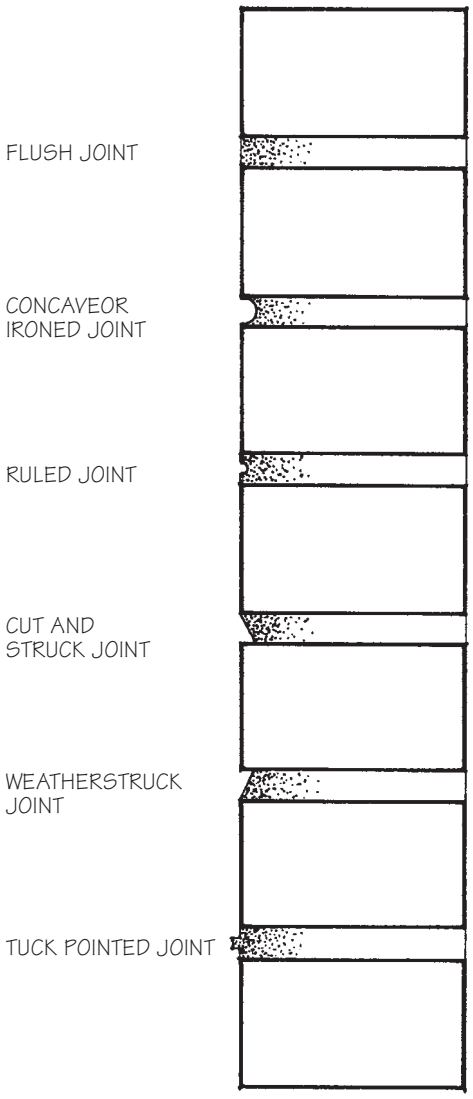
Architectural ceramic ware by John Clift Pottery, Adelaide: tiles, special bricks, ventilator, garden edging

South Australia until Wunderlich established a plant at Edwardstown in the early 1920s. Stoneware tiles were in use as damp-proof courses in masonry buildings, and brickworks supplied ceramic ventilators to allow air flow through brick walls. Walls were finished with glazed ceramic tiles in a rich variety of colours. Terracotta (the Italian words literally mean cooked earth) was sometimes used for ornamental wall panels, usually in conjunction with decorative brickwork. Terracotta mouldings were available for every detail of a house from edging lawns and paving garden pathways to roof cresting and chimney pots.

Brickwork

Brickwork simply means construction made of bricks. Most of the skills of South Australian bricklayers were English in origin, handed down the generations through the apprenticeship system. The bonds, finishes and decorative details used here all have their antecedents in English brickwork.

Bricklaying is a skilled trade, learned during an apprenticeship of several years, and then developed to higher levels of skill over a long period. Bricklayers usually worked in teams with a hierarchy of work according to skill, with skilled senior bricklayers doing the fine face work and the highly visible decorative details, while more junior bricklayers and apprentices were building the interior walls out of hastily-laid commons which would soon disappear under plaster and paint. A team of labourers kept up the supply of bricks and mortar. There were expert teams who would work exclusively



COMMON MORTAR JOINTS

Ruled joints

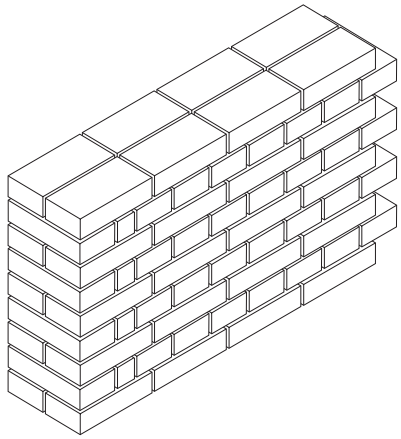
on specialist contracts like multi-storey walls, sewer linings and smokestacks.

The essential task of a bricklayer is to build walls that are strong, vertical and straight. However, depending on where the finished wall was located, and the quality expected of the end product, there were a number of ways in which the brickwork could be finished. The simplest, cheapest standard of construction left the mortar squeezed out of the joints between the bricks; this would only be done in a context like the underfloor foundations of a building, where the wall was not exposed to the weather and would never be seen. Normally the joints were at least roughly 'struck' by scraping the mortar off to form a surface flush with the face of the bricks.

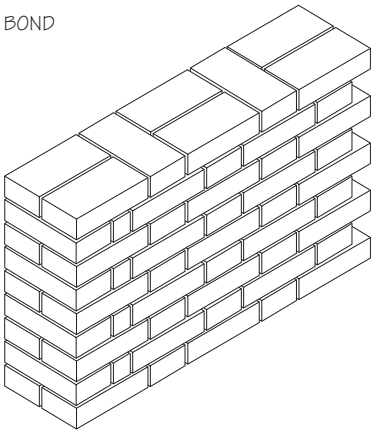
Face bricks were always pointed, that is the joints were carefully treated. There were two reasons for this, first to give the brickwork a more attractive appearance, and second to prevent water penetrating the wall. Often the joints were weathered, that is the mortar was shaped with a trowel blade to slope outward so that water would run off, although in recent decades it has become more common to make the pointing concave by pressing an iron rod into each joint to compress the mortar. There were a number of other forms of decorative pointing. If a flush finish was preferred, it was not simply struck off, but finished by pressing in additional mortar so that there were no air bubbles or irregularities. After the mortar had set, the brick faces would be scrubbed free of any adhering mortar.

The highest quality work was gauged (i.e. measured) brickwork, in which specially made bricks were shaped into elaborate architectural forms by sculpting and rubbing. The bricks were of fine clay, and initially soft enough to shape and rub by hand, but they became durable after exposure to the weather, a process known as case hardening. Far more common in South Australia were ruled joints. The brickwork was finished as a smooth uniform surface by flush pointing with mortar stained with red ochre to match the colour of the bricks. (In cruder work, the finished wall surface was simply washed with red ochre, so that the colour of the mortar superficially matched the bricks.) Then a narrow indented line was ruled with a

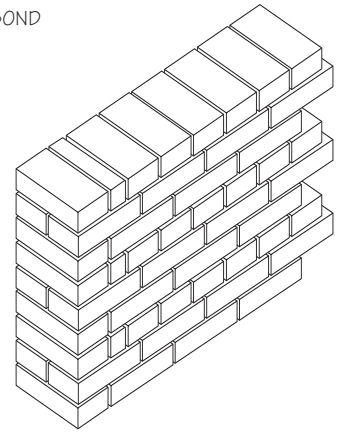
BRICKWORK BONDS



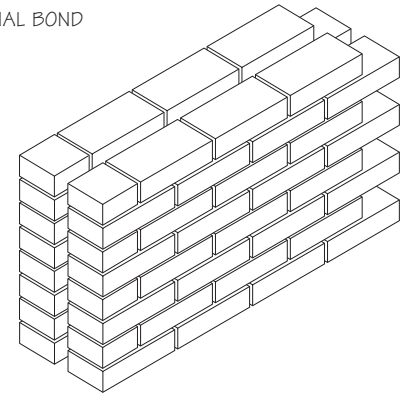
ENGLISH BOND



FLEMISH BOND



COLONIAL BOND



STRETCHER BOND

straightedge along the centre of every joint line, and painted white, creating the illusion that the wall had been laid with microscopically fine mortar joints. In a variation of this technique, the white pointing was sometimes painted only along the horizontal joints, and the vertical joints were left brick-red, making the brickwork appear to be composed of continuous long slabs of brick.

Bonding

To create a stable structure, bricks must be laid so that the joints are broken, that is, there are no vertical joints aligned in adjacent courses to form lines of weakness. Bricklayers have evolved a number of bonds, or regular brickwork patterns, which ensure that each joint is capped by a solid brick.

Stretcher bond is the simplest, with the bricks arranged in simple courses of stretchers. Each course is moved half a bricklength sideways, so that every brick in the wall has a vertical joint centred above and below it. It is most suitable for cavity walls, because a solid wall needs some headers to tie it together. In English bond, courses of stretchers alternate with courses of headers. English garden wall bond, often called colonial bond in Australia, had three courses of stretchers and then a course of headers. Flemish bond is very attractive, with alternate headers and stretchers in every course; it lends itself to decorative treatment when the headers and stretchers are different colours.

These four bonds make up by far the majority of brick walls in South Australia. In some situations where permanent ventilation was required, such as in foundations or stables, walls were built with gaps between bricks, for example by using Flemish bond with the headers omitted. This is sometimes called honeycomb bond. Literally dozens of other bonds can be found in textbooks of brickwork, but most are confined to specific parts of the world, or suited to very rare applications.

Tortola House, Gawler (Heritage SA Files)

Entrance Gates, Adelaide Zoo

Colonial brickwork

Principally because of its cost, the use of brick was limited in early colonial South Australia. Generally the well-to-do built in stone, and the poor built in earth and wood. A relatively small number of early cottages were built with external brick walls, generally in areas close to a brickworks. More commonly, a small amount of brick was used to finish stone walls, at quoins and openings, and perhaps as a string course below the eaves, or coping on a gable. On occasions, a few wealthy land-owners defied popular taste by choosing to build in brick. Both 'Cummins' at Novar Gardens (1841) and Beaumont House (1850) were stylish red brick suburban villas in stretcher bond with only modest adornment. Larger brickworks and technological developments in brickmaking and firing saw the cost of bricks gradually coming down throughout the nineteenth century. By the 1860s the cost of brick construction in Adelaide was roughly equal to that of stone rubble.

Z Ward, Glenside

Economic competitiveness was accompanied by a gradual loosening of popular attitudes toward exposed brick. Tortola House, built for a Gawler merchant in the 1870s by an unknown architect (from Melbourne, one suspects) was a dazzling polychrome brick mansion in exotic Venetian styling. This was to remain a most unusual building in South Australia, for polychrome brickwork is almost unknown here. Whereas Melbourne architects and builders delighted in the enrichment of buildings by the use of multi-coloured brickwork, and in Perth and Sydney bichrome chequered brickwork is common, such decorative uses of mere brick were apparently considered too frivolous for Adelaide's taste.

There were a few flourishes of colourful brickwork during Edward John Woods' time as Architect-in-Chief. His staff introduced bands of diaper work - repeated diagonal patterns - into a few public buildings, notably the first large public school in Adelaide, Flinders Street School (1878), and the fence flanking the entrance gates of the Adelaide Zoo (1882). Their masterpiece of polychrome brickwork was the rather inappropriately exuberant facade of Z Ward (1885) which was built to house the criminally insane at Parkside Hospital, and is now the Department of Primary Industry and Resources Glenside Annex. Although a major public building, Z Ward was hidden at the rear of the hospital grounds, and seen by very few people for many decades. Woods seems to have been personally influential in all these cases, but they were rare exceptions among the plain brick walls all around them. Curiously enough, Woods himself is said earlier to have discouraged a plan to build St Peters Cathedral in polychrome brickwork as he believed Adelaide public taste would not accept it.

The cost of brick construction continued to shrink. In the early 1880s the arrival of the efficient coal-fired Hoffman kiln reduced brick

Federation brick chimneys, St Corantyn

Federation brick details at Marbury school

firing costs to about a quarter of what they had been a few years before. The early production from Adelaide's first Hoffman kiln mostly went into the tunnels for the Adelaide Hills Railway, but over the next few years the new bricks began to have an impact on the market. Large brick buildings steadily became more visible in the city streetscapes throughout the 1880s. The multi-storey Dixson Tobacco Factory (1882) and Sands & McDougall Warehouse (1889) were both built in red brick fronting Light Square, whereas ten years earlier they would have been built of bluestone. The heyday of brick construction was about to dawn.

Federation brickwork

The popularity of exposed red brickwork rose dramatically during the years from about 1890 to 1914, a period of architectural change usually known by Australian architectural historians as the Federation period, although the same stylistic movement is known in England as Edwardian, and in America for some reason as Queen Anne. The full characteristics of Federation architecture: asymmetry practised for its own sake, an emphasis on the roof, often with perversely elaborate roof forms, eccentrically-shaped openings, a fondness for Marseilles tiles and terracotta ridge ornaments, were only partly realised in South Australia. The typical Federation villa in Adelaide is a cautious, slightly asymmetrical composition, probably with a corrugated iron roof, wearing a single candle-snuffer turret at a front corner as a badge of the times. But Adelaide architects' most enthusiastic response to the style was their adoption of exposed brickwork, rich red in colour rather than the orange more typical of the Victorian era, sometimes alternating it with contrasting bands of cream-painted render.

Greater individuality began to appear in the brickwork of the late nineteenth century. More complex bonds appeared in brick walls;

150 Rundle Mall (1887)

SA Museum north wing, the first major public building in red brick (1895)

St Raphaels, Parkside (1916)

Adelaide bricklayers became fond of colonial bond, in which three courses of stretchers are followed by a course of headers. Whereas in the Victorian period, brick ornament was generally confined to a few string courses or cornices, it now began to spread into richer lintels, spandrels and columns. Sometimes the colour of these brickwork details was enhanced by rubbing or gauging them. Occasionally they were washed with a coat of red ochre, and the jointing over-painted in white. A greater variety of special bricks allowed more complex mouldings to be specified in cornices and door surrounds. Conventional chimneys gave way to taller and more elaborate forms as bricklayers showed off their new skills.

The signal for what was coming in the streets of Adelaide can still be seen today in the shops at 150 Rundle Mall (1887), with their tall Flemish-gabled facade in red brick and flamboyant cream detailing. The arrival of the new era can be followed through the larger houses of the time: St Margarets on Brougham Place (1890) and St Corantyn on East Terrace (1892) were both stately stone late Victorian mansions, but ornamented with red brickwork of exceptional richness and quality. (Both houses, as well as others of this era, are the work of architect George Soward.) Later houses such as Springhill Lodge (1897) and Carramar at Unley (c.1898) did away with stone altogether and were built of exposed brick throughout. The South Australian Museum's new North Wing (1895) was the first conspicuous publicly-funded red brick building in the colony, although it aroused public controversy because many people had expected a sandstone French Renaissance composition in keeping with the two existing wings of the complex. The Superintendent of Public Buildings apologised that his budget had not allowed him to build in stone, a comment on what had happened to the relative cost of the two materials.

But by that time the floodgates of public taste were open, and large, vigorous brick buildings were appearing on Adelaide's streets in almost every year. Today the legacy of the Federation period in the metropolitan area includes the Beehive building (1895), Bertram House (1897), the Grenfell Street Mail Exchange and the Colonel Light Hotel (both 1898), the YWCA (now RAA) building on Hindmarsh Square and the School of Mines on North Terrace (both 1900), the Electric Lighting and Traction Company Power Station (now Tandanya) and the Adelaide Stock Exchange (both 1901), West's Coffee Palace (1903), Adelaide Fruit and Produce Exchange (1904), Fowlers Lion Factory and the Adelaide Central Market (both 1906), the Municipal Tramways Trust Office and Tram Barn (1908), the Hampshire Hotel (1911), Glenelg Post Office (1912) and Gawler Chambers (1914). This golden age of South Australian brickwork culminated in the soaring red brick Romanesque towers of St Raphael's church at Parkside (1916). Then the momentum slowed with the austerity brought on by the First World War, which was followed by new tastes and the ascendancy of concrete as the predominant inner-city building material.

Helical Tudor revival chimney on a house at Glen Osmond

Red brick bungalow with sandstone veneer front wall

Twentieth century brickwork

In the later twentieth century, bricks became less controversial and less conspicuous; their visibility diminished in major public and commercial buildings, but they were being manufactured and laid on a previously undreamed-of scale in the suburbs. From about 1920, bricks captured the mass housing market, and became the predominant building material of the inter-war suburban sprawl. The two Hoffman kilns of the 1880s had been joined by four others on the Adelaide Hills and plains with a combined capacity approaching half a million bricks a week. Bricks were now the cheapest building material available, delivered on the site. The usefulness of brick had also been extended by the adoption in the late 1890s of the cavity wall - actually two parallel brick walls with a thin air gap between them - which removed the lingering problems of insulation and watertightness experienced by nineteenth century brick walls exposed to the weather.

In 1924 the State launched the 'Thousand Homes Scheme' to finance private home-builders, and in the following ten years State Bank bungalows swept through the Adelaide suburbs. Nearly 1,200 houses were built in Colonel Light Gardens, probably requiring over twelve million bricks in that suburb alone. But the old prejudices were still alive. In many parts of Adelaide it is possible to drive down a street of brick houses dating from the 1920s and 1930s without seeing a single brick house front. What appear to be sandstone bungalows from the street are in fact red brick bungalows with a veneer of sandstone on the front wall.

Some of the Tudor revival bungalows of the 1920s and 1930s brought exposed red brickwork back into fashion for rich and fanciful details: herringbone panels, arched doorways, elaborate porch columns and tall chimneys with helical twists, all derived from American pattern books vaguely based on late medieval designs. The same era saw a rise in the popularity of salt-glazed bricks, attractive dark brown glossy bricks used for plinths, coping and occasionally some elementary diaper patterns in gable ends. Salt-glazing was often used for finishing drainpipes and 'sanitary' ceramic ware. It was done by firing bricks to stoneware temperature and then throwing common salt into the firebox, generating free chlorine which attacked the hot ceramic surfaces in the kiln, leaving them glazed. In the process the brickworks chimney also poured out clouds of chlorine gas over the neighbouring suburbs. For obvious reasons, salt-glazing was banned in South Australia by the late 1930s.

Beyond the mass market, brick was also being used in public buildings in new and imaginative ways. Young's Shoe Shop in Rundle Street (1926) had a distinctive facade built in glazed grey-green brick, a startling departure from the ferric oxide orthodoxy of Adelaide brickwork. The Barr Smith Library at the University of Adelaide (1932) used red brick in an American collegiate style, and the arrival of cream bricks was heralded in the bold modernist design of Adelaide High School (designed in 1940 although not completed until 1951).

In the 1950s, cream brick was taken up enthusiastically by the mass market to become the staple exterior finish of the post-war decades. It was supplemented by the development of brick veneer construction, in which a light timber frame is lined with plasterboard and faced with a single skin of bricks. What appears to be a brick house can be built at little more than half the price of cavity brick, on lighter foundations, with no visible interior cracking. But there is a hidden price to pay in the longer term, because a brick veneer wall combines all the maintenance disadvantages of brick and all those of timber into a single structure.

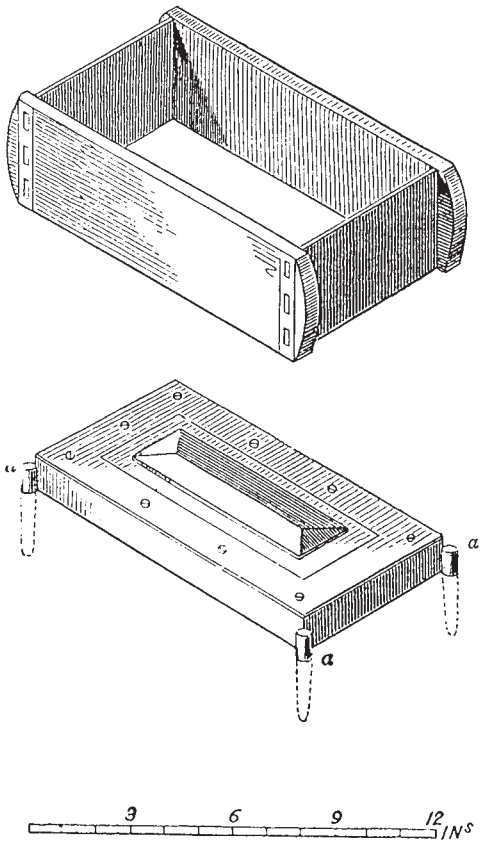
In recent decades, developments in the technology of brickmaking have guaranteed a consistently high quality, and permitted an extraordinarily varied range of styles, colours and textures in ceramic products. Modern houses are built with a variety of coloured bricks, tiles, blocks and pavers which would amaze a nineteenth century brickmaker. The vivid red brick Adelaide Fire Station (1985) made a loud public announcement of the arrival of the new brick age. It polarised Adelaide architectural opinion in a very old-fashioned way, hailed with delight by some critics, but prompting other responses which sounded very much like those which greeted the Museum's North Wing ninety years earlier.

2 EARLY METHODS OF BRICKMAKING

South Australia was settled during a time of rapid technological progress in the manufacture of bricks, and so there was a great diversity of brickmaking techniques used here in the nineteenth and early twentieth century. In general there was a tendency for manual methods to give way to increasingly mechanised methods, but the process was not a simple one, for both techniques remained in use side by side for many decades. While the use of machinery could obviously reduce production labour, the cost of moulding each brick by hand was only one element in brickmaking, and there were many circumstances in which handmade bricks could compete on the market with machine-made bricks. Hand-manufacture of bricks in South Australia persisted at large brickyards such as Halletts until the 1930s, and some special purpose bricks were still being made by hand in smaller brickyards as late as the 1950s.

Handmade bricks

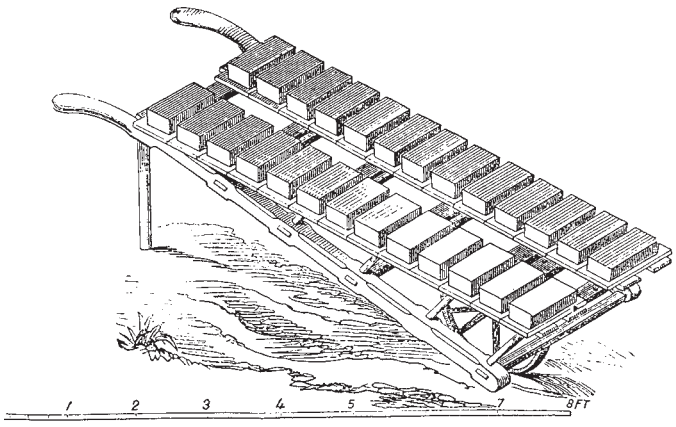
The earliest bricks produced in South Australia were probably those made at the South Australian Company's brickworks established in July 1837 on the bank of the Torrens near Hackney Road, just north of Botanic Park. From here, small brickworks spread down the river, through the city and onto the western plain. The early brickmakers utilised the alluvial clays of the Torrens floodplain, and employed techniques brought from England. The clay was prepared by weathering, soaking and kneading by hand to form a stiff plastic pug. This was delivered by barrow to the moulding table. The moulder sat or stood at the table, and made each brick by taking a mass of clay just a little bigger than required, and throwing it vigorously into a mould which consisted of an open four-sided wooden or iron box which had a removable bottom board called a stock.



Mould and stock for making bricks by hand. (Dobson 1882)

The quality of the brick was determined by the consistency of the clay and the skill of the moulder. The pug had to be plastic enough to spread instantly into the corners of the mould, but stiff enough to dry as quickly as possible and hold its shape during handling. Clay for handmade bricks was usually about 25% water by weight. Depending on the stiffness and stickiness of the clay, it was usually necessary to sand the mould for each brick, or alternatively to lubricate it with water. The excess clay was cut away from the top of the mould with a board called a strike. The mould was then taken by an assistant who up-ended the brick on to a board, and when ten or twelve bricks were lined up, they were wheeled away on a hack barrow for drying.

Thus each moulding table employed a gang of three or four brickmakers whose pace of work was dictated by the speed and skill of the moulder. It is widely claimed that a highly skilled moulder could make 6,000 bricks in a day. Assuming a ten-hour day, that is about six seconds per brick, which is difficult to imagine. In Adelaide the moulders usually took a periodic break from the table by wheeling



A hack barrow. (Dobson 1882)

their own bricks to the hack, and production of 1,200 bricks in a ten-hour day was considered a good rate.

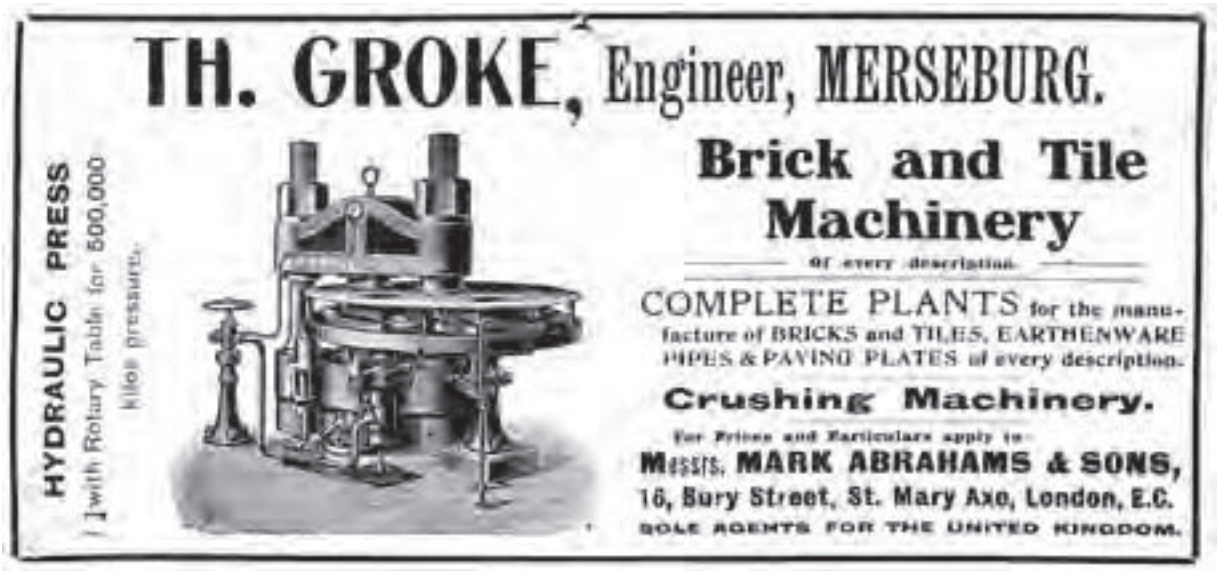
Identifying handmade bricks

There is a high probability of finding handmade bricks in South Australian buildings older than the early twentieth century. Commons are readily identifiable, because most handmade bricks were fairly rough, and show mould marks, air bubbles and poor arrises from the moulding process. There is often a characteristic pattern of creases and folds (not cracks) in the sides of a handmade brick, formed as the clay dragged down the side of the mould. As they were very soft, they often also have hand prints, hack marks and damage from being dropped and handled before drying. Their surfaces may also show the texture of the sand used in the mould. However, carefully made and selected face bricks may not be easily recognised as handmade, for they can be virtually indistinguishable from machine-made bricks.

Top: Characteristic fold marks on a hand-made brick
Above: Hack marks on a hand-made brick

If in doubt, the simplest test for handmade bricks is to measure a number of them very accurately, as they are certain to vary in their dimensions. Even two bricks made in the same mould by the same moulder may differ slightly in their depth, for they will not have exactly the same mass of clay in them, and will shrink to different dimensions during drying and firing. As a brickworks would have a great number of moulds in use - every moulder's gang requiring about four or five at one time - even the best handmade bricks will also vary by a few millimetres in their length and breadth because of slight differences in the mould sizes.

Below: Brick and Pottery Trade Journal 1910



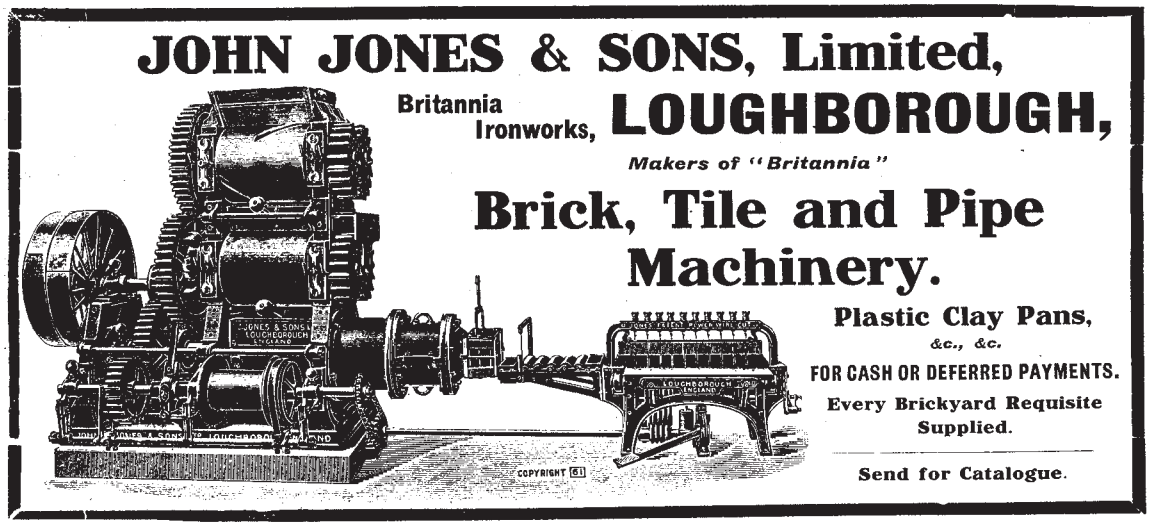
Machine-made bricks

The earliest report of mechanical brick manufacture in South Australia was in October 1840, when Dr Kent began making bricks at Norwood with a steam powered machine of unknown design. It is not clear whether Kent's machine actually moulded bricks, or was simply a mill to pug the clay prior to hand-moulding. This brickworks was short-lived, and over four decades were to pass before machinery began making serious inroads into the trade of the hand-moulder. From the early 1880s onward, the production of bricks in South Australia progressively increased, and large brickyards were established in the western suburbs of Adelaide. Yawning claypits and the tall chimneys of brick kilns dominated the landscape of Brompton, Hindmarsh, Beverley and Welland. The extent to which machines were used in these brickworks is uncertain. Many brickyards continued with hand-moulding, and it was probably not until after the First World War that the majority of South Australian bricks were machine-made.

Nonetheless, a steadily increasing proportion of bricks was being moulded in steam-powered machines by the later nineteenth century. All of these plants have now been scrapped, and business records do not exist for most of the brick-making companies, but advertisements and trade catalogues were circulating, promoting the merits of machinery by the British, German and American firms of Andersons, Bradley & Craven, Britannia, Clayton Howlett, Cottam & Hallam, Grokes, Johnsons, Henry Martin, Murrays, John Whitehead and others. We know that Halletts bought machinery from Thodkinson & Coy in Sydney, Watts at Nairne bought Bradley & Craven brickmaking plant, and the Metropolitan Brick Coy used machinery made by Grokes of Germany. Local foundries also entered the trade; in 1913 John Coumbe & Sons of Kilkenny supplied Halletts' Welland plant with two brickmaking machines which still survive at Beverley, and appear virtually identical to designs in contemporary English catalogues. Another similar machine bought second-hand from Halletts' Torrensville plant is at the Bowyer brickyard at Wattle Flat.

There were several distinct methods of mechanical manufacture, but three techniques were most common. Two of these involved the use of wet plastic clays, but treated it very differently: one squeezed it into a mould, the other extruded it like oblong toothpaste and then cut it into regular blocks. A third method also involved moulding, but used stiff plastic clays or dry shales as the raw material.

Brick and Pottery Trade Journal 1910



Wet plastic pressed bricks

The alluvial clay deposits of the Adelaide Plain were suited to the production of bricks by wet plastic methods; that is from clay which had been tempered and mixed to a relatively soft puggy consistency. Clays for machine manufacture were stiffer than for hand-making, but still contained 15-25% water.

The first plastic method, patented in Britain in 1825, took several forms, but essentially imitated the techniques of the hand-moulder. Clay was deposited from a pugging machine in measured quantities into one of a number of metal moulds and subjected to pressure. The mould moved in either a reciprocal or rotary motion to a new position, where a piston forced the brick out, and the mould was ready for refilling. Machines of this kind could produce over 10,000 bricks in a day, and their product was generally more consistent and highly finished than a hand-moulder's. But they had the disadvantages that the clay required a lot of preparation before moulding, and being very wet, the brick was liable to damage in handling, shrank a great deal, and was slow to dry. While there were experiments with wet plastic moulding machines in South Australia, they were never very popular.

Extruded wirecut bricks

A more common method of brick manufacture was by wirecutting, a technique invented in Britain in 1836. Wet plastic clay was extruded from the pugging machine through an aperture which produced a continuous rectangular stream of clay the dimensions of the flat side of a brick. This was cut into bricks at regular intervals by a number of wires either stretched across a frame, or forming the spokes of a rotating wheel. A single machine could produce 12,000 to 18,000 bricks in a day.

It is not certain when wirecutting was first used in South Australia. The oldest machine-made bricks known to exist here today are in the

Cracking pattern on a wire-cut extruded brick

extensions at the Burra smelter site, built in 1849-53; some of the bricks in the smokestack appear to be wirecut. So wirecutting may have been introduced to South Australia by 1853, but was not in common use for mass production of bricks in Adelaide until the early twentieth century. It was an excellent cheap method of forming commons, but was not suitable for face bricks. Wirecut bricks were not attractive in appearance, and were slow drying. Further, the bricks as they came from the wire did not have frogs, and could not be impressed with the maker's trademark.

Re-pressed bricks

To remedy some of these deficiencies, wet plastic bricks were sometimes placed in an iron mould when partially dried, and subjected to very great pressure. This disguised their wire marks, gave them a highly finished appearance with sharp arrises, and could also be used to add a frog and a manufacturer's brand. At

Re-pressed brick from the Metropolitan Brick Company c1903

some brickworks the bricks were returned to a machine press for the operation, while at others a portable lever press was wheeled around the hacks. This extra pressing converted commons to face bricks, but the additional handling added greatly to their production cost.

Identifying wet plastic bricks

Wirecut bricks are easily recognised by the distinctive marks left during the manufacturing process. The process of extrusion through a smooth opening usually leaves a fine, smooth-textured surface on four faces. However, sometimes grit in the clay makes parallel drag marks on these four sides of the brick while it is being extruded. The metal wires leave curved impressions on the other two faces, usually the largest ones, during cutting. The dimensions of wirecut bricks will be uniform in their length and breadth which are formed by extrusion, but will vary slightly in their depth because of irregularities in the spacing of the cutting wires. They never have frogs, and being soft, will show hack marks and sometimes hand prints. However these characteristics are normally only visible on commons, for re-pressed bricks lose all this evidence.

Bricks which have been re-pressed are identifiable by their regularity. They will be hard and smooth with sharp arrises, and will be consistently uniform in their dimensions. Usually they have a frog or a maker's name on one (occasionally both) of the large faces, and being hard, will not show hack marks. It is normally impossible to tell what initial manufacturing process was used before the second pressing.

Stiff plastic bricks

In the Adelaide Hills, shale deposits provided the raw material for a completely different manufacturing process, originally developed in the USA in 1843. Dry shale was crushed to a fine powder, mixed with a minimum amount of water (10-15%), then forced into a mould and subjected to great pressure to form a brick. Stiff plastic machines were in use in South Australia from the early 1880s onward and could each produce about 10,000 bricks in a day. They were somewhat rough and ready in their operation, and there was a high wastage rate from badly-made bricks in the early years, but they also had very great advantages. The shale deposits that were mined for brick material were of uniform consistency, and free from stones and other foreign matter, so that the preparation costs before moulding were very low. Further, the bricks had less water content and required little drying. Stiff plastic pressing was usually adopted when the large Hoffman kilns were built, and has been a common brick manufacturing method since the early twentieth century.

An even simpler process, called dry pressing, used shales with only 5-10% water content at some Hills brickworks. These bricks had the advantages of no drying shrinkage at all, and no drying time; they could be taken straight from the press to the kiln. However, because suitable shale deposits are rare, this process was rarely used in South Australia.

Identifying stiff plastic bricks

Stiff plastic bricks are usually distinguishable by their regular dimensions. Like re-pressed bricks,

Star cracking on a stiff plastic brick

all the bricks from one mould are normally completely uniform; many of the bricks in a wall will be exactly the same size. The surface usually has a hard glossy appearance, and is often marked by fine cracks. There may be star patterns of cracks where the clay has shrunk around stones in firing. Being hard, they will not usually show hack marks or handling damage.

Firing

Clay bricks must be fired or burnt at high temperature to bring about the chemical changes which make them hard and durable. The firing is done at temperatures in the range 900-1,250°C typically about 1,000°C. Generally speaking, the higher the temperature reached, the more durable the bricks.

The early Adelaide brickmakers burnt their bricks in the open in a large heap, called a clamp, with firewood or sometimes coal intermingled as fuel among the bricks. The clamp could be thought of as a kiln which was built of the bricks that were to be fired. Temperatures were difficult to control, and the quality of the bricks produced in this way was unpredictable, and generally poor. About a fifth of the bricks in each clamp were destroyed by the firing process or were insufficiently fired and had to be done again.

As the industry expanded, permanent kilns were built. The first ones were of the intermittent type, that is, they had to be loaded, sealed, heated, cooled and unloaded for every firing, so the kiln was only in use part of the time, and was subject to intermittent heating and cooling. Many were of updraught design, either circular or square in plan, with the furnace at the bottom and the flue at the top. One simple version of the updraught model was called the Scotch kiln, simply a square box open at the top, with firing ports around the base. Updraught kilns were wasteful of fuel, because a large proportion of the energy produced was simply vented into the sky, and so in time the downdraught kiln replaced them.

Scotch kiln at Bowyer brickworks

The kiln designs that eventually became most popular in South Australia were the downdraught types, sometimes circular, but more often rectangular in plan with a vaulted roof. Furnaces at the sides sent the hot gases up the walls, but they then had to flow downward between the bricks to exit via flues in the kiln floor which led underground to a chimney stack nearby. This design was more efficient because the flame spent more time in contact with the bricks. The downdraught kilns were reliable and long lasting, and produced attractive and well-fired bricks. There are a number of downdraught kilns still standing; some which were constructed in the early twentieth century are still in use in the ceramic industry.

It is uncertain when downdraught kilns first came into use in the brick industry, although Watts brickyard at Nairne built its first one in 1888. Dr Miles Lewis of Melbourne has pointed out that there is apparently no known case of a downdraught kiln in use at an Australian brickworks prior to the introduction of Hoffman kilns. This may be true of South Australia, for none are known to have been used here before the 1880s. The vaulted downdraught kiln does somewhat resemble a section of a Hoffman kiln, and this may indeed have been the inspiration for the design.

Imported coal or coke was adopted as the fuel in most large brickworks, although the downdraught kiln design worked better with a long flame, and hardwood remained the preferred fuel in these kilns. The downdraught kilns had a fuel-to-load ratio of about 1:5; that is a ton of fuel was required to fire five tons of bricks. In the 1940s many brickmakers converted from coal to oil firing, and since the 1970s natural gas has been used almost exclusively as the fuel of the South Australian brick industry.

Hoffman kilns

There was a fundamental change in the technology of brick manufacture with the introduction of continuous kilns. The Hoffman kiln, the continuous kiln design most often used in Australia, was invented in Germany in 1859; its genius was that the fire was never put out, but was progressively led around from one part of the kiln to the next. The principle of the Hoffman kiln anticipated twentieth century mass production, but instead of the product being brought to the process as happened on a Ford assembly line, the process was brought to the product.

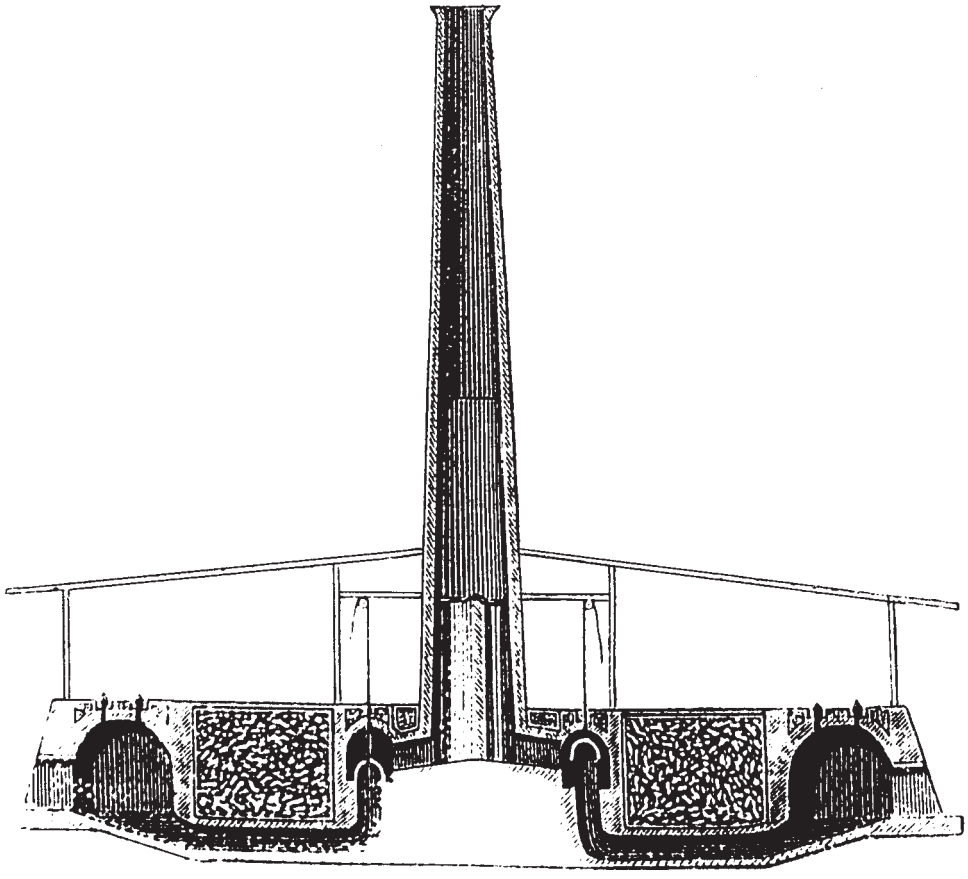
A Hoffman kiln had one long vaulted chamber which could be divided into smaller compartments by temporary stoppings. Above the firing chamber was a gallery with rows of firing ports in the floor, which were fuelled by sweating stokers hauling barrows of coal. Underground flues connected all parts of the firing chamber to a central chimney stack. The bricks were fired in a continuous cycle whereby at any moment, part of the kiln was being

Fire ports of a Hoffman kiln at Allenby Gardens (demolished 1990)
Interior of a Hoffman kiln at Torrensville (Heritage SA files)

loaded with dried bricks, part was being pre-heated, part firing, part cooling, and part being unloaded and made ready to receive the next load. The original Hoffman kiln design had a circular plan, but they were more usually built in South Australia as a rectangular plan, with straight parallel sides but semi-circular ends.

The Hoffman kilns introduced an economy of scale which brought about a dramatic improvement in the efficiency of brick manufacture, and they dominated the brickmaking industry in South Australia from the First World War to the 1970s. They were enormous, holding up to 300,000 bricks for a single firing. They were also very efficient. Wastage of bricks in firing was negligible, and Hoffman kilns had an enviable fuel-to-load ratio of about 1:20, or twenty tons of bricks fired by every ton of coal. All the major brickmaking companies had to

Hoffman Kiln at Torrensville, now the Brickworks Market (Heritage SA files)



Section of a Hoffman Kiln (Dobson 1882)

Circular downdraught kiln at Beverley

keep up the brick supply to these monsters by installing wirecutting or pressing machines, and so the capacity of the Hoffman kilns encouraged the mechanisation of the brick industry. The efficiency of the Hoffman kilns and the mechanisation that accompanied them was the economic breakthrough that brought brick construction into the mass housing market.

The first Hoffman kiln was built at Blackwood in 1882, and eight others were eventually built in the Adelaide metropolitan area. A second went up at Brompton in 1884, four were built between 1911 and 1913 - three of these by Job Hallett & Son - two more appeared in the 1920s, and the last one was built at Glen Osmond in 1951. The last Hoffman kilns went out of service in the early 1980s, a century after the first one was built in South Australia, and all but one have been demolished. Since the 1960s Hoffman kilns have been replaced for the most part by continuous tunnel kilns, where the kiln remains at a constant temperature, and the ceramic product passes slowly through it on a moving trolley.

Brick making machine from Halletts Welland plant (1913) now at Beverley Museum

Remnant Brickworks

Most of South Australia's Hoffman kilns have been demolished, two at Glen Osmond and Allenby Gardens (Welland) as recently as 1991 and 1993 respectively. The only place to see an intact Hoffman kiln in Adelaide today is at the Brickworks Market at Torrensville, where one of Job Hallett & Son's kilns (1913) is preserved as part of the market complex.

The City of Charles Sturt has established a brickmaking museum on the site of the former James brickworks at Beverley (c.1912-1974). There are three vaulted and one circular downdraught kilns still standing there (the circular kiln is the only one of its kind left in South Australia) as well as two brickmaking machines and some other plant which came from Halletts Allenby Gardens (Welland) brickworks (see p 22). This, the last of South Australia's historic brickmaking machinery still in situ, survived remarkably intact, housed in its original two storey building at Allenby Gardens (Welland) until 1994.

Vaulted downdraught kilns are the most common form left in South Australia. There are several still in use at Littlehampton and Nuriootpa. Three still stand at the deserted Lobethal brickworks, and there is one at the Armagh brickworks near Clare. Two others at Poonindie near Port Lincoln were demolished in 1988. All of these kilns are on private property.

There is a very rare Scotch kiln intact at the Bowyer brickworks at Wattle Flat on the Fleurieu Peninsula, as well as a brickmaking machine which was bought from Halletts 1913 Torrensville brickworks when it closed in the early 1980s. These relics too are on private property.

3 CHARACTERISTICS OF EARLY BRICKS

Dimensions

Bricks have tended to become more and more regular in their size as the industry has become increasingly mechanised, but even so the dimensions of the bricks used since the settlement of South Australia have varied surprisingly little. Early bricks tended to be somewhat longer and thinner than modern ones, typically perhaps 245 x 110 x 60mm. By the late nineteenth century their size was about 220 x 110 x 70mm, which with the addition of an allowance for a mortar joint on each side, was 9 x 4.5 x 3 inches. Bricks remained at about that size until metrication in the 1970s standardised their dimensions to 230 x 110 x 76mm.

Bricks in early Adelaide buildings will rarely be found outside the size range:

length	205-245 mm
breadth	108-115 mm
depth	60-70 mm.

The variability of the sizes of individual bricks made by some processes in early South Australia is more noticeable. Handmade bricks, even if all from one batch and used in one building, were likely to have been formed in a number of different moulds. A large brickworks may have had a hundred or more moulds in use at one moment, all varying slightly in dimensions. Remember that there was no good reason to make all bricks the same size.

After moulding, bricks shrink as they lose moisture in the drying process, and then again in the kiln as they are fired. They may decrease in size by as much as 10% of their original linear dimensions between when they are moulded and when they are laid in a wall. In theory, all the bricks in a batch should shrink by the same amount, but in practice there will be variations in the moisture content of the clay and the temperature of firing which will cause differential shrinkage. Thus even bricks made by relatively sophisticated

Kiss marks on a modern brick

mechanised processes will also show some variation in size.

Measurement of the dimensions of a number of bricks will provide useful information about them. If they are notably irregular in size, they are likely to be early and handmade. Generally handmade bricks from the same mould will have two fairly constant dimensions, and the third will be more variable. Averaging the dimensions of a batch of irregularly sized bricks may help to differentiate them from another irregular batch, by making it possible to compare the size ranges rather than the individual bricks.

Hardness

The hardness of bricks may be influenced to some extent by the quality of the clay used, but is generally a function of the firing temperature. As more controlled and hotter firing processes normally accompanied more highly mechanised production methods, better moulded bricks are usually also better fired and more durable. After the late nineteenth century, most brickworks in South Australia produced a good quality product. Many of the earlier handmade bricks however were quite soft, some so poorly fired that they were friable to the touch. Naturally the ones that survive today in exposed locations tend to be those of better quality; most of the poorer bricks have vanished long ago. Early poorly-fired bricks may sometimes be found to survive in places within a building that have been protected from the weather and from rising damp.

Vaulted downdraught kiln at Beverley

Colour

The colour of bricks varies a great deal, because it is affected by the composition of the clay, the temperature of firing, and the chemistry of the atmosphere in the kiln. Most people are familiar with bricks that are orange-red in colour, and this typical 'brick red' is characteristic of ferric oxide, formed by iron in the clay when it is fired in an oxidising atmosphere. Generally the more iron present, the richer the red colour. The presence of other elements will also affect the colour: more calcium will make bricks paler, manganese may make them a dark purple. Some early Adelaide bricks are pale yellow ochre in colour - apparently made from a clay very low in iron oxides - and have lumps of 'breeze' (coke) visible in the clay.

In addition, the same clay fired at different temperatures may produce quite differently coloured bricks. The amount of oxygen and other gases present in the kiln will further determine whether the bricks are oxidised or reduced, and this will affect their colour: rich orange or red bricks are always oxidised, but the same bricks fired in a reducing atmosphere (one that removes oxygen) may be a dark grey or brown. Wood-fired bricks are normally brighter in colour than those fired with coal. As conditions will vary from place to place within the kiln in one firing, depending on how the bricks are stacked, and how the kiln gases flow around them, there may be considerable colour variation even in a batch of bricks made from the same clay and fired in the same kiln on the same day. Even a single brick may show colour variations caused by other bricks touching it or being very close to it in the kiln and so affecting the gas flow over its surface. These are called kiss marks.

The colour of bricks tended to vary erratically in the early decades of settlement, but has become more and more uniform as the industry has gained greater technical control over the manufacturing process. It is now possible to produce load after load of identical bricks, something nineteenth century brickmakers could only dream of. However, modern bricks can also be deliberately manipulated to produce colour variations for decorative purposes.

Dating bricks

People are often tempted to use brick manufacturing processes as an aid to dating the buildings in which they were used, but as a diagnostic tool this method is fraught with a number of difficulties. It is certainly true that there were general characteristics of bricks which altered over time, but many things stayed the same, and many different processes were in use simultaneously for very long periods.

Generally speaking, bricks have tended to become harder, better finished, less brightly coloured, more uniform in appearance and more regular in size as the technology of brickmaking has improved with the passage of time. However there are so many exceptions to this tidy observation that it becomes useless to attempt to apply it to any individual building in practice. We know for example that Dr Kent was making bricks at Norwood with a steam powered machine of unknown design in 1840, and so we are forced to assume that any building constructed in South Australia since that date just might be of machine-made bricks. But Watts' brickworks at Nairne was still making some special bricks by hand in the 1950s, so we must equally well assume that until that time any local building could be of handmade bricks. Thus, far from being a clean-cut division between hand-manufacture and machine-manufacture, there was in fact an overlap of 110 years during which the two technologies existed side by side.

All we can reliably keep in mind to guide us are the generalities. Until about 1882, nearly all bricks in South Australia were handmade, and fired in small kilns. Then from the 1880s onward some bricks were machine-made, and fired in large kilns. From the time the big machines and the Hoffman kilns came to dominate the industry after about 1918, very little changed in the South Australian brick industry until the 1950s. Alas, even this

Occasionally a brick is stamped with a date like this firebrick which has the stamp 'LACKMANNAN 1846'.

Hand-made brick for William Peacock's tannery (1840)

The Kangaroo Island China Stone and Clay Company made high quality bricks at Penneshaw from 1907-1910

Special brick used for cornices or other decorative details

simple sounding process of development can look very blurred when one is facing a wall of anonymous bricks.

Documentary evidence can yield more information. If bricks show a maker's name, a search of trade directories in a public library may quickly turn up the years in which that manufacturer operated under that name. That of course will give the years in which the bricks were made, not necessarily those in which that building was built. And it should always be remembered that old bricks are re-used in new buildings, and that bricks are routinely taken out of and inserted into walls in the course of modification and maintenance. Very occasionally, a brick may be found that is imprinted or scratched with a date. But usually, bricks can only be relied upon to provide relative rather than absolute dating.

Relative dating means that the bricks will give us evidence that one building was built before another, or that parts of one building were built at different times, but they cannot usually tell us what the dates of those events were. Bricks do their best service for the historian when they are taken in a generous sample and a number of them are observed and measured as a group. If the bricks in one wall of a building appear to be hand-moulded and on average 240 mm long, while those in another wall appear to be machine-pressed and roughly 220 mm long, it is reasonable to suppose the walls were built at different times, and perhaps to infer that the pressed bricks were probably made later. To try to do more than this with the evidence of the bricks alone is risky. But a study of bricks and brickwork can contribute information which, when taken together with knowledge from other sources, can be of great assistance in historical research. The following cases exemplify some ways in which the study of bricks and how they are laid can contribute to our knowledge of a building's history.

Case studies

Beaumont House, Glynburn Road, Beaumont

At Beaumont House, which is built predominantly of brick, there is a stone room projecting to the rear of the house. Local tradition said that this was a very early cottage which was on the site before the brick house was built about 1850. (There is a tendency in South Australia to assume that stone parts of a building are older than parts built in other materials - this assumption is frequently wrong.) The National Trust wished to interpret the history of the house for visitors, and commissioned an architectural historian to determine the sequence of building construction. This proved to be a complicated task, involving documentary and pictorial evidence as well as a physical examination of the building.

One crucial piece of evidence came to light when plaster was chipped off the interior wall of the stone room that abutted the rest of the house. This wall proved to be of brick, well-finished in face bricks, with its mortar pointed up just as it was on the other exterior walls of the building. The wall had unmistakably been built as an exterior wall, establishing that the stone room was a later addition to the house.

South Australian Company Buildings, Rundle Street, Adelaide

The South Australian Company constructed a hotel and commercial buildings in Rundle Street East in the nineteenth century (now the Austral Hotel and the row of shops immediately to its west). The building was erected in two stages, in 1879-80 and 1882-83, but the observer standing in Rundle Street can see no sign of this, for it presents a uniform and uninterrupted face in the streetscape. The building's facade is of superior quality sandstone ashlar, and the join between the two construction phases has been handled with impeccable skill.

However, the two phases of construction are revealed by the details of the brickwork at the rear of the building. The York Street frontage is of bluestone with red brick quoins and window surrounds. At first glance the two phases of construction appear indistinguishable, using the same stone and the same bricks. But there is a subtle variation in the brickwork. A series of wings project to the rear of the building, and at their corners there are quoins, indented in bands five courses high and two brick lengths wide at their widest. The 1879 bricklayer began every quoin with two stretchers, then in the second course laid a header, a stretcher, and another header to form a bond, then added another course of two stretchers and so on up. In 1882 the bricklayer reversed this sequence, consistently beginning each quoin with a stretcher and two headers, then using two stretchers for the second course. This sort of fine construction detail would rarely be specified by the architect, but would normally be left to the bricklayer's discretion. In the absence of documentary and photographic information (which does exist for this building), such a detail might provide the only evidence of the two phases of construction.

Saint Mary's College, Franklin Street, Adelaide

Architects were carrying out a study of the college's building history, prior to planning conservation work. They found there was ambiguity in the physical evidence of the sequence of building construction, and the documentary record was not sufficiently complete to make sense of it. In this case a careful study of the bricks helped to answer some questions. Analysis showed that the bricks used in five structures in the college grounds appeared to have come from only four different sources; in other words, two lots of bricks were identical. All the bricks were handmade and wood-fired, but those in the original convent building (brick type 1) were of a fine muddy clay and quite friable. The bricks in the cool room (brick type 2) and the gateway arch (brick type 3) were both harder bricks showing fine quartz particles, but the average dimensions of the two lots of bricks and the colour of their quartz particles were noticeably different.

The bricks in the refectory (brick type 4) and the chapel (brick type 4) however, appeared to be from the same source. They were in the same narrow average size range of 229-232mm x 107-108mm x 63-64mm, they were hard, uniform in colour, and showed identical coarse white quartz particles. The conclusion was that both lots of bricks had been made in the same brickworks within a short period, and this led logically to the probability that the two buildings had been built at about the same time. This proved to be a useful clue in making sense of the other physical evidence.

Heritage Hotel (former Colonel Light Hotel), Light Square, Adelaide

Public controversy arose over the Colonel Light Hotel when a developer planned to demolish it. The conservation lobby claimed the building was the old Shamrock Hotel originally built in 1849, which would make it one of the oldest surviving hotels in South Australia. There was some scepticism about this claim, for the hotel's stylistic details appeared to be characteristic of the 1890s, and the building was unusual in being built almost entirely of brick, which also suggested a date around the turn of the century. Conservationists replied that although the hotel had been superficially modified, the 1849 building was still substantially intact underneath.

The hotel was thoroughly inspected to determine the extent of the modifications to the original structure. Surprisingly, the inspection revealed that the bricks used in the building from the tops of the gables down to the very lowest course of the foundations were absolutely uniform in manufacture. This implied that the existing building had all been built at the same time, and in fact had undergone very little significant modification since. The bricks were handmade, but with modern dimensions; they conformed to a narrow size range and were of high quality. The face bricks were wood-fired, but the commons appeared to have been coal-fired. This suggested they had come from a large brickworks with a Hoffman kiln and had probably been manufactured within fifteen years either side of the turn of the century, which reinforced the stylistic evidence.

However, in the hotel's cellar was a well, which was lined with very different bricks. These were longer and shallower in dimensions, handmade from a soft dark brown muddy clay and wood-fired. They appeared to be much older than the rest of the building. Documentary research subsequently confirmed that a hotel had indeed been built on the site in 1849, and the bricks in the well may be from that date. Both a lease indenture and Council Rate Assessment Books established that the original hotel had been completely demolished in 1898, and the present building constructed the same year. In this case, when the evidence was all in, the style of the building, the documents and the information from the bricks all pointed to the same conclusion.

4 CONSERVATION OF EARLY BRICKWORK

General maintenance

Bricks are a form of masonry, like stone, and they are likely to suffer generally similar conservation problems. There is relatively little specialist conservation advice available for brickwork, but much of what has been written about stonework applies with some modifications. (Refer to Technical Note 3.6 Stone Masonry in South Australia.)

Bricks have the advantage over many other building materials of being relatively inert chemically. They do not rust or rot, water has little immediate effect on them, they are impervious to fire, and fungus and insects do them very little harm. The most common conservation problems likely to affect bricks are the slow effects of simple damp, which are treated at greater length below.

Another advantage of bricks is their modular nature. As brickwork is made up of a large number of identical parts, it lends itself to small repairs by the relatively simple process of removing bricks and replacing them with new ones. Bricks that have become damaged, decayed or disfigured can be removed from the wall, cleaned of adhering mortar, and replaced in position with a new face exposed. Brick replacement is a useful tool in the conservation of brick buildings.

It may be considered desirable to clean bricks that have become discoloured by a coating of dust, soot, mildew or exhaust fumes. However, the outcomes of cleaning should be thought through carefully, because there is a downside. Cleaning may not work, it presents a risk of damage to the brickwork which may be more disfiguring than the dirt, and at the very best it simply turns the clock back so that the process of discolouring begins again immediately. Cleaning brick masonry should be approached in much the same way as cleaning stonework; it should be undertaken only if it is really necessary, and if it can be done without damage to the building fabric. The aim of cleaning should not be to make the wall look new again. (Refer to Technical Note 3.5 Cleaning of Masonry.)

Before commencing any cleaning operation it is important to test the proposed technique on a small unobtrusive area to determine whether it will work, and what the outcome will look like. The cleaning techniques used should commence with gentle washing or misting with clean water, which should be sufficient to remove dry dust and soot. If the bricks are stained with a greasy deposit, warm or hot water and a suitable detergent may be used. Any change in cleaning technique should begin with testing on a small scale. (Refer to Technical Note 3.5 Cleaning of Masonry.)

If it is necessary to scrub the wall to remove dirt, manual washing with a nylon bristle brush is the most vigorous cleaning technique that should be used. Do NOT use metal brushes, abrasives, high water pressure, grit blasting or any form of power tool on brickwork. Bricks and mortar are simply too soft to withstand these techniques without serious damage.

If there is lichen or other organic growth present on the wall, it should respond to the same cleaning techniques: washing the wall, if necessary with warm water and some detergent, then brushing or scraping with nylon tools. Lichen is unlikely to harm brickwork, but growth over an extensive area may inhibit evaporation and retain dampness in the wall.

It is important to maintain the other building elements that come with brickwork. Brick walls were frequently bound together with hoop iron ties, thin metal straps laid in the mortar to give tensile strength to the brickwork, and resist any tendency for the wall to lean outward at the ends. The ends of these ties can sometimes be seen protruding and folded down at the building corners. If the ties deteriorate to the point where they break, there will sometimes be some resulting movement in the brickwork, although this will rarely be sufficiently serious to require remedial attention. Sometimes as the ties rust they may swell, and assist in opening up a gap between brick layers. In this case it is usually necessary to rake out the affected joints and the rusted ties, and re-point the joints.

In cavity walls, it is important to preserve the integrity of the cavities, because they both insulate the house and help keep damp from penetrating to the interior. Sometimes mortar or rubbish will be found to have fallen into the cavity and bridged the gap. The space of the cavity is maintained by ties of galvanised steel, which may also rust and deteriorate, and this will occasionally lead to movement in the wall. These problems can be repaired by taking out bricks from the wall to clean out the cavity and replace damaged ties, but this is work for an expert bricklayer.

Brick walls were designed to have free air circulation within the wall cavities and

under the floor, and most brickwork has regularly spaced ventilating panels of decorative terracotta or cast iron along the tops and bottoms of walls. If this ventilation is obstructed, by dirt or leaves, too many paint layers, or thoughtless renovation, the building will suffer. Moisture will build up in wall cavities, leading to damp in interior walls. Inadequate ventilation under the floor can lead to fungal decay in floorboards and other timber. Regular checking and maintenance of all ventilators is an essential part of keeping brick buildings healthy.

Cracking

Many people become alarmed when they notice signs of cracking in their brick building. It is almost inevitable that there will be some slow cracking in a masonry wall, because the bricks and mortar have little tensile strength - that means they cannot stretch - so that any tiny shift in the ground under the foundations will cause a crack to open in the walls above. Buildings on parts of the Adelaide Plain may be particularly vulnerable to cracking because of the clay soils on which they stand, which react to changes in moisture content by expanding or contracting. Ironically, the same abundance of local clay that allowed many of the houses to be built in the first place is responsible for the cracks in their walls in later decades.

In a brick wall the cracking will usually show up as lines running diagonally through the mortar joints, typically down from the upper corner of a wall, or diagonally upward from the corners of a door or window. Although it may appear unsightly, a crack even as wide as ten millimetres is not likely to cause any significant problems to a masonry building. Cracking is usually an aesthetic issue rather than a structural problem.

Thin, slow-moving cracks in brick walls are completely normal. A sudden increase in the number, length or width of cracks in a brick wall, cracking that is accompanied by a wall leaning inwards on one side of it, or cracking that suddenly leaves the mortar and travels through the bricks, may be cause for concern. It would be wise to consult a conservation architect before attempting to remedy problems of this kind.

Rising damp

Rising damp or ground damp, or what many South Australians know as 'salt damp', gives rise to common conservation problems in all forms of masonry, brick as well as stone. Most bricks are porous; they allow water to soak into them and to evaporate from them. When brickwork is in contact with the ground, they soak up some of the water that is in the soil. Some of that water then evaporates from brick surfaces that are in contact with the air. A hydrological flow is set up, with water continuously moving upward from the ground through tiny spaces in the bricks by capillary action, and evaporating from the surface of the wall. Problems arise because the water contains salts in solution, and they cannot evaporate with the water. They remain behind, forming crystals on the brick surface, and in a layer just under the surface. The growth of these crystals can exercise powerful forces, which cause mechanical damage to the bricks by levering small particles off the surface. The result is a zone or line of damage, usually roughly horizontal, where the brick surface is loose and crumbly, and particles can be seen falling off onto the ground. (Refer to Technical Note 3.8 Rising Damp and Salt Attack.)

Any attempt to deal with rising damp by stopping the water coming OUT of the wall will fail; the forces involved are too great to bottle up. The only successful approach is to limit the water going INTO the wall, and the first step is to find out why it is happening. Buildings should have a damp proof course of impervious material built into the walls to intercept the flow of water. Many materials have been used for damp courses: slate, ceramic tiles, bitumen and sand, sheet lead, even glass. However, nineteenth century South Australian buildings did not always

Characteristic effect of salt attack on brickwork

Salt attack has been worsened by the use of hard render in an attempt to seal in damp

Ceramic dampcourse in a stone wall. Note the decayed stone under the dampcourse. The concrete path has covered the damp course at right, and is allowing water to enter the wall

have them, apparently because the early builders misunderstood the implications of the dry climate; or the building may have a damp course which has deteriorated, or been damaged. The ground level may have been raised, allowing water to enter the wall above the damp course. Laying concrete paths or aprons around a building increases the water flow in the walls. Blocking the ventilators in brickwork may have caused moisture to build up in wall cavities and underfloor spaces, increasing the load on the walls, or there may be water entering the wall from a controllable cause such a lawn sprinkler, or a leaking pipe.

If the problem cannot be alleviated by attention to all these matters, then the remedy must come from the affected wall itself. At this point it would be wise to consult a specialist such as an architect experienced in conservation. Do NOT attempt to seal moisture in the wall by rendering, painting, or using a hard concrete mortar. All these methods will make the problem much worse by increasing the load on the softer brickwork still exposed The best remedy is the exact opposite: remove all render, paint and hard mortar which is preventing water evaporating from the surface, and spread the evaporation over the largest area possible. If the bricks are set in a hard mortar, then it would be desirable to rake it out as deeply as necessary, and replace it with a soft lime mortar.

Spreading the evaporation load should be tried for a period of time before investigating the more expensive options such as inserting a damp course into the wall or injecting water-repellent compounds. These should be contemplated only after considering expert advice.

Falling damp

Not all damp problems come from the ground. Rising damp usually affects large areas of a building. If brickwork is affected by damp only in patches, there is usually a more local cause of water penetration. Old brick walls without a

cavity may be waterproofed with a lime wash or render, and if this deteriorates it will allow water into the interior. Cavity walls rely on the air gap for their watertightness, and if damp appears as a patch on an interior wall, it may be that something has fallen into the cavity and bridged the gap. Water penetration at the top of a brick wall, from a leaking gutter or damaged flashing, may cause decay. At any point where brickwork penetrates a roof, the flashing along the exposed bricks is a potential weak point in the wall's defences. Party walls and parapets which are exposed to the weather should be capped with mortar or coping or metal flashing, and if any of these decay they will allow water into the brickwork. Flashing was traditionally done in lead, but in the early twentieth century there were experiments with cheaper substitutes such as malthoid, which will now be badly deteriorated. Water from any one of these causes may cause the same fretting and crumbly surface as rising damp, but it is unlikely to appear in a horizontal zone along the wall, the characteristic mark of damp coming from the ground.

The result of using soft bricks with hard mortar

Water penetration vertically into the bricks or mortar at the top of a masonry wall is always a cause for concern, as it will cause rapid deterioration of the brickwork.

Efflorescence

Efflorescence is a white powdery substance that appears on the surface of bricks. It consists of crystals formed by the salts left behind after the evaporation of water. All bricks have water in them, and that water will contain some soluble salts, so a small amount of efflorescence is normal in new brick walls. It is usually harmless, and should stop after a while. It can be wiped or washed off the surface, but remember that vigorously hosing down the wall will soak the bricks, and probably result in another episode of efflorescence as the water evaporates. If wiping off the efflorescence reveals a crumbling brick surface underneath, then it should be treated as rising damp.
Efflorescence that takes the form of curved lines roughly parallel with the outline of the brick is coming out of the mortar joints, and means that the water, lime or sand in the mortar contained a high proportion of salt. Efflorescence should be a short-lived phenomenon in new bricks. If it persists for years, or appears for the first time on an old wall, it is an indication that something has changed in the wall's hydrology. Either more water is moving through the wall, or the water has become charged with more salt than previously. Sources of rising and falling damp should be investigated.

Pointing

In a well-built brick wall, deterioration should happen more quickly in the mortar than in the bricks. The wall is designed to have its mortar repaired or replaced relatively simply, and this is a normal, although infrequent, part

Rising damp will sometimes attack bricks unevenly. Note the deterioration of mortar

of the maintenance of a brick building. A wall is re-pointed by first raking out the deteriorated mortar from the joints with a raking tool for a depth of about 12mm, or deeper if necessary until solid mortar is visible. Then the wall is simply pointed again just as it was done when it was first built.

It is important that the replacement mortar match the hardness of the old mortar, or that it be no harder than the old mortar. Nineteenth century mortar normally consisted of nothing more than lime, sharp sand and water, a mixture which we now call lime mortar or soft mortar. In the early twentieth century, bricklayers began adding about 10% cement to mortars exposed to the weather. Any more cement than that is likely to be damaging to bricks. In the 1940s the practice developed of using cement mortars, that is pure concrete, on some industrial buildings in the belief that the walls would be more durable. The result today is walls with the hard mortar still intact, but reduced to a honeycomb around the holes where the bricks have decayed.

In more recent decades there have been misguided attempts to cure rising damp by re-pointing the walls with harder mortar. The results are invariably disastrous; the impervious mortar forces the wall's entire evaporation load onto the adjacent bricks, accelerating their deterioration. Generally speaking, the softer the mortar, the longer the bricks will survive.

Replacing bricks

Bricks will often be seen to be weathering unevenly in a wall. Sometimes a local source of damp such as a leaking gutter may prove to be the cause, but on other occasions a patch of brickwork, or even a single brick, will inexplicably decay faster than those surrounding it. These cases are probably due to variations in the brickmaking process; a lower firing temperature in part of the kiln, or greater salinity in a batch of clay.

Decayed bricks may be removed from a wall simply by raking out the mortar to a depth where the brick comes away freely. (Another reason to avoid using hard concrete mortar is that it is almost impossible to rake out without damaging the bricks.) The brick can then be replaced by a new one, or sometimes it is possible to clean the brick, turn it through 180˚ and re-insert it in its position. There are brickworks that specialise in supplying reproduction bricks for people carrying out maintenance of brickwork, but matching the sizes and colours of old handmade bricks is not always easy. Sometimes a demolition yard will be able to supply an acceptable substitute.

Paint

It is not usually necessary to paint bricks, indeed that has always been one of the reasons for their popularity. It is unwise to paint bricks that have not been painted previously, first because it creates an unnecessary maintenance problem as the paint will have to be renewed every few years, and second because it may also create a damp problem in the masonry if the paint hinders evaporation of water from the wall surface. If it absolutely necessary to paint brickwork, because its colour is unacceptable for example, it is essential to choose a paint which permits water evaporation.

A number of conservation problems are likely to arise with bricks that have already been painted. The first, every few years, is the deterioration of the paint. If faced with re-painting brickwork, ask whether it is necessary

to renew the paint, or whether removing it altogether might be a simpler and cheaper option in the long run.

It may be possible to find out why and when the bricks were painted. Some early bricks were very porous, and before cavity walls became common, brick walls sometimes allowed damp to soak through into the building interior. Sometimes limewashing and painting was done in an attempt to stop water penetration. If that was the case, and it is still working, removing the paint may not be a good idea. It is also possible that under the paint is an unsightly patchwork of mis-matched bricks which were covered up for very good reasons.

Far more commonly, brickwork was painted in an attempt to 'modernise' the building. In the 1950s and 1960s Victorian building details became very unfashionable, and it was common practice to update red brick walls by painting them, usually white. If that was the case, then removal of the paint might be considered a more attractive option than re-painting.

In either case, it would be wise to proceed with caution. A small area of paint should be removed to investigate the nature of the underlying surface. (Refer to Technical Note 3.4 Removal of Paint from Masonry.) If the bricks are found to be porous, or unacceptably ugly, it might be wise to stop there. Removal of paint from a small area will also give some indication of what the resulting appearance will be. Sometimes the paint will prove to have poor adhesion to the brick surface, and can be cleaned off almost completely. Usually however it will be difficult to remove all the paint from cavities in the bricks and mortar, particularly in the case of early handmade bricks with uneven, porous surfaces. Do not be tempted to use wire brushes or abrasive washing techniques; the resulting damage to bricks and mortar will look far worse than the remaining paint. Generally, removal of 90% of the paint from the surface can be considered a good result.

Ivy

Ivy growing on brickwork may be a problem, but not necessarily; it depends on both the ivy and the bricks. In some circumstances, the ivy leaves may help to shed water from the wall. In others, ivy may reduce evaporation and assist in keeping the brickwork damp, leading to decay. Some species of ivy such as Virginia creeper are fairly benign, and do little damage. Others attach themselves very aggressively, and the roots of some Ficus species will penetrate the masonry in search of water, and cannot be removed without damage to the bricks and mortar.

The ivy's impact will also depend on the durability of the bricks: aggressive ivy growing on soft bricks may do a lot of damage, but benign ivy will have very little effect on hard bricks. To determine the extent of the problem, remove just a small section of ivy, let the wall dry out, and inspect the result. If it is necessary to remove ivy from a wall, first cut the ivy off at the ground and let it die. Do not attempt to remove the ivy growth from the wall until it is thoroughly dried out so that it is crisp to the touch. Cleaning off the adhering roots should be done in the same way as cleaning off lichen: warm water, detergent, nylon brushes, but nothing more vigorous. Accept that a certain amount of root material will remain attached to the wall when the job is finished.

Chimneys

Of all the bricks used in a building, those in the chimneys are subject to the most demanding physical conditions. Not only are they completely at the mercy of wind and rain, subject to thermal expansion and contraction, and exposed to corrosive acidic flue gases, but they are also out of sight and inaccessible, and likely to be inspected and maintained only on vary rare occasions. It is not unusual for chimney cornices to lose bricks in a storm; on inspection of the damage it is often found that the mortar has deteriorated to the point where daylight is visible between the remaining bricks.

Chimney tops suffer a demanding cycle of horizontal damp penetration; their masonry is soaked in every rainfall, and then rapidly dried out by sun and wind. Near the coast, there will be a heavy salt load left behind by evaporation. South Australian chimneys exposed to salt spray will visibly deteriorate most rapidly on the south and west sides.

Chimneys should be inspected regularly as part of the ongoing maintenance program of an historic building. The problem most likely to arise is deterioration of mortar joints, which can be repaired by raking out and re-pointing. If the mortar is deteriorating, do NOT be tempted to reduce the maintenance task by using a harder concrete mortar, because if evaporation from the joints is reduced, the rapid wetting and drying of the chimney will quickly destroy the bricks. The chimney top may be flashed over with sheetmetal or capped with mortar, which should be checked for condition, because vertical penetration of water into the brickwork will accelerate its decay. Decayed bricks can be replaced as necessary. As chimney tops are so rarely visited, the opportunity should also be taken to inspect the chimney for other problems such as decay of the roof flashing. Use a bright light to look down the chimney to inspect the condition of the interior lining, and over a wood-burning fireplace, look for any buildup of soot and resin.

GLOSSARY OF TERMS

Arris	Sharp edge between any two faces on a brick
Bichrome	Decorative brickwork in two colours
Bonding	Regular pattern in which bricks are laid to give strength
Bricks	Uniform blocks of fired clay, used as building material
Brick veneer	An external skin of bricks on a timber-framed building
Bullnose	Brick with one arris curved, often used for coping
Cavity wall	Wall with two layers of brickwork separated by an air gap
Ceramic	Describes clay when made hard and durable by heating
Chequered	Simple repeating brickwork pattern using bricks of two colours
Clamp	Stack of bricks fired in the open
Clay	Natural earth composed of very fine particles of aluminium silicates
Commons	Low quality cheap bricks, not usually left exposed
Concave joint	Mortar pressed into a joint with an iron rod
Coping	Top layer of bricks on edge to finish off a wall
Cornice	Horizontal projecting ledge, usually near the top of a wall
Damp Course	A horizontal layer of waterproof material built into the bottom of a wall
Diaper	Regular pattern on a wall made by using bricks of varying colours
Drypressing	Brickmaking by squeezing relatively dry clay or shale in a mould
Effloresecence	White salty deposit caused by evaporation on surface of bricks
Face bricks	Bricks selected for attractive appearance and good quality
Firebricks	High quality white bricks used to build furnaces
Flush joint	Mortar left level with the surface of the bricks
Friable	Crumbly, allowing particles to be rubbed from the surface
Frog	Hollow in the flat face of a brick
Hack	Stack of bricks drying under cover
Hack marks	Surface indentations caused by the way bricks are stacked for drying
Header	Brick laid so that its end is visible in the wall
Honeycomb	Brick wall with a pattern of gaps left to allow ventilation
Joint	Mortar layer between bricks
Kick	Raised part of a stock, to form a frog in handmade bricks
Kiln	Furnace in which bricks are heated to high temperature
Kiss marks	Colour variations caused by the way bricks are stacked in the kiln
Mortar	Mixture of sand, lime, water and sometimes cement
Mould	Box in which bricks are formed, either by hand or machine
Nogging	Bricks used to fill in between studs of a timber frame
Pavers	Durable flat bricks or tiles used to cover the ground surface
Plasticity	Degree of softness or workability of clay
Plinth	The foundation courses of a building projecting slightly outward
Pointing	Careful or decorative finish to mortar joints
Polychrome	Decorative brickwork of more than two colours; rare in South Australia
Pressed bricks	Hard, sharp-edged bricks formed in a high pressure mould
Pug	Clay prepared for brickmaking
Refractories	High quality white ceramic ware for use at high temperatures
Re-pressing	Pressing half-dry bricks a second time to improve their hardness and appearance
Ruled joints	Pointing with thin joint line painted on stained mortar
Quoins	Dressed corners of a stone building; often of brick in South Australia
Salt glaze	Glossy dark brown surface on ceramic ware, made by chlorine in the kiln

Sandstocks	Bricks with a rough surface left by sand in the mould
Shale	Sedimentary rock composed of ancient alluvial clay
Specials	Bricks made an unusual shape for a specific purpose, e.g. bullnose
Stock	Removable board forming the floor of a mould for handmade bricks
Stoneware	Ceramic ware fired to very high temperature, durable and non-porous
Stretcher	Brick laid so that its long side is visible in the wall
Strike	Board used to wipe away excess clay from a handmade brick mould
String course	Narrow horizontal band of decorative brickwork
Struck joint	Joint between bricks with the mortar roughly wiped away
Terracotta	Fired clay decoration, usually orange in colour with a fine smooth finish
Ties	Hoop iron straps or wires incorporated into brickwork for strength
Tiles	Broad flat bricks, normally used for covering rather than building
Vitrified	Clay when fired to very high temperature, durable and non-porous
Voussoir	Tapered brick for use in an arch
Weathered joint	Joint with mortar sloping outward so water runs off
Wet process	Brickmaking by mechanically moulding plastic clay into bricks
Wirecutting	Brickmaking by cutting extruded plastic clay with stretched wires

FURTHER READING

The best histories of the South Australian brickmaking industry are Anthony Moore's ***Brickmakers in South Australia*** and Noris Ioannou's ***Ceramics in South Australia.*** A good general history of brickwork with an excellent illustrated glossary is Ronald Brunskill's ***Brick Building in Britain.*** The following sources were consulted in the preparation of this booklet:

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SOME NOTABLE BRICK BUILDINGS IN THE CITY OF ADELAIDE

Date	Building	Address	Architect
1883	Zoological Gardens main entrance	Frome Road	E J Woods
1887	Shops	150 -154 Rundle Mall	D Garlick & Son
1889	Former Sands & McDougall Warehouse	73-79 Light Square	D Garlick & Son
1895	SA Museum North Wing	North Terrace	CEO Smyth
1895	Beehive Corner	cnr Rundle Mall/ King William Street	? English & Soward
1898	Bertram House (former Bible House)	73 Grenfell Street	A Wells
1898	Wilkinson & Co (later Grenfell Street Mail Exchange	101-107 Grenfell Street	English & Soward
1898	Colonel Light Hotel (now Heritage Hotel)	cnr Light Square/ Currie Street	Unknown
1900	Young Women's Christian Association (now Royal Automobile Association)	49-51 Hindmarsh Square	R J Haddon & G de L Evans
1901	Power Station (now Tandanya)	241-259 Grenfell Street	English & Soward
1901	Former Adelaide Stock Exchange	Exchange Place	HA Dunn & HE Fuller
1903	School of Mines & Industries (now University of SA)	North Terrace	CEO Smyth
1903	Austral Stores (later West's Coffee Palace)	108-120 Hindley Street	AS Conrad
1904	Former Adelaide Fruit & Produce Exchange	26-36 East Terrace	HJ Cowell
1906	Fowler's 'Lion' Factory (now Lion Arts Centre)	69-78 North Terrace	F Counsell
1903/ 1906	City (now Central) Market	Grote Street & Gouger Street	Unknown
1908	Former Municipal Tramways Trust (MTT) Administration Building	Hackney Road	Garlick, Sibley & Wooldridge
1910	City Refuse Destructor Chimney	41-48 Halifax Street	Unknown
1911	Hampshire Hotel	110 Grote Street	K Milne
1914	Gawler Chambers	North Terrace	English & Soward
1926	Former Young's Shoe Co	55 Rundle Mall	Rutt & Lawson
1932	Barr Smith Library University of Adelaide	Victoria Drive	WH Bagot
1951	Adelaide High School	West Terrace	EB Fitzgerald & JK Brogan

NOTES