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CONCRETE MASONRY
ASSOCIATION OF AUSTRALIA

CM04

Concrete Masonry – Manufacture

ABN 33 065 618 804.

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The Standards referenced in this manual were current at the time of publication.

Product: Austral Masonry GB Veneer Split Face®

Colour: Limestone

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1 History

Masonry construction is one of the oldest forms of construction used by man. Structures of stone, mud brick and clay brick, some built thousands of years ago, remain to bear witness to the durability of masonry. Not until the nineteenth century, with the development of hydraulic cements, did concrete masonry begin to evolve. It began in the United States, where large heavy solid blocks were made of a moulded mixture of quicklime and moist sand cured by steam.

The next developments were seen in England, where solid blocks were made using powdered lime, fine aggregates and boiling water to give rapid set. Some of these blocks were used in London, in houses in Pall Mall and in the Royal College of Surgeons' building.

Solid blocks, however, proved unpopular and impractical because of their weight. About 1866, the development of techniques of moulding hollow blocks began. During the following ten years, a number of patents on hollow blocks were granted in England and the United States. These did not cover manufacturing methods, as blocks were usually moulded in wooden moulds.

By about 1900, a number of 'machines' for making blocks began to appear in the United States. These were nothing more than moulds with removable sides, cores and bases, in some cases with arrangements for turning the freshly moulded block to permit its removal. Mould filling and concrete tamping were by hand. In the early moulds, the face of the block was formed on the removable mould bottom, which could, if desired, be provided with a patterned or rock-face finish. The cores were supported horizontally. To remove the block, the mould sides had to be demounted, core extracted and the block taken away on the mould base to be cured. For the next block, a fresh mould base, referred to as a pallet, was inserted and the process repeated.

Later 'machines', about 1904, had vertical cores, fold-down moulds sides, and a pallet with cut-outs so it would fit over the cores. The pallet was placed on the bottom of the mould and was used to lift the freshly moulded block out of the mould after hand tamping.

Although the early blocks were much the same height and thickness as the largest sizes now made, they were up to twice as long and therefore correspondingly heavier and difficult to handle. The early 'machines' could make only about two hundred blocks per ten-hour day with three men (Figure 1).

Between 1914 and 1924, power tamping replaced hand tamping, improving density, strength and uniformity. One manufacturer developed and sold a semi-automatic machine capable of making 1800 blocks per day with the same number of men as had made only 200 blocks on the older machines. During this period, the dimensions of units were standardised gradually, leading to the full modular coordination we have today.

Figure 2 illustrates a blockmaking machine of this era.

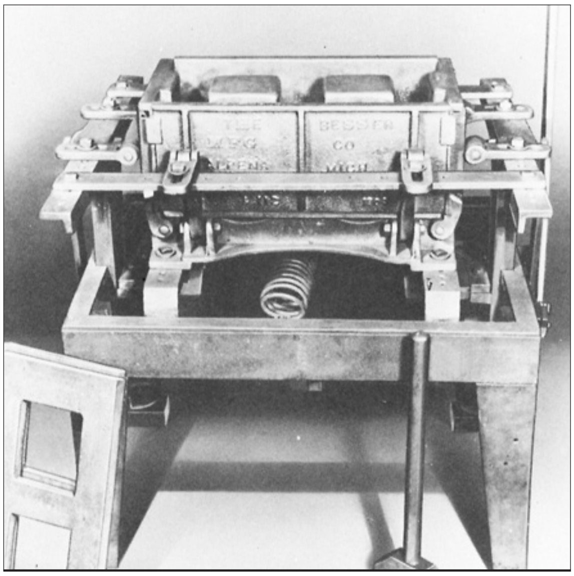

Figure 1

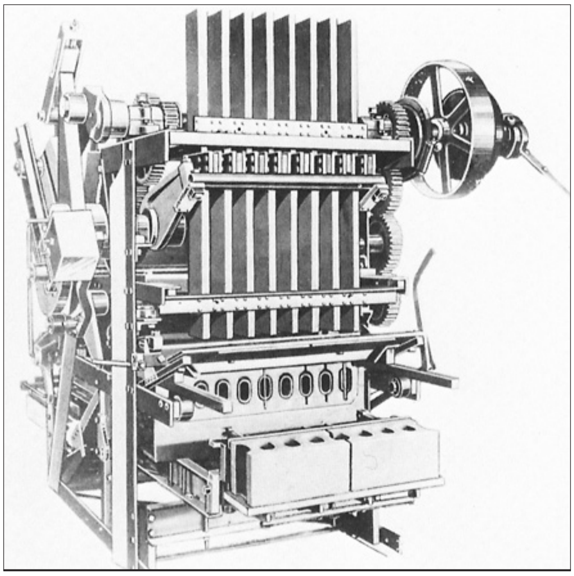

Figure 2

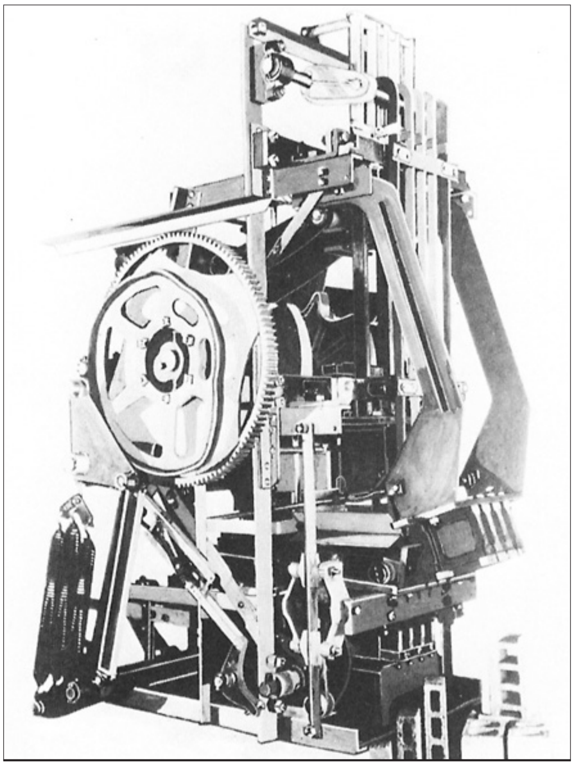

Figure 3

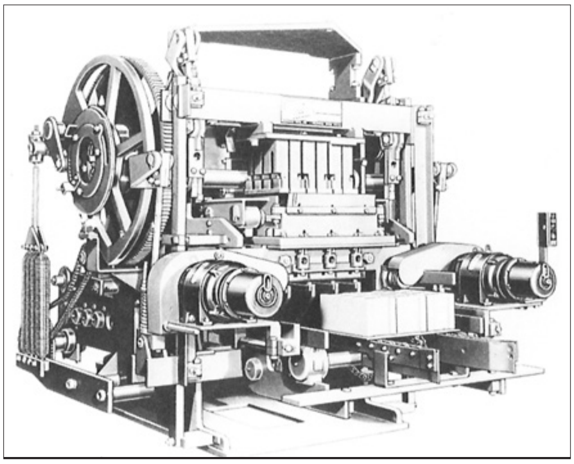

Figure 4

Perhaps the greatest single advance in blockmaking machinery was made in 1924 with the introduction of the first successful 'stripper' machine using plain pallets that did not have to be profiled around the cores. In this machine, the block was extruded downwards through the mould, exactly the same as in modern machines. Apart from feeding empty pallets and removal of the freshly made blocks, the machine was fully mechanised and automatic in operation. It used power tamping and could produce 3000 blocks per day. Today's fully automatic blockmaking machines are descended from the 1924 machine.

During the following fifteen years, productivity and automation developed. A 1929 machine is illustrated in Figure 3. In 1939, tamping was superseded by mould vibration while the "green" concrete in the mould was under pressure. This greatly improved face texture and sharpness of arrises and gave higher block strength. These machines could make 5000 blocks per day (Figure 4).

Since 1939, there have been progressive improvements in productivity and product quality, resulting initially from the introduction of automatic controls to regulate block height and density and later from the automation of ancillary equipment such as raw materials handling, weigh batching and mixing.

Further productivity improvements have been gained by developing automatic equipment to remove green blocks from the blockmaking machine and place them either on racks or directly in the curing chambers. This is achieved by the introduction of rack transfer systems to move racks to the curing chambers, and by other equipment which will withdraw cured blocks from the curing chambers and package them ready for despatch. Figure 5 shows a modern plant incorporating a transfer system.

Figure 5

From air curing with occasional water sprays used early in this century, curing techniques have also been developed and refined. Low- and high-pressure steam curing systems and burner curing systems are used now. In some cases, these are supplemented by the introduction of carbon dioxide into the curing chambers after curing is completed, to reduce block shrinkage.

In Australia, concrete masonry followed American developments, although the introduction of modern high-production extrusion machines occurred much later. Blocks were originally made in primitive moulds. This practice continued until the 1950s when the first modern blockmaking plant was established in Adelaide. The introduction of similar machinery to other Australian cities and towns followed.

Several types of block-, brick- and paver-making machines are used in Australia. Typical modern blockmaking machines are shown in Figures 6, 7 and 8.

With the introduction of segmental paving into the Australian market in 1974, a new type of concrete unit machine began to make its appearance. Originating in Europe, these dedicated paving machines featured larger pallet areas (0.5 to 1.0 m^2) but slower cycle times (20 to 30 seconds). The long cycle times mean that the surface can be more effectively compacted, resulting in better wear characteristics. The dedicated paving machines are particularly suited to producing units with complex plan shapes (such as dentated interlocking pavers) and thicknesses in the range of 60 to 80 mm. The paving machines were generally used to augment the older hollow-block machines, which concentrated on the production of hollow blocks and rectangular pavers

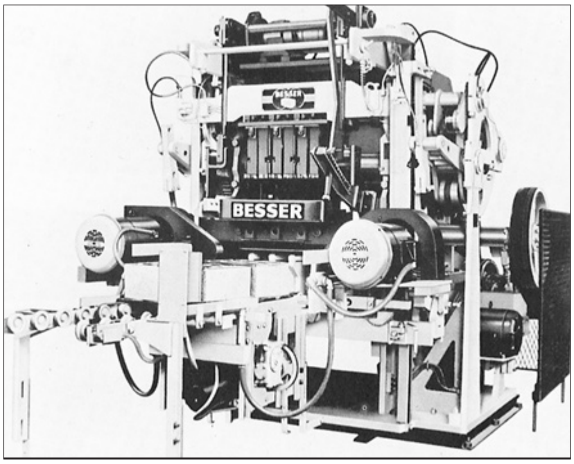

Figure 6

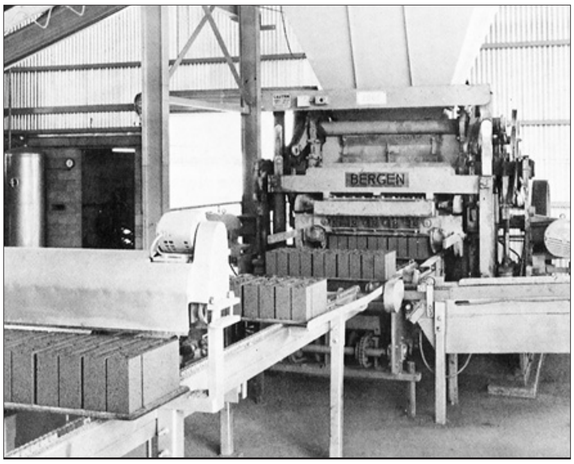

Figure 7

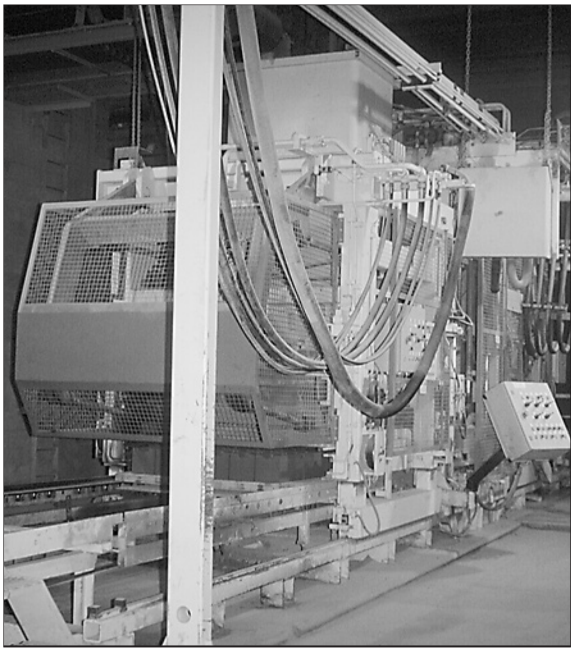

Figure 8

2 Manufacturing Methods and Quality Control

Most concrete masonry units used in Australia are manufactured by automatic machinery of advanced design and capable of a very high output with a high degree of uniformity. A typical flow diagram, Figure 9, illustrates the sequence of manufacturing operations and the points of regular quality control checks employed by well-managed factories. These checks cover raw materials, manufacturing operations, methods and processes as well as the finished product. Figures 10 to Figure 26 illustrate some of these features in more detail.

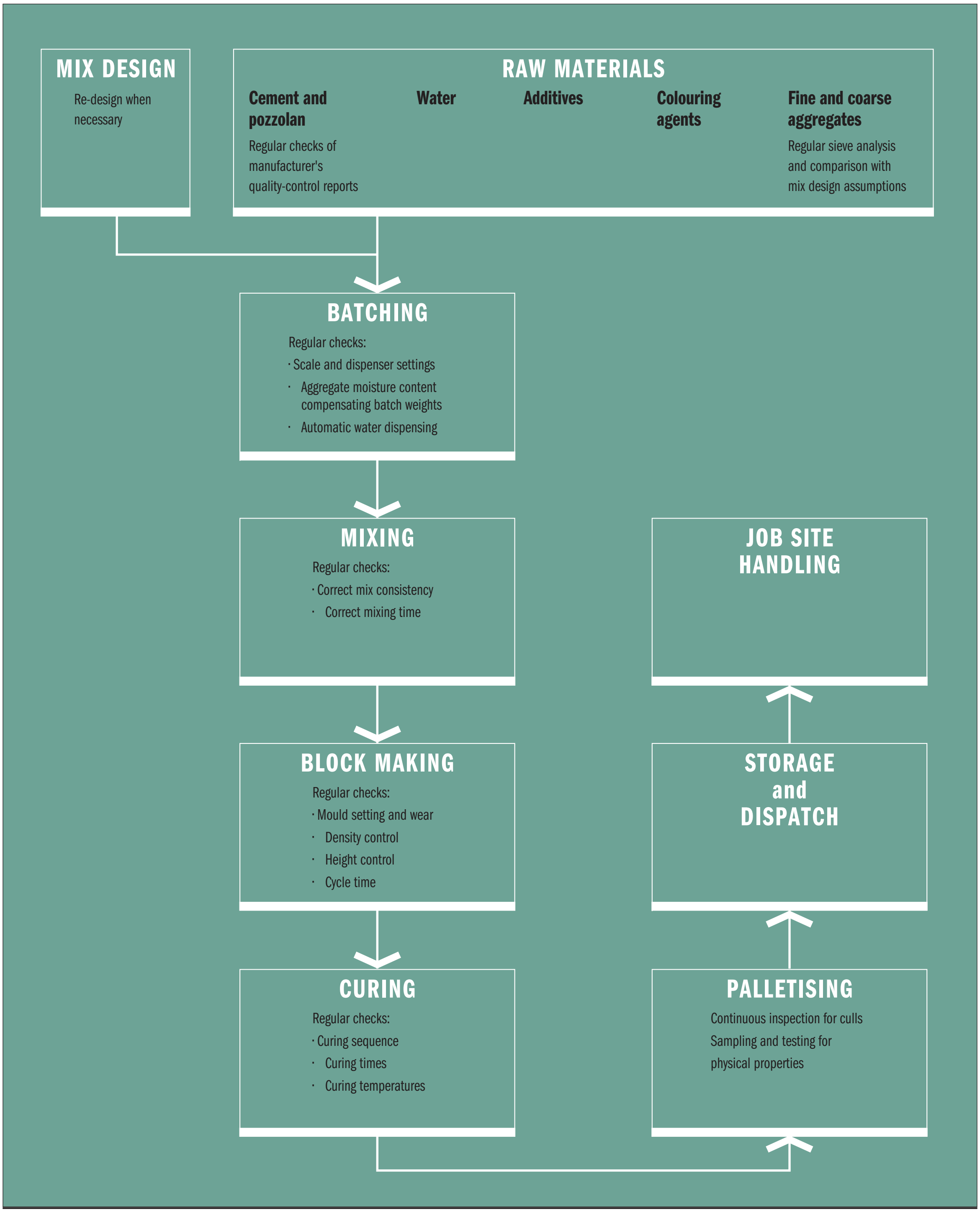

Figure 9 *Concrete masonry Manufacture – Typical Flow diagram*

2.1 Concrete Manufacture

Raw materials are delivered to silos and bins, with the various aggregates separated, see Figure 10. Cement and aggregates are weighed automatically to predetermined quantities. Figure 11 shows a typical control panel for automatic weigh batching and mixing.

The concrete ingredients are proportioned to produce the desired properties in the finished units. If incoming raw materials change in grading or moisture content, the mix proportions are adjusted to compensate.

Very 'dry' cohesive concrete is used in masonry manufacture, in conjunction with powerful mould vibration at the same time as pressure is applied to the concrete in the mould. As freshly moulded units are extruded down from the machine mould approximately every ten seconds, they must have sufficient 'green strength' to permit them to be handled without damage or distortion.

The mixing of concrete is controlled automatically in most plants and is linked with the batching plant to provide a concrete output suited to the consumption of the block machine. A typical mixer for masonry concrete is shown in Figure 12. A moisture sensor controls the addition of water. It maintains the correct moisture content and consistency in the concrete as it is delivered from the mixer to the blockmaking machine. In some plants, automatic compensation of fine aggregate weight for moisture content is provided by feedback from the moisture sensor to the batch weigher, but in others the operator will note changes and compensate manually.

Figure 10 *Aggregate Silos*

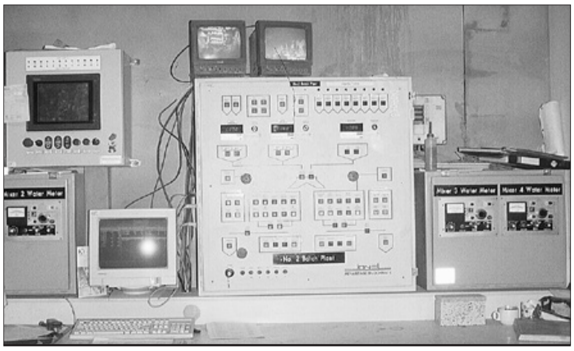

Figure 11 *Auto Weigh Batching and Mixing Controls*

2.2 Blockmaking Machinery

From the mixer, concrete of the correct proportions and workability is transported either by gravity or mechanically to the blockmaking machine.

Machine pallets are heavy steel plates designed to act as a mould bottom. Before each new cycle of the machine, a fresh machine pallet is placed under the mould. The mould is filled and the blocks vibrated. The blocks are then extruded downwards from the mould, remaining on the pallet which travels with them to form a tray on which they are transported until they are cured and about to be assembled into 'cubes' at the packaging station.

Figure 13 shows a concrete block mould, with cores, stripper shoes and head. The latter are laid back at an angle in this photograph to show the details. They normally occupy a vertical position. During mould filling, the head and shoes are raised clear of the mould to allow concrete to enter. When the mould is filled and while it is being vibrated, the head and shoes press on the top of the 'green' blocks. At the end of the vibration period, they are moved down to extrude the blocks from the mould. This particular mould is fitted to make four 1501 blocks, ie four 400 x 150 x 200 mm hollow blocks and is quite small by modern standards. At the lower left and right of the mould, the drive pulleys for the two vibrator units may be seen. The latter are attached to the mould body and are driven by two powerful electric motors by means of belts.

Figure 12 *Typical Mixer for Concrete Masonry Manufacture*

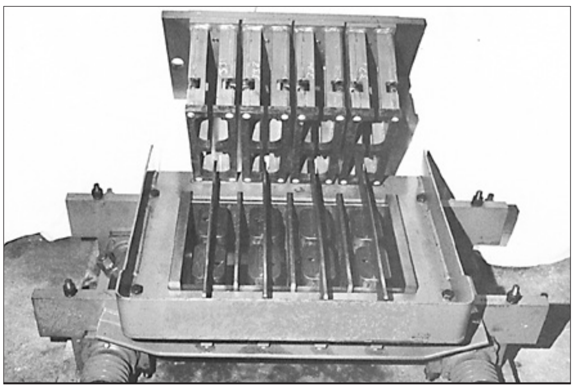

Figure 13 *Concrete Block Mould*

Most high production block machines used in Australia employ similar mould, core, stripper shoe and machine pallet arrangements. They differ only in size, the number of units that can be made per machine cycle (ie on each machine pallet), the system of actuation (electro-mechanical or electro-hydraulic) and the method by which vibration is applied to the mould and the 'green' blocks. Mould vibration systems are either vibrator units directly attached to the mould or remote units connected to the mould by rods.

Most concrete segmental pavers are manufactured using specialised paving machines of European origin, as described previously. Hollow-block machines are also widely used for the production of some types of concrete segmental pavers. Rectangular units can be manufactured 'on edge' in the block machine, ensuring that the whole of the machine cavity is effectively used. Thus, for each machine cycle a larger number of units may be manufactured in this way than would otherwise result from units manufactured 'on the flat'.

Checks are made frequently on both moulds and cores for correct setting and wear. Machine controls are provided to set the height of the blocks. These checks ensure dimensional accuracy. Frequent checks are made for density, vibration and machine cycle time to ensure that the finished units will have satisfactory physical properties.

Moulded 'green' blocks are transported mechanically from the block machine on the machine pallets to the curing chambers. Several alternative systems for handling 'green' blocks are employed. These are shown in Figures 14, 15, 16 and 17. As well as loading 'green' blocks into the curing chambers, these systems also unload the cured blocks coming from the curing chambers, see Figure 18.

The process flow may be briefly described as follows. Freshly moulded or 'green' concrete units are deposited on a steel pallet. These may be:

- loaded into steel racks for transport by forklift or kiln car to and from the kilns or curing areas;
- loaded directly onto an automatic transfer car; or
- transported to and from the kiln or curing area by a conveyor system.

When the hardened concrete units have been returned from the kiln or curing area, they are automatically removed from the steel pallets, realigned and pushed into a cubic shape using an automatic cubing machine. In some factories, cubes of finished product are shrink-wrapped. When required, units may be split, rumbled or polished using equipment installed at the factory.

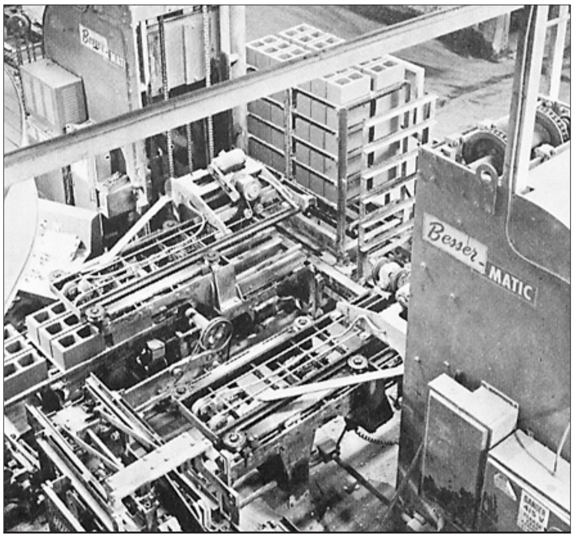

Figure 14 *Blockmaking Machine with Automatic Rack Loading and Unloading Equipment*

Figure 15 *Forklift Truck Handling Racks of Blocks from Automatic Loading and Unloading Equipment, to and from Curing Chambers*

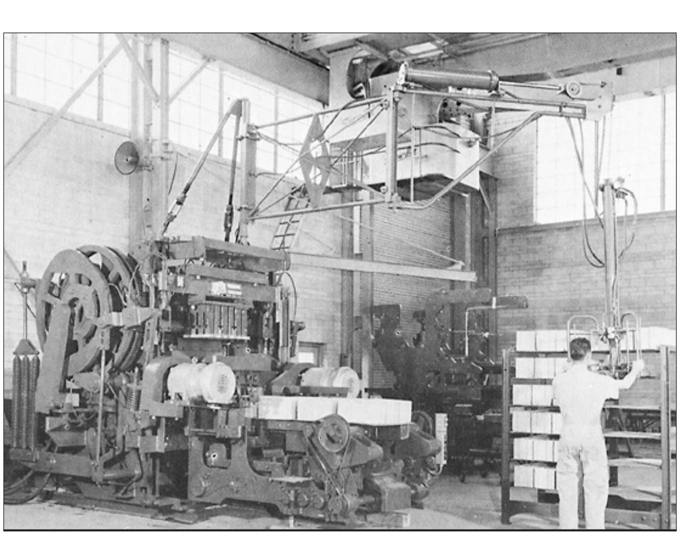

Figure 16 *Blockmaking Machine with Manually-operated Offbearer, Loading and Unloading Racks*

Figure 17 *Automatic Rack-transfer Car System, Handling Loaded Racks to and from Curing Chambers*

Figure 18 *Cured Blocks on Machine Pallets being Transported to the 'Cubing' Machine after Unloading from the Kilns*

2.3 Curing

In the early days of concrete masonry, units were usually cured by being left in the storage yard for at least four weeks and sprinkled occasionally with water. Curing was doubtful and variable and depended on weather conditions. Extreme colour variations, caused by differential surface drying, resulted from this method of curing. With the arrival of high production manufacturing and handling equipment, accelerated curing techniques became necessary to avoid enormous accumulation of stock.

Low-pressure steam curing was one of the earliest accelerated curing methods used. In this system, saturated steam, at atmospheric pressure and at temperatures above about 70°C, is introduced into insulated chambers containing racks of 'green' blocks. Hydration, the chemical reaction between cement and water which causes hardening, is accelerated at high temperature in a vapour-saturated atmosphere. About 70 to 80% of the 28-day atmospheric-temperature cured strength of the concrete is developed in 18 to 24 hours by this process. Units may thus be handled and packaged the day after moulding

Other low-pressure curing systems use gas or oil burners to heat the curing chamber. Steam is generated by spraying water on a hot plate that is heated by the burner. These systems offer economies in capital expenditure, as a steam boiler is not needed. They can be programmed for automatic operation without the need for an attendant, resulting in economy in operation. The results achieved are generally similar to those available with medium temperature low-pressure steam curing. Burner systems have the advantage that a drying period may be added at the end of the curing cycle. A typical installation of this type is shown in Figures 19 and 20.

Figure 21 shows a modern installation employing automatic handling of 20-high racks.

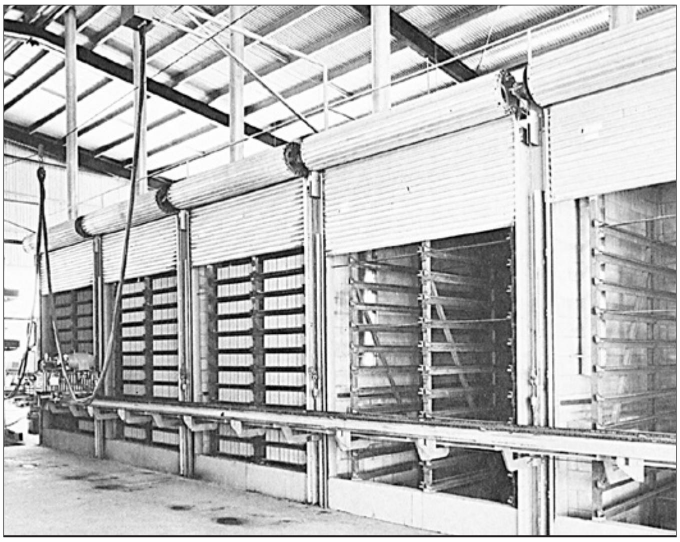

Figure 19 *Typical Low-pressure Installation using Burners to Heat the Chamber and Produce the Steam*

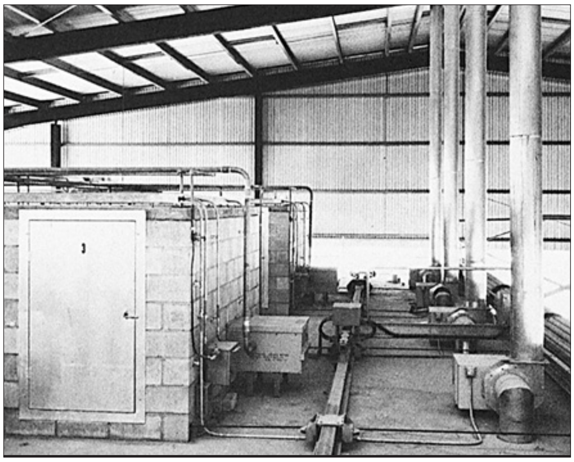

Figure 20 *Rear View of above Installation*

2.4 Palletising and Packaging

After being cured, blocks are unloaded from the racks or curing chambers. They are removed mechanically from the machine pallets and transported by conveyor to the palletising station, where they are assembled into 'cubes' of standard sizes, usually measuring approximately 1.2 x 1.2 x 1.2 m. **Figures 22 and 23** show typical cubing equipment.

Between the machine pallet stripping station and the cuber, inspection is often made for units of sub-standard appearance. If any are found, they are rejected and removed. Sampling for testing for compliance with Australian Standards AS/NZS 4455 and AS/NZS 4456, as appropriate, is carried out also at this stage.

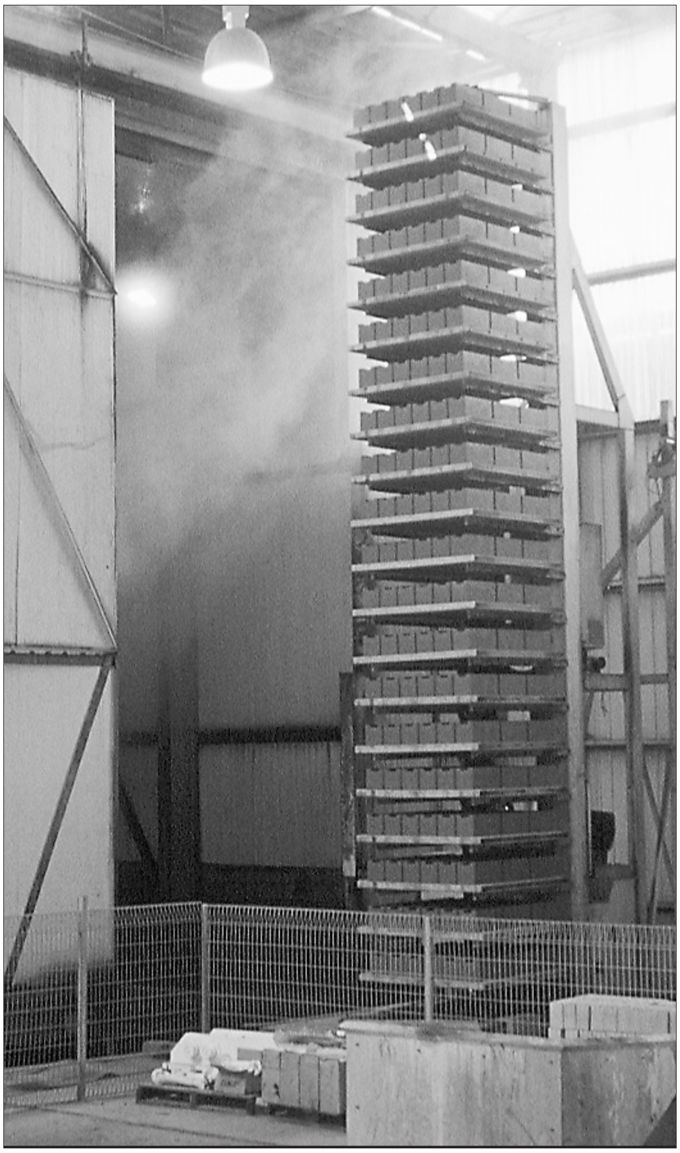

Figure 21 *Low-pressure Installation with automatic Handling of 20-High Racks*

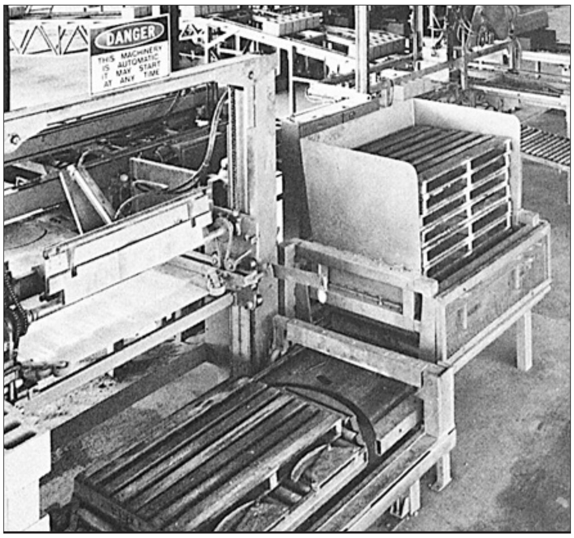

Figure 22 *'Cuber' with Magazine of Pallets on Right*

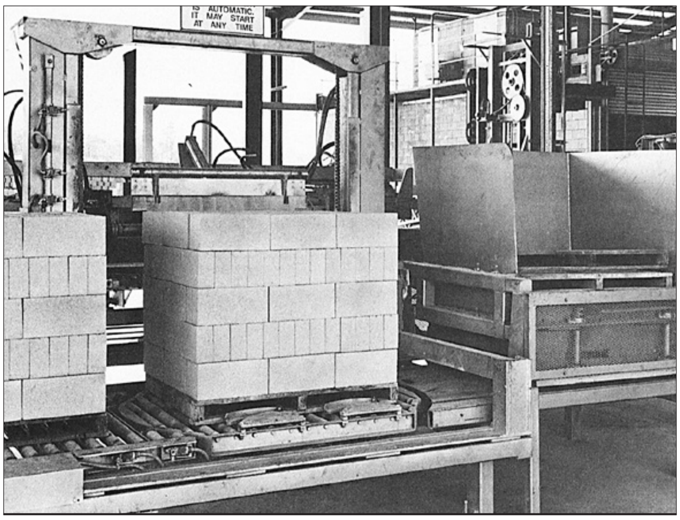

Figure 23 *'Cuber' with two Finished 'Cubes' of Blocks on Wood Pallets*

2.5 Storage and Handling

After palletising, the 'cubes' are usually moved by forklift truck (Figure 24) and stacked in a storage area for future transport to job sites (Figure 25). Normally, loading is carried out in the storage yard by forklift truck.

Road delivery vehicles fitted with mechanical handling equipment are common to avoid laborious and time-consuming unloading of units by hand at job sites. Figure 26 shows typical truck-mounted handling equipment. Alternatively, forklift trucks are often carried on the road delivery trucks to facilitate unloading on site.

Figure 24

Figure 25

Figure 26

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