NEW ZEALAND'S BLOCK PAVING HISTORY AND FUTURE

G. Kuipers
Consulting Engineer – Auckland, New Zealand
G. O'Sullivan
Market Development Manager – Firth Industries Ltd

1. SUMMARY:

New Zealand is a South Pacific nation with a small population, but with an active and modern construction industry which is closely tied to North American and British design standards and construction techniques.

This paper first gives an outline of the growth in usage of flexible concrete block pavements in New Zealand, tracing this development back from the early seventies. It then deals with design choices and applications. An early preference was established for the use of profiled blocks of medium strength and thickness which culminated in the publication of New Zealand Standard 3116-1981: "Interlocking Concrete Block Paving". This standard is widely used and quoted in New Zealand engineering practices, and this paper examines some requirements of this standard. Later, the block shape preference shifted to cobblestones and rectangular blocks.

The paper describes the various types of blocks available on the market and their usage for specific purposes such as parking areas, roading, commercial developments, shopping plazas and light to very heavily loaded industrial pavements. Economic considerations are given and the future of the concrete block paving industry discussed.

2. HISTORY:

On the international scene interlocking paving blocks were introduced in the early 1950's, first in the Netherlands which already had a great depth of experience in segmental paving (8) (2). This new type of paving quickly spread throughout most West-European countries, and the concrete paving block industry was firmly established by the early seventies.

In New Zealand, the engineering profession and manufacturers started to get seriously interested by the mid-seventies, although interlocking paving blocks were first manufactured on a small scale in the early seventies (5).

Two parallel but interrelated phenomena occurred. Firstly, designers and specifiers, having studied overseas trends, started to look upon concrete block paving as an economic long-life alternative to asphaltic or monolithic concrete pavements for a variety of applications. Secondly, the present concrete industry geared itself up to meet the new challenge and by 1977 the major manufacturers were equipped to produce paving blocks on either Besser or Columbia block machines. In 1982, two major manufacturers commissioned new machines which showed improvements in economy and quality over the older building block machines.

Any kind of construction in New Zealand is usually preceded by economic and technical investigations and by design and specification performed by either private consulting engineering firms or by local and government authorities. The designers and specifiers in these two types of organisation depend on overseas literature, study trips and visits by overseas experts to broaden their knowledge in an engineering field which is new to New Zealand. Such was the case in New Zealand from the mid seventies on with regard to flexible block pavements (5).

In August 1976 C.F. Morrish described progress in Australia to the Concrete Masonry Association of New Zealand, and gave a public lecture in Auckland to potential specifiers in December. In the same month the New Zealand Portland Cement Association published an information bulletin based on the publications of the Cement and Concrete Associations of Australia and the United Kingdom, the Portland Cement Institute of South Africa, Dr J.F. Balado from Argentina and personal communications from Mr A.A. van der Vlist of the Netherlands Cement Association.

A committee was set up in 1977 with representatives from the Roading Division of the Ministry of Works and Development, Hamilton City Council, Concrete Masonry Association, Concrete Research Association and the New Zealand Portland Cement Association, and a specification and Code of Practice was published in April 1978. These formed the basis for the New Zealand Standard NZS 3116, published in 1981.

A section of block paving was tested at the Canterbury University test track, and the results reported by Seddon in 1980 (2). The New Zealand Concrete Research Association made an investigation into the required properties of bedding sand in 1979. Test areas were established in a number of places, including two trafficked by heavy industrial vehicles at Lyttelton and Mt Maunganui, arranged by the respective Harbour Boards. PCA issued design recommendations for heavy industrial pavements in 1978, and these recommendations were further updated 1983. Morrish and Shackel described Australian practice and Australian and South African research in a series of lectures in New Zealand in August 1981.

Full-scale trials were conducted at the New Zealand Steel Expansion Site at Glenbrook, near Auckland, in March 1982 to determine the suitability of New Zealand-produced paving blocks for heavy industrial loading. Results of these trials were discussed at the Second International Conference on Concrete Block Paving in Delft in the Netherlands (6).

3. DOMESTIC AND RESIDENTIAL APPLICATIONS:

From a commercial angle, the industry geared up to meet a demand which obviously had yet to be created. During the period from 1977 to 1980, a variety of block shapes were introduced to the paving market in what now is seen to be a fairly haphazard fashion. The customers reacted to this inflow of new shapes and ideas, and by 1981 the commercial picture became a lot clearer. Before we discuss the New Zealand preferences in block shapes, it is worthwhile to background our style of living which we believe is reflected in the demand for segmental paving.

New Zealand has a temperate climate varying from near sub-tropical latitudes in the North of the North Island to much cooler conditions in the South of the South Island. Projected on a European map, New Zealand stretches from the North of France to Midland Morocco, and the average temperature range reflects this large stretch of land.

New Zealanders on the whole have a great liking for outdoor living, but because of climatic variations, families in the North spend more of their leisure time outdoors than families do in the South. This outdoor living is reflected by the large number of properties with swimming pools, outdoor spa pools, driveways, parking and barbecue areas close to the house. Pavement in and around these areas is now for a large extent done in concrete paving blocks, and it is not so surprising that this domestic leisure market accounts for the majority of the block market in New Zealand. A logical consequence is that the concrete block demand in the warmer North of the North Island is probably twice the national average which by late 1989 stood at 0.3 square metres per person. This compares with 1.5 square metres in Germany and 0.05 square metres in the United States of America in 1988.

The concrete block market is therefore to a large extent dominated by individual customers who may place an order for no more than 1,000 blocks at any one time. The most popular block shape that emerged, out of at least 20 different shapes and sizes, was the cobblestone which is a block 23 x 19cm in plan and either 4, 6 or 8 cm thick. The 6cm Unidecor block also shares in the domestic market, but the profiled (zig-zag) unipave shape is seldom used for domestic purposes. The reasons for the cobblestone preference are twofold. Firstly, and most importantly, cobblestones are about 20% less in cost than any other concrete blocks. Secondly, most people tend to prefer their simple traditional shape to the more complex alternatives.

4. URBAN PAVEMENTS AND COMMERCIAL APPLICATIONS:

The commercial market has experienced a much less spectacular, but nevertheless steady rise in demand for concrete block pavements. Initially, local authorities such as city councils, became involved in the usage of flexible concrete block pavements for lightly trafficked residential roads, footpaths, bus stops and shopping malls. The most common shape for these pavements used to be the profiled Unipave block either 6 or 8 cm thick, but after 1982 there has been a marked swing to rectangular blocks for vehicular pavements and cobblestones for pedestrian areas. Later, commercial users such as shopping centres, oil companies, breweries and private land developers started to specify both profiled and rectangular blocks for their parking lots and terminals. The herringbone pattern is almost invariably used when laying the blocks. It is interesting to note that few local authorities have become heavy block users, while most other councils have only used small amounts of blocks. It is possible that due to the recent public acceptance of block paving the majority of local bodies may in future be persuaded to utilise more block pavements in appropriate areas. These will hopefully include residential streets with low to medium traffic and speed requirements, as many people believe that an interlocking block pavement is aesthetically more pleasing than an asphalt or concrete pavement.

On the industrial scene, two of New Zealand's harbour boards were forerunners in the utilisation of block pavements for their hard-standing areas. In 1979 the Lyttelton Harbour Board paved a trial area of the access road to a roll-on berth in 20 x 10 x 10 cm thick rectangular concrete blocks. The board monitors the trial area on a regular basis and reports no failures over a period of 10 years.

In late 1977, the Bay of Plenty Harbour Board paved an area in front of the roll-on - roll-off warehouse in 8cm thick Unipave blocks. This was followed in 1981 by an area in the Export Timber yard using the same blocks. Some damage has taken place in both areas.

In 1982, a trial area was paved at New Zealand Steel expansion site using 8cm thick Unipave blocks from two of the major manufacturers. After six months, more than 50% of the blocks had cracked.

The decision was made to pave the entire 36,000 square metre site in 10 x 20 x 12 cm thick rectangular blocks with a minimum flexural tensile strength of 6 N/mm^2. After 6 years of use, the failure rate is less than 2% which is quite remarkable given the high axle loading of 168 tons on 6 Boeing 747 aircraft tyres.

Further major industrial developments have included a Liquid Petroleum Gas (LPG) depot, several timber mills, dairy produce factories and heavy industrial manufacturing plants. The heaviest wheel load designed for is 50 tons, inflicting 50 passes per day on the pavement over a period of 20 years. This pavement is in excellent condition after 16 months of use.

From these observations, it is clear that the future for concrete block pavements in New Zealand lies in a mixture of applications. The industry believes that the most important growth areas are in urban roading and in the industrial sector.

Summarising: For a population of just over 3 million, New Zealand paved zero square metres in 1975, 500,000 in 1981, 700,000 in 1982 and 1 million square metres in 1986. There has been a slight flattening of demand due to the low level of the economy over the last two years.

5. DESIGN PROCEDURES:

Present-day design in New Zealand is based on mechanistic design approaches using either a multi-layered elastic stress model and assigning an equivalent modulus of elasticity to the block layer, or a block joint shear capacity model with subgrade strain as failure criterion. The required basecourse thickness resulting from these two different approaches are reasonably similar. The latter approach however enables the designer to rake account of variations in block thickness such as 6, 8, 10 and 12 cm.

6. PAVER PREFERENCES AND STANDARDS:

As described before, the New Zealand market is at present dominated by the cobblestone, the rectangular block and the profiled Unipave block in a ratio of approximately 2:1:1. Economics and aesthetic appeal govern the choice of the cobblestone shape for domestic and architectural pavements.

The history of the early dominance of the Unipave shape for heavier trafficked pavements is not clear. In Europe, some countries on the whole prefer simple rectangular shapes, while others prefer profiled shapes. When the manufacturers in New Zealands decided to go for a profiled block, they probably made their decision for commercial reasons in the first place. If a new product needs to be introduced, then an entirely different shape will be better recognised and therefore easier marketed than a standard brick shape cast in concrete. The end user became the governing force in the marketing process, and the Unipave block was initially the clear winner for just about all commercial and industrial pavements.

This breakthrough was enhanced by the fact that interlocking profiled block pavements have given good service to their users in the majority of low to medium loading applications. The profiled Unipave shape has a 10% larger interface with its surrounding blocks than a rectangular block has. It also affords more resistance against horizontal displacements. Hence, there should be an improved shear transfer between the blocks, and therefore more beneficial load sharing, provided:

(i) that the pavement is laid correctly with equal width and properly filled joints around all block sides.

(ii) that pavement deflections are kept quite low.

If these two criteria are not met, then the more complex Unipave zig-zag shape with its pronounced projections and re-entrants is much more prone to damage than a simple rectangular shape. To avoid this damage, many designers and specifiers now prefer to use rectangular blocks for roading and industrial pavements. Designers and users should never forget that, no matter how good our intentions, pavements are often laid under less than ideal conditions. The end product will never be as good as that which can be achieved under test facility conditions.

The New Zealand Standard on Interlocking Concrete Block Paving (1) deals with design shape, compressive strength, testing, pavement design, block placing and joint filling.

A minimum characteristic compressive strength of 40N/mm^2 is specified. By contrast, the German Code of Practice specifies an average compressive strength of 60N/mm^2, while the Dutch Standard NEN 8\7000 specifies a 6N/mm^2 minimum flexural tensile stress probably equivalent to a compressive cylinder strength of 55N/mm^2, depending on the aggregates used.

Obviously, the strength requirements in New Zealand are quite a bit lower than those in Germany and Holland, even after allowing for the fact that our compression tests are performed on cylinders and that cubes should show a 25% increase in compressive strength. However, the high strength requirements for West-European blocks seem to be at least partially caused by the need for higher durability in the light of their severe winters.

NZS 3116 leaves it open to the designer and manufacturer to choose a block shape and size most suitable for the end user, although a minimum thickness of 6 cm is specified.

To quote:
"PAVING BLOCK means a rectangular or shaped solid unit manufactured to close tolerances with plane or dentated sides, top and bottom faces parallel, preferably with arrises of the top surface chamfered, and of a size that can be hand placed".

This definition gives the designer and specifier enough scope to choose the block shape appropriate for his job. Summarising, we would personally prefer the New Zealand Standard to specify a minimum characteristic flexural tensile strength of say 6N/mm^2. As an added bonus; if all Standards in the world would express the strength requirements in flexural tension, then we would overcome the confusing problem of comparing cube strength with cylinder strengths.

7. PAVER SUPPLY AND LAYING COSTS:

Recent costs received for medium to large sized paving contracts in the Auckland area (in the North of the North Island) are hereby given in United States Dollars per square metre. They are for the manufacture and supply to a site within 10 kilometres from the manufacturing plant and apply to paving blocks with an average strength of 50N/mm^2.

19 x 23 x 6 cm thick cobblestones	$13.00
19 x 23 x 8 cm thick cobblestones	$14.00
Ave 22 x 11 x 6 cm Unipave blocks	$15.00
20 x 10 x 8 cm rectangular blocks	$14.00
20 x 10 x 12 cm rectangular blocks	$17.00

A few interesting facts emerge. Firstly, the difference in cost between a light cobblestone (which is appropriate only for very lightly trafficked areas) and a heavy rectangular block (which should withstand the highest static and traffic loads known today) is only US$4.00 per square metre, or just over 30%. Secondly, the difference in cost between an 8cm thick rectangular block and a 12cm thick rectangular block is only US$2.00 per square metre, or 13%, or roughly equivalent to the cost of the basecourse that the deeper block replaces.

Cost variations for block laying and compaction are large, as they are dependent on the degree of competition between the contractors at the time of tender, on the size and complexity of the job, on the block shape and weight, on the job location and on the pavement laying pattern. For a pure manual laying operation New Zealand costs average out at approximately US$5.00 per square metre.

A recent development in New Zealand has been the introduction of mechanical paving machines which can double the block laying rate and thereby greatly reducing the laying cost.

8. CONCLUSIONS:

This paper describes the growth in utilisation of block pavements in New Zealand. After a hesitant start the industry, the engineering profession and the end users are now gearing up to hopefully make New Zealand one of the

larger users of paving blocks per person in the world. The present demand mainly comes from the domestic sector, but it is expected that municipal, commercial and industrial users will in future create a larger share of the total market.

9. REFERENCES:

1. NZS 3116-1981: New Standard for Interlocking Concrete Block Paving.

2. Proceedings of the First International Conference on Concrete Block Paving - Newcastle-upon-Tyne - 1980.

3. NEN 7000: Betonstraatstenen - published by the Dutch Institute of Normalisation - 1966.

4. TONKIN & TAYLOR LTD: The behaviour of a Test Strip in Concrete Paving Blocks - Final Report Recommendations - 1982.

5. J.B. TAIT: Interlocking Concrete Block Paving - Proc. New Zealand Roading Symposium - 1983.

6. G. KUIPERS: The Choice of an Appropriate Block Shape for Heavy Industrial Pavements - Proc. Second International Conference on Concrete Block Paving - Delft 1984.

7. F.P.S. LU and P.A. SEDDEN: Relative Economy of Different Pavement Types for New Zealand - Proc. new Zealand Roading Symposium - 1979.

8. G.H. KELLERSMAN: Concrete Block Paving in Indonesia - a Labour Intensive Technology - 1981.