CONCRETE BLOCK PAVING IN GREAT BRITAIN BY 1986

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ABSTRACT

This paper outlines the last decade of the use of concrete block paving in the United Kingdom. The experience of the use of blocks on a very wide range of paving applications has been excellent, with remarkably few problems in block manufacture, specification, design, construction or long-term performance. The paper describes a type of failure that is causing concern, especially as it takes a form not reported anywhere else in the world. In conclusion, attempts are made to forecast future applications for block pavements.

INTRODUCTION

Since the introduction of the concept of using concrete block paving for highway construction in Great Britain ten years ago (Lilley and Knapton 1976; Lilley and Collins 1976), this method of paving has become well established and widely accepted beyond its original use for lightly-trafficked roads. In 1976 the sales of concrete block paving were in the order of 50,000 m^2, mainly into the 'patio' market. The annual sales for 1986 are estimated to be more than 100 times greater and approaching 0.1 m^2/head of population. Based on sales in other parts of northern Europe, the concrete block paving industry can look forward to a further ten-fold increase in sales to 1 m^2/head/annum.

It is interesting to trace the history of block paving to establish the reasons for this phenominal growth which took place at a time when all other parts of the construction industry were in severe recession. The original intended highway market for paving blocks was residential roads, the design and construction of which presents special problems. The U.K. is small and has a large population anxious to protect its remaining countryside. These factors have led to very high density housing, 50+ houses/ha being common. Considerable effort has been applied to designing the layout of housing developments to both maximise the density and minimise the social impact of such close living. Many design guides, such as the Design Bulletin Number 32 (e.g. Department of Environment and Department of Transport 1977) were being published in the 1970s. These guides abandoned the traditional road concepts, in which roads were basically straight, with good sight-lines, giving precedence to vehicles, to pavements giving precedence to pedestrians and children playing. In these new design methods the houses tend to be built around irregular-shaped courtyards, the paved areas in front of the houses serving as playground, car park and vehicle access (Fig. 1). The appearance of these courtyards is important as they provide the only 'view' from the houses; the irregular shapes of the courtyards, and their access, mitigates against paving with traditional road surfacing materials, laid mechanically, both factors which encouraged people to consider paving blocks in the early days. There have been many instances of speculative developers using concrete paving blocks, both within the curtilage of the properties and in the access roads to give an 'up-market' appearance to the houses and thereby aid sales. The obvious advantage of blocks, i.e. the provision of hard, easy to clean, oil resistant and durable surfaces, led engineers to adopt blocks for almost every other paving need, including industrial estates, petrol station forecourts, playgrounds, vehicle car parks, footways, dockside paving and recently aircraft hardstandings and the turning areas at the end of a runway (Emery 1986). Typical applications of block paving in the U.K. are shown in the Appendix.

To promote the idea of using concrete blocks as a paving material, many questions had to be resolved before highway engineers could be expected to accept them. It was necessary to produce a specification for the blocks themselves, a pavement design method and a guide to ensure economic block laying - few engineers could believe



Fig. 1 - Rectory Farm housing estate, Northampton

that laying blocks one at a time, by hand, could be competive, although the same people accept brick walling without question.

SPECIFICATION FOR THE BLOCKS

The original specification for the blocks was written to ensure the retention of certain essential short- and long-term properties: close plan dimensional tolerances, to ensure interlock; close thickness tolerances, to ensure the retention of acceptable pavement smoothness; resistance to polishing, to give good long-term skid resistant surfaces and resistance to damage by freezing and thawing, a problem greatly aggravated by the use of de-icing salts. Considerable research and development work went into the production of the Specification, which was produced in its final form in 1980 by the Cement and Concrete Association (CACA), the County Surveyors' Society and Interpave - the trade association of paving block manufacturers. A similar specification produced by CACA alone had been widely adopted before the publication of the tripartite specification. The essential requirements of these specifications was plan dimensions within ± 2 mm of stated size, and thickness within ± 3 mm of stated value. The sand fraction of the aggregate used for block manufacture should not contain more than 25 per cent acid soluable material, a value chosen from experience with in situ concrete roads and required to prevent excessive polishing and loss of skid resistance. Research reported by Clark (1980) showed that resistance to frost damage was directly related to the water/cement ratio of the blocks. The moisture content of the mix is largely controlled by the manufacturing method and therefore the only way to lower the water/cement ratio was to raise the cement content. The specified minimum cement content is presently 380 kg/m^3. When the British Standard for concrete paving blocks (BS 6717) is published later this year it is anticipated that it will allow partial cement replacement with pulverised fuel ash or granulated blast furnace slag. The same Standard will also formalise an agreement made with manufacturers some years ago that rectangular blocks, the most widely used paving blocks in the U.K., shall all be made to a plan dimension 200 mm x 100 mm. Compressive strength is used as a day-to-day check on block quality. The minimum average strength of 16 blocks at the time of delivery is specified as 49 MPa, with an absolute minimum of 40 MPa.

This specification has resulted in blocks that have performed well under U.K. climatic conditions but research is in progress still to find a repeatable and reproducable method of measuring freeze-thaw resistance so that a minimum cement content need not be specified in order to ensure durability.

PAVEMENT DESIGN

At both the First and Second International Conferences on Concrete Block Paving, held in 1980 and 1984 respectively, many papers were presented on pavement design by various analytical methods. Such ideas were considered in the early development of paving blocks in the U.K., but were disregarded at the time. Most pavement design in the U.K. is based on empirical methods and the national design guide for all public roads was Road Note 29 (TRRL 1970). Rather than evolve a 'special' method of pavement design for block pavements, it was decided to carry out research work to discover the thickness of asphalt to which blocks and laying course were equivalent (Knapton 1976; Clark 1981). Once this had been established, block pavements, at least for public roads, could be designed using a nationally-accepted and proven

design method familiar to road designers. This approach has worked well, although more sophisticated methods are needed when designing pavements beyond the scope of Road Note 29.

Road Note 29, and the associated Specification for Road and Bridge Works (Department of Transport, Scottish Development Department and Welsh Office 1976), allows a very wide choice of both sub-base and roadbase materials. However, it was decided not to allow the choice of Type 2 materials, i.e. unbound granular materials within a specified but broad grading envelope, for use with block paving because, in their dry state, most of these materials have high CBRs which can drop a great deal when the materials become wet. Fears of this happening, due to water penetration through newly-laid block pavements and the evidence that a good support (say CBR greater than 30) is essential to allow blocks to interlock, ruled out the use of this type of material. This has turned out to be a prudent decision, as the few failures of block pavements that have occurred are where these materials have been used immediately beneath the laying course. There has been a large number of pavements built, mainly RO-RO and LO-LO areas in docks carrying axle loads well in excess of those permitted on the public road. The method of design now recommended for this type of work is the British Ports Association (1982) Design Manual, itself based on analytical design methods.

There is little doubt that in the near future the whole subject of pavement design will need to be re-considered, although for lightly-loaded pavements it is still considered that simplicity in use is preferable to very sophisticated design methods.

CONSTRUCTION METHODS

Ten years ago it was necessary to issue both construction specifications and advisory guides to aid contractors (Cement and Concrete Association 1978; Lilley and Collins 1976). These gave guidance on the surface regularity of the sub-base or roadbase immediately beneath the laying course. It was felt that it was realistic to specify the surface regularity to be within ± 20 mm of target. This in turn set the general laying course thickness as 50 ± 20 mm. Circumstantial evidence supports the conclusion that these decisions were not far in error; laying courses much thicker than 70 mm often result in undue settlement. The author believes now that if the surface regularity of the layer immediately beneath the laying course could economically be laid within a surface tolerance of, say, ± 10 mm, it would be advantageous to reduce the laying course thickness to a mean of 30 mm. Under these conditions it may be possible to use concrete paving blocks on roads carrying much faster traffic than the 50 to 60 km/h maximum speed presently recommended. The only other lesson learned is that the surface of the layer immediately beneath the laying course must be close-knit to ensure that the laying course is not lost into surface voids.

The recommendations for the laying course were for a clean, sharp sand, with a silt/clay content not greater than 3 per cent by mass. A broad grading envelope is also given in a Code of Practice (Cement and Concrete Association, County Surveyors' Society and Interpave 1983). In general this approach has been very satisfactory but recently problems have arisen in the north-west of England on sites carrying heavy channelised traffic. The problem has so far been limited to bus stations built on bound roadbases and shows as 'elephant footprints' in the wheel track after two to three years heavy trafficking. Initially the footprints appear as depressions some 200 to 300 mm in diameter which, with time, grow to eliptical shapes usually some 600 mm wide to a metre or more long. These depressions at their centres are 50 mm deep, i.e. the laying course depth.

Investigations, which are still in progress, have shown that the laying course has not been lost sideways or downwards. This has led to the conclusion that the sand has degraded to a material fine enough to pump-up through the joints between the blocks. The problem has been studied in two ways: (a) by comparing the gradings of samples of sand taken from beneath wheel tracks and from parts of the pavement that have carried little or no traffic, and (b) comparing how gradings change when sand samples are subjected to 6 hours in a ball-mill. On sites that have performed badly it has been found that the sand from beneath the wheel tracks is far finer than elsewhere but only slightly finer on sites that have performed well for many years. The sands that perform poorly also degrade most rapidly in the ball-mill. Although most sands in the U.K. have been satisfactory it is intended to develop a test procedure based on using a ball-mill, probably combined with shear box testing. It will also be necessary to set pass levels for different applications carrying different traffic loadings. In the ten years of wide use of block paving, this laying course degradation has proved to be the only serious problem that has occurred with block pavements built following the original recommendations.

Efforts have been made to lay blocks mechanically but this has not proved successful, because, it is believed, machine laying has not generally been cheaper or quicker than hand laying. In broad terms two concepts have been tried, one in which special shaped blocks are used, and the other using rectangular blocks which are produced, packed, transported and laid in herringbone bond. It is clear that at present machine laying is only viable for large areas. Fig. 2 shows special blocks being laid mechanically in a manner being used to extend the RO-RO at Dover this year. It is interesting to note that the largest contract in the U.K., Felixstowe LO-LO, also completed this year, has had 180,000 m^2 of rectangular blocks laid by hand. This contract was completed well within time by adjusting the number of laying teams to suit the availability of cement-stabilised roadbase and blocks.

It is the author's opinion that efforts to mechanise the construction of block pavements should be devoted at least initially to the spreading and possibly pre-compaction of the laying course, an operation which is very labour intensive.

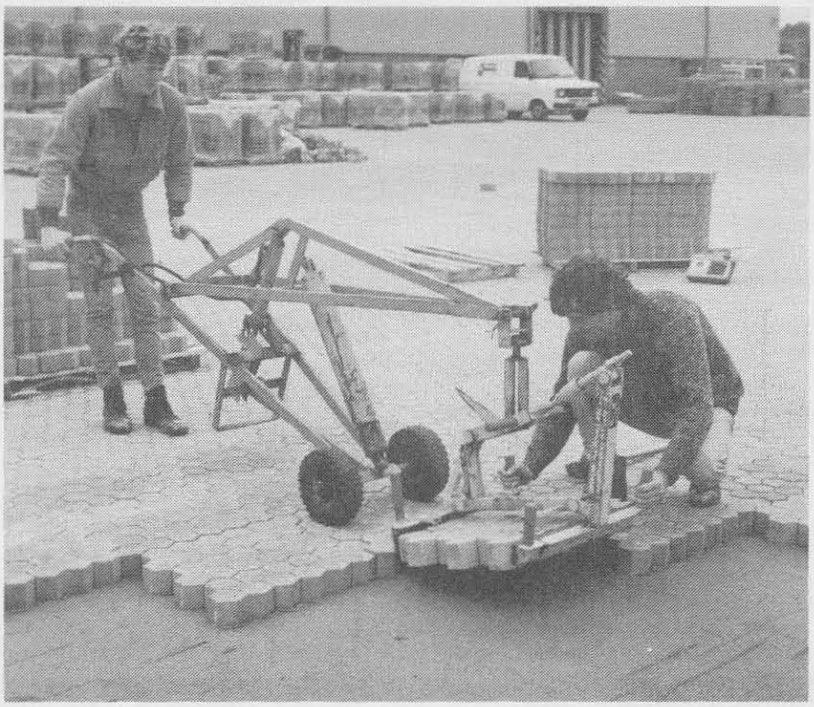


Fig. 2 - Mechanical laying of concrete block paving

MANUFACTURE

A decade ago most paving blocks were made in simple 'hammer' presses making two blocks at a time. Now nearly all blocks are made on large multi-head presses with sophisticated methods of controlling batching and mixing, commonly computer assisted. It is estimated that there are more than 30 large presses in the U.K. with both existing producers increasing the number of plants and new firms joining their ranks. Most producers make poly-sided as well as rectangular blocks, which have proved the most popular. The greater sales of rectangular blocks is believed to be due to the freedom given to the client in being able to change the supplier at any time, not always possible when using poly-sided blocks. Evidence from the field seems to support the conclusions reached many years ago that both types of block give similar and very satisfactory performance (Knapton 1976).

Several producers now make multi-colour blocks to meet the demands of architects who now see blocks as a means of creating paved areas that can be designed to add attractive appearance, something they were unable to do with most other paving materials.

At times plant capacity is greater than sales and at such times producers look for alternative products. One such product is a kerb-block, which is laid on a concrete bedding and with a concrete backing (Fig. 3). This form of kerbing is far less obtrusive than the conventional precast concrete kerbs used in the U.K. and for this reason ideal for many prestigious areas. No Standard has yet been written for these kerb-blocks but they are made from the same mixes and on the same machines as used for block manufacture.

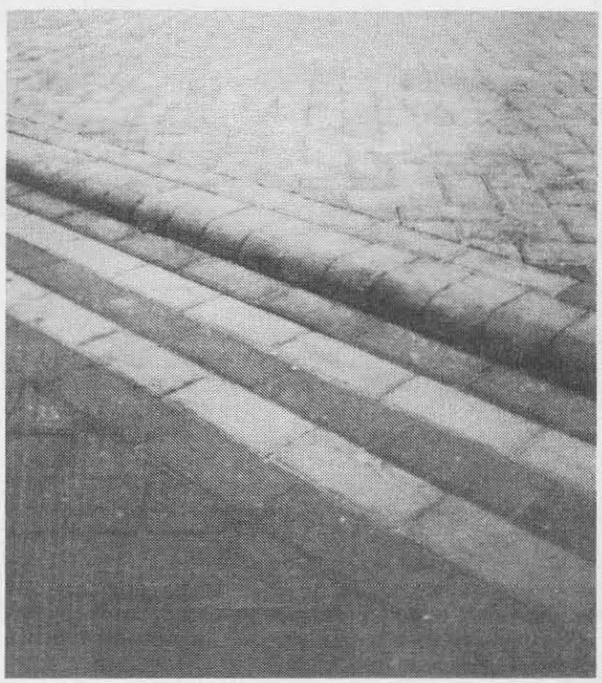


Fig. 3 - Purpose made kerb blocks

For special purposes, blocks are made with applied surface coatings, such as reflective paints for road markings.

THE FUTURE

With such a wide use of concrete block pavements it is difficult to predict the future. Undoubtedly concrete block paving has been a great success in the U.K. and has met customer needs in providing attractive, durable, easily-repairable and economic paving for every purpose, from the garden patio to the port. There have been few failures, so it may be argued that further economies are possible in pavement design to take maximum benefit of the load spreading ability of the blocks. The author believes that with slightly better construction techniques and better standards of block thickness control it may well be possible to raise the speed of traffic for which block pavements can be used and a major trial seems well worthwhile. For certain applications, such as footways and pedestrian precincts, it is both financially and aesthetically advantageous to mix paving blocks and paving flags, giving even greater scope in the future to create new and different surface patterns in areas such as pedestrian precincts.

An application of blocks which has begun and will undoubtedly grow is their use as overlays to existing pavements. This type of work to date has been mainly in run-down residential areas of towns and cities. As part of the upgrading, when the houses have been improved the road is also improved aesthetically and structurally by overlaying it with blocks. By the judicious use of planters, vehicle movements are restricted so the area is one for both older people to sit-out and children to play. There is no need to be concerned in this case with pavement design, provided the old road is in a satisfactory condition. The block overlay can also increase its strength; also, the future traffic will be less.

Another way of using blocks as an overlay, to protect and strengthen existing pavements, has been reported by Emery (1986). In this case blocks were originally set in bituminous hardstandings at Luton International Airport where fuel and oil spillage had softened the surfacing. By the simple expedient of cutting out the asphalt beyond the affected areas and inserting blocks, rapid, cheap and long-lasting repairs have been made. Since these simple beginnings and following independent research, blocks have also been used as overlays at the aircraft turning areas at the runway ends, again very successfully (Fig. 4). Plate bearing tests on these pavements have shown increases in strength of 14 and 21 per cent on bituminous and rigid pavements respectively. This ability to upgrade existing pavements structually to these significant amounts must mean yet another application for concrete blocks.

Another major asset of block paving is that blocks can be removed and re-used. This not only means easier and cheaper access to underground services but also the ability to change any road signs built into a pavement. For example, recently an application has been made to patent a design of blocks that will allow even easier installation of complex road markings in the future.

Significant developments in new block shapes and surface finishes can be anticipated. It can be finally concluded that concrete block paving has a very attractive and useful future, provided its design and construction are kept simple.



Fig. 4 - Luton International Airport, Bedfordshire

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Alan Lilley is a Principal Civil Engineer in the Pavements Engineering Group of the Cement and Concrete Assocaition (U.K.). He is concerned with research and development, advisory work and training for all forms of cementition paving, both internal and external. In 1958 he was elected to Membership of the Institution of Highway Engineers (now Institution of Highways and Transportation) and since that time has served on several of the Institution's Committees and Council. He became a Chartered Engineer in 1958, on being granted Membership of the Institution of Civil Engineers. In 1970 he was awarded a Degree of Master of Philosophy, for a thesis entitled 'Cement Stabilized Materials for Bases and Sub-Bases of Road and Airfield Pavements'. He also served on several British Standard Committees, currently being a member of the committee producing the first British Standard for Concrete Paving Blocks, which is also revising the Standards for Precast Concrete Flags and Precast Concrete Kerbs.

He first realised the possibilities of concrete paving blocks as a highway material in the early part of the 1970s and in those days was greatly concerned with the development and promotion of the concept at what was a difficult period for the whole construction industry in the U.K. He was both a member of the Organising Committee and presenter at the First International Conference on Concrete Block Paving held in 1980 at the University of Newcastle. He also gave a paper at the Second International Conference held at the University of Technology, Delft, in 1984.

His interest in precast paving has been maintained by examining the causes of failure of flag paving and how they can be overcome and very recently with an unusual fault developing in some heavily-trafficked block pavements caused by degradation of the laying course sand.

APPENDIX:

SOME APPLICATIONS OF CONCRETE BLOCK PAVING IN THE U.K.



Playground at Neath Hill Housing Estate, Milton Keynes



Motorway service station in Wales



Container park, Dover docks



Central bus station, Cardiff, Wales



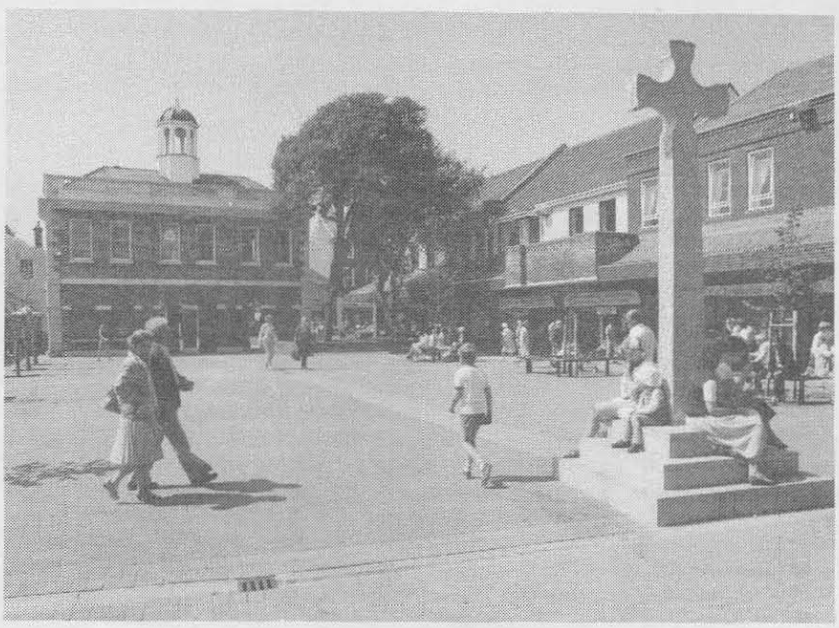
Lewisham market, South London



St Mellons housing estate, Wales



Spotlands area, Cardiff, Wales



Saxon Square, Christchurch, Dorset