CONCRETE BLOCK PAVING - QUALITY CONSTRUCTION BY DESIGN

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SUMMARY

Concrete block paving is now accepted throughout the United Kingdom for a very wide range of applications. The growth in its use over the last ten years is attributed to a number of reasons, including good appearance, good performance and economy. This paper attempts to consider some of the factors, in design detailing of the blocks and block laying, which influence the cost of the finished pavement and suggests simple methods of saving without detracting from the pavement's structural integrity.

INTRODUCTION

During the last decade, the annual sales of concrete paving blocks have increased from a little over nil to estimated current annual sales measured in area of 2 million m^2, despite this period being one of the greatest recessions for 50 years. Figure 1 shows the growth in annual sales over the period. During this time, a great deal has been learned by the producers, specifiers and layers of blocks of the factors which influence the economic and successful uses of block paving in a wide spectrum from private drives to heavily-trafficked industrial pavements.

During this ten year period, users, manufacturers and contractors have had to learn how to design both blocks and block pavements to ensure that the end product was at least as good as traditional pavements and competitive for the various uses. Advice on block paving first appeared in publications produced by the Cement and Concrete Association[1,2] and in manufacturers' sales literature, all of which, in turn, was based, to a large extent on experience overseas, mainly Northern Europe. The Second International Conference on Concrete Block Paving provides an opportunity to review the original advice and to consider how the quality, performance and economics may be further improved by forethought and detailing of block paving.

Performance and design detail are of concern to three main groups:

(i) specifiers and designers - this group includes both local and central government bodies responsible for a range of pavements, such as residential roads, precincts and car parks, and private owners requiring pavements such as storage depots and petrol station forecourts;

(ii) block manufacturers;

(iii) contractors, including block laying specialists.

The requirements of these groups are sometimes similar and at other times different; some of these requirements and their interaction are considered in order to indicate ways of design detailing which could further improve the design and competitiveness of concrete block paving.

USER REQUIREMENTS

(a) A basic requirement of any users is an easily maintained pavement, which means that it must be easy to clean and resistant to damage by weather or traffic. To achieve these requirements, the blocks themselves need to be dense and not liable to absorb water or oil easily and resistant to polishing so they do not become slippery under the action of traffic. In the United Kingdom, they must also be resistant to damage by ice and de-icing salts. The Specification[3] was written with all these requirements in mind and has proved satisfactory in all these respects.

Blocks, like any form of road surfacing, will be marred by oil spillage but, unlike oil-based surfacings, are not structurally damaged.

(b) With time and the action of traffic, any pavement will deteriorate, which may result in faults in the surface, base or subgrade. Faults may also be brought about by other actions, such as a need to break into the road to install or repair underground services. Although a few of the blocks, made before the Specification[3] was published and not complying with it, have failed those complying have proved durable and there is ample reason to believe they will last for several decades. This means that faults in a block pavement are usually due to faults or failures of the sub-structure or foundation or as a result of breaking into

the pavement for access. Whatever the cause, when reconstruction becomes necessary, the majority of blocks can be re-used although, inevitably, some blocks will be broken and lost in the reconstruction period, which means some replacements will be needed. The ability to re-use the majority of the surfacing will greatly reduce long-term pavement maintenance costs. The potential problem of having to obtain some replacement blocks in future has made certain authorities place an embargo on the use of shaped and/or coloured blocks. For the same reason, the Specification[3] only gives one plan size for rectangular blocks (200 x 100 mm). However, the problem may not be as great as originally thought, as the authority responsible for maintenance needs only to hold a small stock of replacements which could come from the small number of blocks left over inevitably at the end of the original contract.

(c) Skidding resistance, even in areas carrying low-speed traffic, is of concern. For example, there are now many residential areas with shared surfaces - children playing in the area also used by the motorist. In this type of situation, even when driving very slowly, the ability to stop quickly without skidding is essential. This requirement has been met by placing a restriction on the maximum amount of calcareous fine aggregate used in the blocks. Some block manufacturers have ample and readily available supplies of calcareous aggregate and this restriction has increased their material costs.

(d) It is obviously an advantage to the designing authority and the contractors if the construction of the sub-structure of a block pavement is similar to that of other roads. This is the case in the UK for the earthworks, sub-base and, where needed, roadbase materials and construction although there is an embargo on the use of certain unbound materials (known as Type 2) immediately beneath the laying course sand because they are often moisture-susceptible.

The early recommendations for the laying course sand were that it should be sharp and not contain more than 3% silt and clay. A Code of Practice[4], produced jointly by the Cement and Concrete Association, the County Surveyors' Society and Interpave, gives a specific grading envelope for the laying course sand. Difficulties have generally only arisen if laying course sand contained significant (more than 10%) silt/clay size materials.

The continuous growth in the use of block paving is taken as proof that the fundamental requirements of the user are being achieved economically.

MANUFACTURERS' REQUIREMENTS

(a) The manufacture of paving blocks has several requirements which are not of direct concern to either the user or the laying contractor. However, the major task is to produce blocks which are acceptable to the user, at a competitive price. To meet this need, it is necessary to have a mutually agreed specification, which has been done although it is hoped that this will be replaced in the not too distant future by a British Standard.

(b) It is axiomatic that no manufacturer will stay in business if his product is not profitable and making an acceptable return on his investment. In the early part of the period being considered, many paving blocks produced in the UK were made on presses used for concrete brick manufacture, two being produced with each cycle. Blocks produced this way were technically satisfactory but production was slow and the labour costs relatively high because of the amount of handling between initial pressing and final dispatch to site. However, despite the disadvantages, this method of manufacture did allow a market to be developed without large capital investment.

As a result of the market growth, many manufacturers have now invested in multi head block presses with high output and much lower labour demand. Maximizing the potential of the relatively expensive machines demands high level of plant utilization; this means that sales must keep in line with the production rate and plant delays must be minimized. Plant delays are due to routine maintenance, a break-down in the production and packaging line, or changing of moulds. Moulds will have to be changed due to wear or when a different block shape is required. Mould wear causes an increase in the plan size of the blocks and the greater the overall tolerance on length and width the longer the mould, an expensive item, can be kept in service. The user and layer, however, do not want large variation in block sizes as this could impair the development of interlock as well as ease of laying. The ± 2 mm tolerance on length and width specified is a compromise which appears acceptable to all three groups although criticisms sometimes arise when a manufacturer changes a mould causing a marked difference in block dimensions within these tolerances. The total cost of moulds places a restraint on the producer, discouraging him from producing a multiplicity of different shapes so, in this respect, users and manufacturers have a common need. Despite this, most British manufacturers make shaped as well as rectangular blocks, presumably with the intention of giving some marketing advantage over competitors by claiming technical and/or aesthetic merits for their particular block. The manufacture of coloured blocks is

also to provide a marketing advantage.

(c) As it is impossible to obtain a continuous balance between maximum production capacity and sales, manufacturers build-up stocks when sales are below average, in an attempt to cater for the periods when the sales exceed production capacity. The stock size is a matter of economic judgement. With a good balance between production and sales, early delivery and acceptance by the client are desirable. For this reason, no age was specified for strength testing of the blocks[3]; they are required to meet all the requirements including compressive strength at the time of delivery. This method of specification allows the manufacturer to decide the most economic stock size and if, for example, it would be to his advantage to use steam curing and to reduce the time delay between manufacture and delivery. Sampling and testing for strength by the purchaser is cumbersome and some simpler method of control is desirable, alternatively a certification system by the manufacturer could be used and is under review at present.

(d) The Specification[3] was couched in a way as to ensure that blocks would be small enough to be held in one hand, to maximize the rates of hand laying. The growing use of blocks in paving large areas is encouraging manufacturers to promote machine laying and one manufacturer is already marketing a block specifically to be laid mechanically. This particular block does not comply with the size limits of the Specification and, with the benefit of hindsight, it seems that the Specification could now be restricting future market development. The ideas is a specification which, while satisfying the user will, in no way, impair future developments - an impossible dream! Possibly the only practical solution is a continuous exchange of views between users, manufacturers and layers.

LAYING CONTRACTORS' REQUIREMENTS

Most block laying in the UK is carried out manually by specialist firms sub-contracting to a larger organization. The earthworks, drainage, base construction and kerbing are usually carried out by the main contractor, leaving the specialist contractor to undertake the placing of the laying course and the blocks. Working this way, the laying contractor does not have to invest in expensive plant and relies on the skill of the operative to lay blocks to the satisfaction of the client and at a cost which yields an adequate profit.

(a) The first requirement of the laying gang is access to the laying site, free of obstructions and edge restraints and any ironwork within the carriageway installed correctly. Without this, he cannot start work and his most valuable asset, the laying gang, is being wasted.

(b) The sub-base, or where used the roadbase, must be to correct levels and with its surface free of voids. If the levels are wrong, it is a great temptation to carry on with the work, relying on the laying course to rectify the errors. This is not satisfactory as major variations in laying course thickness lead to irregularities in the running surface, possibly not fully seen until it has been trafficked for some while. Laying course sand will also in the end find its way into any voids in the sub-base or roadbase which will also lead to an irregular running surface.

(c) It is axiomatic that the block layers require a steady supply of blocks at the laying face, an evermoving location. Normally, blocks arrive on site in banded "cubes" or on pallets and are off-loaded by fork-lift truck or crane, few suppliers having vehicles with their own off-loading equipment. The "cubes" are then broken down into small lots for delivery to the laying face, usually by barrow but sometimes carried by hand. The costs of off-loading the lorry can be high if a fork-lift truck or crane has to be brought in just for that purpose. A cheap method of off-loading which keeps the blocks orderly and undamaged, ideally combined with a system of secondary transport to the laying face is highly desirable.

(d) When submitting a tender, the block laying contractor will adjust his price depending upon the potential risk of having work condemned. For this reason, he, in common with the client and block supplier, would also like a rapid acceptance test for the blocks. Perhaps the greatest risk of having block laying condemned is failure to meet the surface level and regularity requirements. Because blocks are easy to remove and replace without any visual effect, the risk of work being condemned on these grounds is even greater than with other paving. For these reasons, the designer should not specify needlessly high standards for surface levels and regularity. The Code of Practice[4] and earlier recommendations[1,2] set less demanding standards than frequently specified (if not achieved) for other types of pavements. Very high standards should only be demanded if they are necessary.

(e) To maximize his profits and ensure being competitive the laying contractor must lay at the highest possible rate per man day and minimize block wastage. Cutting blocks to fit edges wastes both time and blocks but the problem can be minimized by selecting the block alignment. For example, by laying blocks in line with an edge restraint rather than at 45°, the amount of cutting is greatly reduced, as illustrated in Figure 2.

Another simple and effective design expedient to simplify and speed block laying is to lay against a flush edge or channel rather than a vertical face. To fit part blocks to a vertical face requires a measurement for each block cut, but they can be "eyed-in" if laid to a flush channel, see Figure 3.

On some large paving schemes in the UK, flush channels precast or insitu concrete strips have been used to sub-divide the work, and give the layers a "target". This is no longer recommended as it increases costs by adding to the amount of edge cutting.

Few special edge blocks are used in the UK probably because of the relative ease of cutting. Special edge blocks could create problems for both manufacturers and layers and to-date have not proved economically viable.

Further thought needs to be given to the spreading and levelling of the laying course sand. The uniformity of spreading affects the final surface regularity and therefore a good standard is important. The amount of sand needed is large, approximately 0.1 tonne/m^2 of paving, and the cost of supplying and spreading is significant. Reducing the laying course thickness from 50 mm to, say, 25 or 30 mm could help in this respect although some of the benefit would be lost by increased costs in achieving higher surface regularity standards in the layer immediately below the laying course.

As mentioned briefly earlier in this paper, block manufacturers are examining ways of laying blocks mechanically, perhaps thought should also be given to spreading and screeding the laying course mechanically, a relatively simple task which is at present very labour-intensive.

CONCLUSIONS

From humble beginnings some ten years ago, concrete block paving has become a widely accepted form of paving in the UK, satisfying the needs of a large number of designers and users. Initially, use was encouraged by the pleasing appearance of block pavements, but with time and observation of performance, great confidence has been developed by specifiers and developers. The very wide range of applications is the proof that appearance is not the only reason for success, block paving is also durable and economic. Initially, block paving was dearer than traditional paving, but blocks are now produced more cheaply and laying prices have also fallen as contractors gain experience. As a result, block paving is often cheaper than the methods it replaces. Even so, the author believes that further economies are possible, without detracting in any way from the quality of the end product, by attention to design details to simplify and speed block laying.

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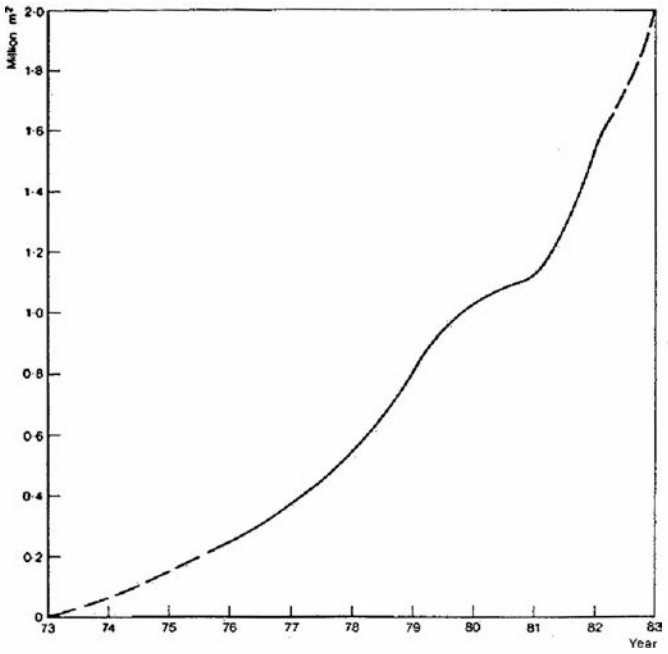
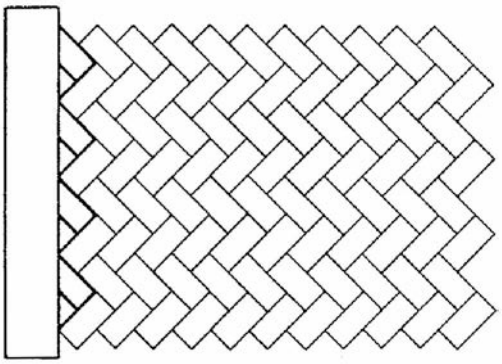
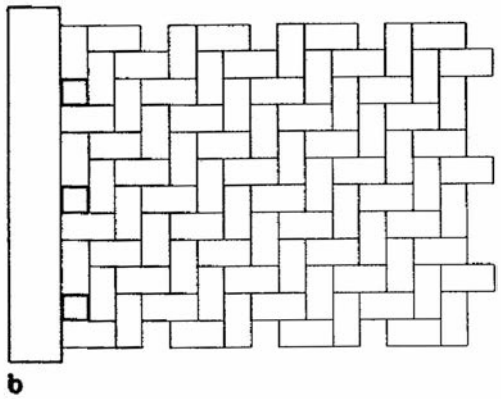


Figure 1: Concrete paving block sales in the U.K.

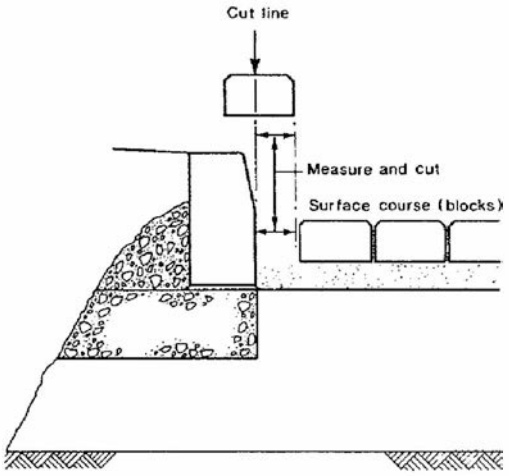


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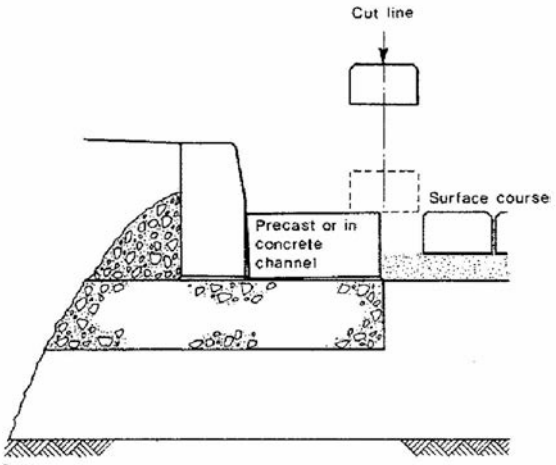


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Figure 2: The effect of block layout on edge cutting



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b

Figure 3: The benefit of a flushedge restraint