THE MANUFACTURE AND USE OF INTERLOCKING CONCRETE PAVING BLOCKS IN GHANA

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Abstract
In Ghana, the recent re-emergence of the use of interlocking concrete paving blocks particularly for paving the driveways and courtyards of private homes and some public precincts has created a sudden upsurge in the use of and demand for concrete paving blocks. This has led to the proliferation of concrete block manufacturers and pavement constructors of all shades and sizes. Associated with these developments are problems and issues related to the structure and design of interlocking concrete block pavements, product and construction quality, construction guides and customer support services. To appreciate the extent and magnitude of these problems, a number of small-scale and big-time producers of interlocking concrete paving blocks in areas of the country where the materials are mostly used were identified and quizzed in a study on aspects of production, marketing and sales, strategies for promoting product use, technical support for users and suchlike issues related to interlocking concrete paving. This paper discusses the results of the study and focuses on the direction and needs of concrete block paving technology in Ghana.

Introduction
In many countries the world over, interlocking concrete paving blocks have been and are being used to construct structurally sound pavements for pedestrian and vehicular traffic including aircraft landings and have become a major material in heavy-duty industrial paving as well [1,2,3]. Concrete paving blocks are particularly suited for application on surfaces subjected to high punching shear such as obtains at container terminals where conventional flexible pavements may not prove suitable and in paving public precincts and streets in residential neighbourhoods where pigmented blocks can be laid to any desired pattern to enhance environmental appeal or even as an aid to local area traffic management [3,4]. They are also appropriate for paving surfaces subjected to oil spillage and offer easy maintenance access to underground utility lines [2,4].

The use of interlocking concrete paving blocks in Ghana is not recent though it does not appear use was sustained for long in the past. Traces of concrete paving exist along some sidewalks and other pedestrian precincts in some parts of the capital city as evidence of past usage. In recent

times, there has been an upsurge in the use of concrete paving blocks though large scale and extensive use of the blocks is not commonplace. In some residential neighbourhoods, the current trend which is seen as a new fad is concrete-block paving of driveways and courtyards of private homes. There is also a gradual increase in the use of concrete blocks for paving pedestrian walkways in recent constructions in the cities and rehabilitating old walkways in urban activity centers.

Even though interlocking concrete paving is still considered a relatively new technology in the paving world, many new developments have occurred within the last decade that have advanced the technology considerably and improved our understanding of the behaviour and performance of concrete block pavements [3]. Most of the improvements have come about through research, the use and control of proper quality materials for production and construction, and also through information update based on field performance. In addition, mechanistic design concepts based on flexible pavement design approaches have made it possible to design structurally sound concrete block pavements to withstand all kinds of traffic and industrial loading [1,2,5].

Today annual production of interlocking concrete paving blocks have soared to millions of square meters of blocks in many countries where the materials are extensively used. The major reasons for this upsurge are attributed partly to mechanized production methods that churn out blocks to close dimensional tolerances and partly to aesthetics and local area traffic management schemes derived from concrete block pavements [2]. In Ghana, the current upsurge appears to be due mainly to the aesthetic appeal, the ease of construction of interlocking concrete block surfacing and the realization that concrete block paving of courtyards is a viable alternative to mass concreting which has a high tendency to develop cracks under the hot environmental weather.

Despite their enormous potential as surfacing materials, concrete paving blocks are not receiving sufficient attention and support from the road sector and allied industries in Ghana. Because of this, there does not appear to be any sustained or systematic research efforts at the present aimed at providing the necessary technical guidelines for concrete block paving. Like any pavement, the design and construction of interlocking concrete block pavements must not compromise sound engineering principles if construction durability, longevity and proper performance are to be assured. Judging from the quality of products and construction exhibited by the industry it does not appear the principles are being maintained. Expertise in the construction of concrete block pavements vary from poor to very good. Whereas in some cases blocks have been laid to a near-perfect pattern with evidence of good compaction and sufficient edge restraint, in others, haphazard construction, uneven laying patterns, inadequate bedding preparation and inadequate structural capacity characterize the construction.

To appreciate better the extent of production and use of interlocking concrete paving blocks and the associated problems, a number of small-scale and big-time producers of the materials were identified and quizzed on aspects of production, marketing and sales, strategies for promoting product use, technical support for product users and suchlike issues related to interlocking concrete paving blocks. This was accomplished through the administration of questionnaires to a number of block manufacturers, road and metropolitan authorities and supplemented with visits.

Information from such studies is seen as part of the feedback required by the industry to help it develop better strategies for improved product use and performance. This approach has been

highlighted by Hodgkinson [3] who believes that the progressive feedback of information from those involved with the design and building of interlocking concrete block pavements creates the need to reinforce the principles which affect the success or otherwise of these pavements. This paper takes a look at some of the pertinent issues of the emerging concrete block paving technology in Ghana and focuses on the technical needs and direction of the technology in the country.

Profile of Block Manufacturers

In the past, the manufacture of interlocking concrete paving blocks was the preserve of a few companies specialized in the production of concrete products because of the low demand then. Today with the re-emergence of the use of these blocks and the accompanying growing demand, many companies both small and large have proliferated on the market to satisfy demand and/or have added production of concrete paving blocks to their line of products. The profile of the manufacturers contacted in the study ranges from small roadside/backyard producers to big-time producers specialized in the manufacture of concrete products.

Equipment being used by this range of manufacturers range from simple vibrating tables and hand presses to heavily-mechanized sophisticated concrete mixing and vibro-compacting systems. While the well-established companies use batching and feed mixing by skip in mix preparation and subject blocks to controlled curing conditions, many of the small-scale producers prepare mix by hand leading to mix inhomogeneity and poor quality product aside improper curing which causes cracks to develop. The quality and surface characteristics of products from such an assorted type of manufacturers vary and appear to be closely related to the level of sophistication of production equipment and processes.

Many of the small-scale producers sustain their businesses with small orders from or by producing mainly on demand for small-scale users such as private home owners or by pre-financing production with deposits from customers. Sometimes it is also possible with some of such manufacturers for customers to negotiate for a price rebate by agreeing to partly pre-finance production of the order. But undoubtedly, practically all the market leaders have extensive stockpiles for instant delivery. There are also some big construction companies that sometimes opt to manufacture these blocks on their own when contracted to undertake large-scale construction of concrete block pavements. These are considered non-regular manufacturers of concrete block pavers.

Production, Usage and Product Promotion

Level of Block Manufacture

Many of the block producers describe their production as having experienced a significant to sharp increase within the last few years. None of the companies is experiencing problems with the supply of raw materials but almost all find the continuous increases in material cost due to inflationary effects as detrimental to block sales as the resulting price increases in unit cost of blocks have the potential of putting off many would-be users.

An indication of the growing level of block production is provided by the statistics of a typical small-scale producer whose first year production of 1,500 tons has now shot up to 4,500 tons in the fourth year- a three-fold increase in block production. Depending on the size of the company, block production may range between 300,000 and 5,000,000 pieces per year. Even though

practically all the big-time producers refused to divulge information on their production levels, it is estimated that annual block production in the country may be upwards of 300,000 m^2.

Blocks available on the market are produced mostly to 70 and 80 mm thickness in a variety of shapes including rectangular, square, hexagonal and octagonal. Pigmented blocks are also available with red and black being the predominant colour of choice. Block dimensions vary with typical values being 100 mm x 200 mm, 150 mm x 200 mm, 100 mm x 100 mm and 100 mm sides for hexagonal and octagonal blocks. Qualitywise, most of the companies gave block strength values that ranged from 18 to 40 N/mm^2 after 28 days of curing. No independent confirmation of these figures through sample block strength tests was carried out during the study. The unit price of blocks averages the equivalent of $1.67 and $2.00 for non-pigmented and pigmented blocks respectively.

Block Usage Levels

At the current level of usage, available data on concrete-block paved public precincts indicate that only about 51,000 m^2 of pedestrian walkways within the Accra Metropolis, for example (see Table 1), and slightly under 10,000 m^2 within the Kumasi Metropolis have been covered with concrete paving blocks.

Table 1. Concrete-block-paved sidewalks in the city of Accra

Road Name	Length (m)	Sidewalk Width (m)	Area (m^2) [1]
Guggisberg Avenue	1,800	3	10,800
Eduardo Modhlana	1,400	3	8,400
Nii Teiko Din Street	800	2	3,200
Kwame Nkrumah Circle	800	3	4,800
Brewry Rd./Loop/Link	1,061	2	4,244
Aditrom Street	466	2	1,864
Aheneakwa Rd./Official Street	1,309	2	5,236
Hall Avenue	313	2	1,252
Castle Road	365	2	1,460
Adama Street	313	2	1,252
Okai Mensah St./Link	757	2	3,028
Chatfield Ave./Link	725	2	2,900
Amugi Street	365	2	1,460
Location Links	164	2	656

[1] sidewalk on both sides of road

These exclude 107,300 m^2 of the ground area of the Tema Harbour which was paved with rectangular paving blocks some couple of years back. The above figures are only indicative of paved public precincts for which data is available. The current shift towards the use of interlocking concrete blocks for paving the walkways in Accra by the metropolitan authorities,

for example, appears to have been necessitated by the fact that a more durable paving material was needed to reduce high walkway deterioration in highly pedestrianized areas and concrete blocks were the first trial choice.

Other potential large-scale users are governmental agencies such as the Ghana Highway Authority (GHA), the Department of Urban Roads (DUR) and metropolitan authorities. GHA cites speed restrictions (50-60 km/h), ride quality and other problems related to operational efficiency as reasons for not considering the material in paving programs. The DUR which together with the metropolitan authorities has the responsibility of developing urban and residential streets faces budgetary problems that stunt even minimal development and is unlikely to adopt concrete block paving any time soon.

Estimates of block use at the national level is made difficult by the fact that records of use within private precincts are difficult to collect and was not considered at this level of the study. But based on production estimates, some 300,000 m^2 of interlocking concrete paving blocks are being used annually in the country. The bulk of this is used by the private sector in paving private homes.

Product Promotion and Marketing

None of the companies contacted had any clear policies on strategies for promoting product use. Almost all were of the opinion that product promotion and sales could be helped if more public construction by government involved the use of concrete paving blocks. Even the big-time producers with the means to afford media advertisement appeared content with the current level of custom and seem to rely on self-exposition through the quality of their products and construction expertise to improve block sales without resort to expensive media advertisement. Invariably, all the small-scale producers use promotion and sale strategies that involve mainly roadside display of block types, possible laying patterns and block combinations that enhance aesthetics. In general, many of the companies have adopted a do-nothing approach to product promotion because they see the steady increase in inquiries about and demand for concrete paving blocks as well as the proliferation of block manufacturers as signs of optimism for the future of the concrete paving block industry in the country.

Customer Technical Support Services

Practically all the companies both small and large involved in the manufacture of concrete paving blocks also double as constructors of concrete block pavements. Technical support services to customers are provided in the form of technical supervisors and a laying team with the quality of the construction being dependent on the experience and skills of the workmen. Many of the small-scale block producers are invariably of low or no proven expertise in block pavement construction. But except on large scale government projects for which specialists knowledge would definitely be sought, many users of interlocking concrete blocks use or rely on the services of such constructors. This situation can lead to many performance problems in many of the constructions at a later time. In do-it-yourself construction, some of the manufacturers said they also offer guidance to customers as to the laying patterns and block combinations suitable for each shape and type of block.

Technical Problems Related to Construction

The ease with which concrete block pavements can be laid even by untrained hands comes with a price. Many see the construction of interlocking concrete pavements as easy-to-do or do-it-

yourself construction just because they focus more on the laying aspects or geometric arrangements of the blocks and less on the functional and structural aspect of the pavement. But in so far as interlocking concrete block pavements are considered to behave like conventional flexible pavements, their construction must ensure protection of the subgrade from excessive compressive strain through the use of sufficient thickness of good quality material interposed between the subgrade and the block-sand bedding layer.

It is very important to note that deficiencies in the underlying layers cannot be compensated for by the surface quality of the pavement [3]. Even though in most cases the current level of application in Ghana subjects block pavements mainly to light loading regimes, in areas of clayey subgrade and high water table such as obtains for the geotechnical conditions in one city where the blocks have very high demand potential, the occurrence of permanent deformation due to subgrade saturation and subsequent failure in shear under even such light loading conditions cannot be ruled out. This is especially true with channelized traffic conditions such as obtains on driveways leading to courtyards and garages.

In countries where the blocks have high use potential, guidelines [6,7,8] relating the selection and construction of a number of structural options are available to suit the particular loading and subgrade conditions being dealt with. Any structural inadequacies have the potential of causing a loss of confidence in the performance of concrete block pavements.

Other construction and technical problems evolve around the provision of edge restraint, laying patterns in relation to the direction of traffic and the use of bedding and jointing sand. In a number of cases, the type of bedding and jointing sand observed being used ranged from fine silty sand to coarse sand, quarry dust and even medium-size granitic chippings. Obviously where granitic chippings have been used for bedding, the gain in vertical interlock from the upward migration of bedding sand into inter-block joint spaces during compaction does not come about. Technical deficiencies also manifested as amateurish construction in a few cases in which the paving blocks had been or were being laid directly on the prepared ground without the use of a sand bedding layer. Even at the time of the construction when the pavement had not come under any loading, considerable surface unevenness and block misalignment were apparent and widespread.

Industry Needs

Based on the study, two aspects of interlocking concrete paving technology stand out as needing urgent attention. These relate to material/product quality and technical guidelines and documentation for the construction of interlocking concrete block pavements.

Product Quality Specifications

Product quality is an essential ingredient to the overall performance of concrete block paving and must conform to a set standard. Despite the diverse methods of production, variability in product quality must be reduced to a minimum. Paving blocks that are substandard due to poor quality concrete or production that was not quality-controlled may break under load or undergo spalling [9]. It is very necessary that the industry provides some forum for discussing issues of importance to the survival of the industry and a means of ensuring that the market is not awash with poor quality and substandard products. Such issues may be better addressed by the manufacturers by establishing an umbrella organization along the lines of the cement and concrete associations in some countries.

Technical Specifications and Support

Technical specifications bear directly on the future of concrete block paving as they provide the necessary framework for design, construction and successful performance of concrete block pavements. The essence of these is to make technical expertise readily available to users and practitioners of the technology in the country. Development of the industry and technology in this regard calls for;

- Research to provide structural design and construction options to suit local soil and climatic conditions, bedding and jointing sand specifications.
- Documentation to provide construction guide and technical support needs of block users and constructors of interlocking concrete block pavements.

Conclusions

This paper has highlighted some aspects of the re-emergence of the use of interlocking concrete paving blocks in Ghana. In particular, focus was placed on block manufacture, product use and promotion, and more importantly on the technical problems and support needs associated with interlocking concrete block pavement construction. Even though the current level of application subjects most of these pavements to only light loading regimes, lack of sufficient attention to detailed structural design considerations and options must be seen as a major setback and danger to the future performance of interlocking concrete pavements in Ghana. In the light of these problems and the fact that there is a proliferation of block manufacturers and constructors some of low or no proven expertise, it is suggested that technical documents addressing material quality, design options that suit local soil and climatic conditions, and construction quality, be developed through sustained research in and documentation of the performance of interlocking concrete block pavements in Ghana.

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