EVALUATION OF INTERLOCKING CONCRETE PAVEMENT PERFORMANCE IN AN URBAN NORTHERN CONTEXT

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SUMMARY

Road pavement surfacing is now an intrinsic part of the development and personalization of municipal public space projects. Through its variety of forms, colors, and textures, interlocking concrete pavements provide an answer to concerns in urban design. Nevertheless, the use of interlocking concrete pavements by cities in the province of Québec remains low. Little is known about the structural behaviour of this type of pavement in northern conditions since only few studies have focused on this topic. This research project aims at the determination of criteria for the design of interlocking concrete pavement in northern environment. For this purpose, a state-of-the-art and practices in northern countries has been done and parameters linked to performance of this type of pavement have been identified. Furthermore, the experience with interlocking concrete pavement as road surfacing in Québec has been reviewed. An evaluation of nine sites in Québec City, six in Montréal City, and three in Longueuil City, yielded to the identification of the main parameters linked to the degradation of interlocking concrete pavements in urban northern context. This assessment has enabled pinpointing of the problems associated with this type of pavement and to identify the causes of failures as well as the reasons behind the success of existing sites, in particular, the key role of the bedding sand. An experimental program was also carried out in laboratory, which consisted in verifying and quantifying the relative importance of these significant parameters using cyclic testing on systems consisting of two types of concrete blocks laid on bedding sands of different thicknesses and mineralogical sources.

Finally, the article presents the second part of the research project that has been undertaken by Université Laval in collaboration with the cities of Québec and Montréal as well as the companies Permacon, Transpavé, Techmix and Techni-Seal. The project will require numerical simulations that can represent interlocking concrete pavement behaviour, experimental program on road structures paved with interlocking concrete blocks using a laboratory load and climate simulator, and validation of the design criteria through the construction of interlocking concrete roads in northern municipalities. This project will enable to determine optimized design criteria for roads paved with interlocking concrete blocks. The main objective of the project is to propose structures adapted to interlocking concrete block pavement in northern context. Indeed, the optimization of road design according to criteria will help promote the use of interlocking concrete block pavement on municipal roads in Québec.

1. INTRODUCTION

Roads surfaced with concrete blocks are considered to be flexible pavements for which bituminous concrete is replaced by interlocking concrete blocks laid on a granular bed known as the bedding sand. Interlocking concrete pavements cover an increasingly wide range of applications, essentially in urban areas. These applications bring together, among others, pedestrian walkways, sidewalks, service stations, intersections, bus lanes, port zones, parks, and automobile and airport parking lots.

This wide field of applications can be explained by the many technical, aesthetic, and economic advantages offered by this type of pavement. Despite its many advantages, the use of concrete block paving as surfacing material remains low in Québec. Until now, the use of concrete block pavement has not been the object of many studies which take into account Québec specificities. Thus, Université Laval, in collaboration with the cities of Québec and Montréal as well as the companies Permacon, Transpavé, Techmix and Techni-Seal, undertook a research project whose main objective is to determine and optimize design criteria for roads surfaced with interlocking concrete blocks.

2. STATE OF THE ART AND PRACTICE

2.1 Introduction

According to a study completed by Shackel (2003), the production and the use of interlocking concrete pavements are increasing in North America since the seventies. Nevertheless, this type of pavement is still not very common in Québec. A large part of the literature coming from a northern context (Northern Europe and Japan) deals with the wear of interlocking concrete blocks due to studded tires which are not often used in North America. Besides, very few studies were made on the structural behaviour of this type of pavement. Until now, there is no interlocking concrete pavement design method in Québec. The city of Montréal (*Ville de Montréal* (2002)) proposed technical specifications (7VM-10) for the placing of interlocking concrete pavement laid on bedding sand. However, it appears that design and placing are major performance criteria.

2.2 Municipal and Environment Advantages

From an architectural point of view, interlocking concrete pavements improve aestheticism and organization of urban zones through the variety of shapes and colors available. Until recently, financial cost has been the main criterion when it comes to choose a type of pavement. But in the actual context, environmental impacts due to the choice of materials are now taken into consideration. According to Shackel et Pearson (2005), the LEED (Leadership in Energy and Environmental Design) administrated by the US Canadian and Australian Green Building Councils has shown that, from an environmental point of view, the use of concrete permeable blocks was a better and more desirable choice than asphalt concrete or in-situ concrete. Concrete permeable blocks offer the advantage of controlling and filtering run-off water.

On the financial side, many studies (Baker et Burak (2003)) have shown that on a short term basis, interlocking concrete block pavement is more expensive than asphalt pavement. However, it seems that maintenance cost and the possibility to re-use concrete blocks make this type of pavement less or as expensive as asphalt. Furthermore, concrete blocks facilitate the access to municipal underground infrastructures since they are easy to remove and put back into place (Kuijpers 1984). According to Shackel et Candy (1988), skid resistance of concrete and asphalt are equivalent as well as the riding comfort for speeds below 60 km/h.

2.3 Northern Context Advantages

Road construction and rehabilitation imply a close-down of the area; these delays are an important factor, especially in urban zones. Interlocking concrete block paving does not require curing as other types of pavement do. Moreover, low temperatures often make it difficult to put into place an asphalt pavement but do not affect the installation of concrete blocks. It is therefore possible to extend to all year long the installation period of interlocking concrete paving.

A research project (Burak 2003) studied the use of interlocking concrete blocks as a repairing material for road pavements. Usually, winter repairing includes many operations: to firstly put some cold patching, then in spring to remove and replace it by some hot-mix asphalt patching. In this study, the road surface was repaired using interlocking concrete blocks placed over a low density material. The road still shows excellent mechanical performances after six years. This method is less constringent and expensive than traditional winter repairing.

2.4 Design in a Northern Context

In Québec, design methods for flexible pavements usually include Boussinesq and Odemark equations as well as the AASHTO empirical method. Dutruel and Dardare (1985) have reproduced in a laboratory an interlocking concrete pavement with a cyclic load applied on it. Results showed that under a cyclic load, the interlocking block pavement acts as a slab. Load distribution was similar to what is found in flexible pavements. Furthermore, under a load, stress distribution in the structure corresponded to Boussinesq theory.

Leong and Tighe (2005) have proposed a design model for interlocking concrete pavements in the Canadian municipal context. Their model is based on the AASHTO 1993 empirical equation which is used in Québec:

$$\log W = Z_R \times S_0 + 9.36 \times \log(SN+1) - 0.20 + \frac{\log\left(\frac{p_i - p_t}{p_i - 1.5}\right)}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32 \times \log(M_R) - 8.07 \qquad \textbf{(1)}$$

where W is the life expectancy of the road, Z_R is the normal deviation, S_0 is the standard error estimation, SN is the structural number, P_i is the initial viability index, P_t is the final viability index and M_R is the base resilient modulus. Their study considered a bedding sand of 25 mm and 80 mm thick concrete blocks. Their model consists in determining base thickness according to its type: non-treated granular base, gravel cement base or gravel asphalt base and for a life expectancy of 20 or 40 years. Thickness is defined according to the quality of drainage, traffic and different types of soils as identified by the AASHTO. In Québec, the *Ministère des transports du Québec* (1999) uses a chart-based, empirical method where the total thickness is chosen according to the freezing index. This chart is used with the AASHTO model and provides acceptable frost protection. In the design method of Leong and Tighe (2005), the “concrete blocks – bedding sand" system corresponds to an equal thickness of asphalt with an equivalent modulus of 3100 MPa. Equivalent modulus values found in the literature are very spread apart. For example, Rada et al. (1994) have studied interlocking pavement of 3 different sites after 6 to 8 years of service. Their study clearly shows that higher traffic causes a higher equivalent modulus for the “concrete blocks – bedding sand” system: from 813 MPa for a low traffic area to 3808 MPa for a high traffic area. Therefore, the choice of the equivalent modulus value is very important.

There are various ways of determining the equivalent modulus. Major ones include backcalculation based on CBR or FWD tests. A standard plate test can also be used. This test, explained by Dutruel and

Dardare (1985), consists in applying a load to an interlocking concrete pavement on a circular plate. Once the pavement has been broken, lines of ruptures are measured and a mean radius is calculated. A modulus can be determined with the rupture lines theory and by taking into consideration the hypothesis that the plate is on an elastic pavement structure built on an elastoplastic base.

2.5 Use of Interlocking Blocks in Permafrost Zones

Half of the Canadian soils area is under permafrost conditions. Beaty (2000) produced an assessment of the advantages of using traditional interlocking pavements and proposed construction methods. In permafrost zones, pavement color is important to maintain a thermal balance. The use of white concrete blocks would diminish sun rays absorption and would limit maintenance work. Beaty proposed to build directly on natural soil, to insulate with polystyrene, to use a cement stabilized base to minimize thickness of pavement and to limit the fine aggregate fraction in the bedding sand.

2.6 Parameter Affecting Road Pavements

Four main parameters affect the performance of concrete blocks. In the case of vertical loads, the shape of blocks has no significant influence on the performance of pavement. However, it is important to control horizontal loads. Increasing the thickness of concrete blocks reduces strains, deflections, as well as the stress transferred to lower layers. Moreover, there are many ways of laying down the blocks, the most common of which are the broken line, herringbone, and chevron patterns. It seems that the best performance is obtained with blocks laid in herringbone pattern and that this benefit is more important if the road is exposed to horizontal loads. When it comes to freeze-thaw resistance, Ghafoori and Smith (1996) have demonstrated that the Canadian norm (CSA-A231.2) is more suitable than American norms (ASTM C67, C666 and C672).

The bedding sand is the essential element of roads paved with concrete blocks and it is one of the main causes for its failure. Its purpose is to provide a uniform support to blocks in order to avoid the concentration of stresses (an important source of damage), to fill the bottom part of joints to ensure the interlocking of blocks, to constitute a barrier to the propagation of cracks, and to contribute to the distribution of stresses resulting from wheel loads. In order to achieve its role, the bedding sand must exhibit the following properties: to be easily compactable, not susceptible to frost, able to fill joints, resistant to mechanical damage, and self-draining. The thickness must be 30 mm ± 5 mm. For the gradation, the bedding sand is generally a sand whose maximum particle size is 5 mm. Cook and Knapton (1992) have shown that the bedding sand is the cause of some damage observed in the United States and in England. Indeed, sands with angular grains break more easily under the effect of traffic loads. These studies pointed at the danger associated with a large amount of particles passing the 80 µm sieve. In Canada, the trend is to eliminate all particles passing the 80 µm sieve (due to frost problem). According to Beaty (1996), it also seems that the sand must have an uniform water content in order to allow for change in volume during compaction. After having studied the causes of pavement failures under heavy loads, Lilley and Dowson (1988) concluded that the most important property of sand used for bedding sands is its resistance to repetitive loads without breaking. Therefore, sand containing quartz and feldspar, which are more resistant to mechanical damage, are better suited for the laying of blocks.

Two main characteristics of joints are likely to affect in-service performance of roads paved with concrete blocks. These are their width and their mechanical strength. To avoid the pumping of bedding sand material through joints, the maximum recommended width of joints is 2 to 6 mm. According to Panda and Ghosh (2002), shear and expansion stresses are the main criteria in selecting sand for joints.

This study shows that the best sand for these joints is one with coarse angular grains (quarry sand) likely to resist shear.

The main factors influencing the performance of the base layer are the type of material used and the thickness of the base layer. With respect to the thickness, the variation in elevation of its finished surface must be very low: a high variation can cause variations in thickness of the bedding sand, which could become a cause of future failure. For an optimal solution, the quality and thickness of the base layer must be compatible with the thickness of blocks concrete. It appears that materials used for the base layer of bituminous concrete road pavement can be used effectively for concrete block pavement. These materials are granular materials (crushed stone), stabilized granular materials, poor concrete, and even bituminous concrete. The choice of material depends essentially on the climate.

One of the main concerns related to the use of concrete blocks as road pavement in a northern environment is the water infiltration through the joints which is very damaging for base and subbase layers. For this reason, it is recommended to provide an adequate slope (transversal profile) for water draining purposes and to reduce the permeability of joints, or, even better, to seal them. Ishai et al. (1999) has shown that the choice of sand grading for the laying of blocks must take into account the mechanical strength and especially the water infiltration. Water infiltration can wash away the sand if the flow speed is high which result in shifting of the blocks. These authors have noticed that indented blocks (multidirectional blocks) remain better in place than rectangular blocks (unidirectional) under water infiltration or water flow at high speed. Tests carried out have shown that coarse particle sands (5 mm in diameter) are less susceptible to being washed away than finer particle sands.

In this section, it has been shown that many parameters affect the performance of interlocking concrete pavement. In order to assess the factors contributing to good performances in a northern environment, the use of concrete blocks as pavement material for several sites in the province of Québec was documented.

3. PRELIMINARY STUDY (PHASE 1)

3.1 Studied Sites: Observation, Measurements and Samplings

Several test sites were identified in three different municipalities. Overall, 18 test sites were selected: 9 in Québec City, 6 in Montréal, and 3 in Longueuil. Evaluation on the various sites consisted of measuring rutting, the thickness of blocks, and the thickness of the bedding sand (5 measurements per site), the vertical and horizontal shift of blocks, the deterioration of joints, the shape of blocks as well as bonding and blocking of blocks. Sample of the joint-filling material, the bedding sand and the base layer were also taken during the site visit.

The purpose of visual observation of the concrete blocks was to evaluate the presence of scaling, the wear, and the type of failure. The results show that no scaling of blocks was observed on the sites studied, which indicates a good behavior of blocks with respect to this type of damage. However, a large amount of wear was observed at five sites. The main types of failures observed sporadically are corner breaks and breakage in two halves. The general aspect of the sites was good in most cases, except for two sites in Québec City where severe rutting was observed.

For thickness of bedding sand, the average value of thickness is the result of five measurements of the bedding sand thickness for a single site. According to the results, the average value of bedding sand thickness in Québec City is 30 mm with a standard deviation of 8 mm, which demonstrates a certain

homogeneity of this parameter. However, in Montréal, the average value at the sites studied is 41 mm with a standard deviation of 33 mm showing a high level of variability in bedding sand thickness. Finally, in Longueuil, results are similar to those in Québec City with an average of 35 mm and a standard deviation of 12 mm.

The measurements and readings carried out on the surface of sites show that only three sites in Québec City present vertical shifting, and that no horizontal shifting has been observed. Moreover, according to the results, it is clear that rutting is a type of damage that is frequent for this type of pavement, as 12 out of the 19 sites are affected by. It should be noticed that the joints are mostly damaged by trenching between them and the thickness of blocks seems to be linked with the development of transversal rutting. In fact it is possible to notice that the three sites presenting a maximum transversal rutting greater than 30 mm are covered by blocks of 80 mm in thickness or less. This represents a trend observed on the studied sites. However, more data is necessary to confirm this observation. Nevertheless, this observation is consistent with expectations, since thicker blocks accentuate the slab effect, increasing pavement strength. Moreover maximum transverse rutting is compared to blocks pattern. It can be seen that, according to the results obtained, the herringbone pattern seems to be the least performing.

For each site, the maximum rutting value was measured using a precision rut ruler. One value of elevation is taken every 100 mm in order to obtain the transversal and longitudinal profile of each site. The results show that the maximum rutting values vary considerably ranging between 0 and 60 mm. It should be noticed that five sites present maximum rut above 20 mm. As far as the maximum longitudinal distortions are concerned, no one exceeded 20 mm and the deepest distortion was measured at one site in Longueuil.

3.2 Laboratory Materials Characterization Tests

3.2.1 Base Materials

Tests were conducted in order to measure the grading of base materials and to determine the value of certain parameters in terms of percentage of fine particles. From these results, it can be seen that the majority of base materials are equivalent to the granular material (0-20mm) recommended by Québec Ministry of Transportation (MTQ). Aside from two sites in Longueil, where the base layer is a cement stabilized granular material, all other sites are built using unbound granular materials. Modified Proctor tests were carried out in order to determine the CBR value of base materials. Optimum water content and dry specific density ρ_d were determined. The results showed that W and ρ_d values do not vary much for the granular material samples. Therefore, assuming that these materials were placed at a dry specific density close to the optimum Proctor density, this parameter seems of little interest in order to explain poor performance. CBR tests were done on base materials in order to verify that the base layer does not constitute a source of degradation of pavement, since these tests provide an estimate of the bearing capacity of a granular material. Most of the results for the CBR values obtained are found between 100% and 200%.

3.2.2 Bedding Sand Materials

The percentage of fine particles in the bedding sand materials can be a source of pavement degradation in northern environments. A large quantity of fine particles in a granular material can make it prone to freezing, negatively affecting draining and making it more plastic. However, a low quantity of fine particles can improve granular stacking and thus improve the bearing capacity of the material, thereby improving the load capacity of the material. Gradation analysis by sieving and sedimentation were conducted in order to determine the percentage of fine particles and their size distribution. From the

gradation curves obtained, the percentage of gravel (5 mm retained), the percentage of fine particles (passing 80 µm), and the percentage of particles below 5 µm were determined. The result show that the percentage of fine particles in the bedding sand at the sites under study varied between 7% and 22%. Seven out of eighteen sites have more than 15% fine particles and most of them have more than 5% of particles below 5 µm, in other words nearly the size of clay particles. The granular materials whose grading is uniform are generally more likely to develop important permanent strains due to their instability.

3.2.3 Joint-filling Materials

Given the narrow width of joints between blocks, it was not possible to take samples of joint-filling materials on all sites. Moreover, where this was possible, the quantity of material sampled was insufficient to conduct a grading analysis. Maximum diameter values indicate that type 0-5 mm and 0-2.5 mm materials are usually used as joint-filling materials in practice. It is however possible to question the width of joints in which particles having a d_{max} of 10 mm were found. Nevertheless, sites having a large percentage of fine particles may display a lower permeability which can improve the performance of the pavement. However, a large quantity of fine particles may make the material plastic, depending on the mineralogy of these particles.

3.2.4 Analysis of Results – Rutting Performance

For each site, the total number of heavy vehicles was estimated by multiplying the annual average daily traffic (AADT) of heavy vehicles by the age of the pavement. In Montréal City, AADT information was provided directly. In Québec City, the Réseau de Transport de la Capitale (RTC) was able to provide the number of buses traveling on each site per year. Very little information was available for Longueuil City. The combination of these two sources of information yields to an estimate of the ratio of the number of buses per year and the number of buses for all sites. This coefficient multiplied by the number of buses per year and by the age of the site gives an estimate of the total number of heavy vehicles having traveled each site. It was not possible to obtain enough relevant information to estimate the total number of heavy vehicles in Longueuil City. No criterion was found in the literature to establish threshold values for sites having a low, average, and good rutting performance. That is why threshold values used by the Québec Ministry of Transport for performance contracts determined for the construction of highways using bituminous concrete were used. These are presented in Table 1.

Table 1. Rutting performance contracts criteria for highways

	Grouping in 10 sectors	Any individual measure
At acceptance of work	< 5 mm	< 5 mm
At 7 years	< 8 mm	< 12 mm

These values being used for highways, they are stricter than values expected in an urban context since highway speeds are much greater than those on urban roads and the risk of hydroplaning is greater. Nevertheless, it could be appropriate to use these values since they represent a strict performance criterion for pavements. In this study, we used criteria specific for each individual measurement. As the sites evaluated could not be considered new constructions, the value of 12 mm at 7 years was used as a limit value marking the beginning of poor behaviour. It seemed reasonable to assume that the rutting value after construction of the sites was 0 mm. By drawing the maximum depth of rutting against the age of the pavement, it is possible to draw a straight line from 0 mm at age 0 that connects to the point 12 mm at age 7. Moreover, the Québec Ministry of Transport specifies that a rut depth of 20 mm as a typical terminal value at age 15 years. Therefore, a straight line was drawn between 12 mm-7 years and 20 mm-15 years. All data points falling above the line were considered to be

representing poor performance. Another line was drawn using half of the values describes above i.e.: 6 mm at age 7 and 10 mm at age 15. This new line was used to separate sites having a good performance from sites having an average performance. The results of this analysis are presented in Figure 1. Using this figure, sites can be classified as having good, fair or bad performance from the point of view of structural rutting, which is the main performance criteria used in this study.

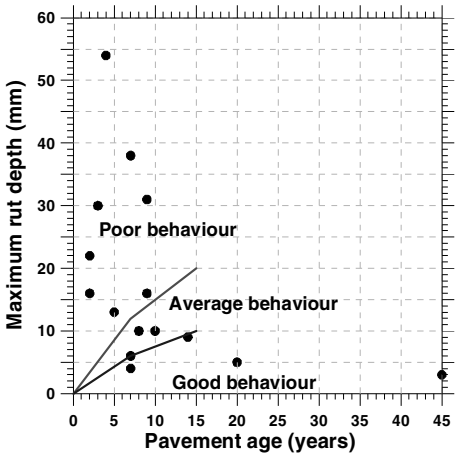

Figure 1. Distribution of sites having a good, an average and a poor performance

Five sites have a good behaviour. For these sites, three have bedding sand 35 mm thick which could partly explain their good performance. It should be noticed that three sites are exposed to relatively low traffic given their age. This might be the explanation for their good performance. Moreover, in the case of the majority of sites, the uniformity coefficient of the bedding sand is very high (124, 100, and 95). Granular stacking of these materials is therefore good and they are less likely to experience permanent strain. Two sites have an average behaviour. These sites have in common a beginning of joint degradation and also experience heavy traffic which could explain their average behaviour. Moreover, the average thickness of their bedding sand is relatively small. The rest of sites have a poor behaviour. These sites have a bedding sand thickness generally within standards. However, it was observed that these sites often have a bedding sand of irregular thickness. In the majority of cases, the uniformity coefficient of the base material is below 40 and they were submitted to relatively high traffic loads which can partly explain their poor performance. A common characteristic of all these sites is the degradation of joints from a relatively advanced state to a very advanced state.

3.2.5 Laboratory Study of the Influence of Bedding Sand

The bedding sand is a structural layer that is specific to interlocking concrete pavement. As a result, considering the few studies available for this type of pavement, the influence of bedding sand on performance has been carefully investigated in this study. Up until now, the influence of bedding sand was observed through data collected on site. In this section, laboratory tests were carried out to assess the influence of the thickness of bedding sand and the type of material used. Two thicknesses were tested, 25.4 mm and 50.8 mm, and two types of materials were tested, a natural granitic sand and a limestone dust. Moreover, two types of concrete blocks, interlocked blocks and rectangular blocks were also examined, both 100 mm in thickness.

Laboratory tests were conducted on a loading frame. The bedding sand used was compacted, to a water content of 5%, directly into a mould especially designed for these tests, until it reached the desired thickness after 300 cycles of loading corresponding to the energy equivalent to that of a compactor used in laying the blocks at job site. Three blocks were then placed into the mould on the bedding

sand, and the joint material similar to the material used for the bedding sand was then put in place. A 40 kN load was applied at the center of the middle block. The loading time was 0.1 second and the rest time was 0.9 second. Cumulative permanent strain was measured at 3 points using a wall-thickness micrometer on the middle block after the application of 100,000 cyclic loads. In order to compare the performance of each configuration, the average permanent strain on the middle block, (i.e. the one on which the load was applied) was calculated. Comparative results obtained are presented in Table 2.

Table 2. Comparative results of cyclic loading tests

	Rectangular blocks		Interlocked blocks	
Thickness of bedding sand (mm)	25.4	50.8	25.4	50.8
Permanent strain (mm) – Limestone dust	7.74	14	6.89	13.41
Permanent strain (mm) – Granitic sand	4.57	10.04	6.32	9.47

It can be seen that the thickness of the bedding sand has a major influence on the permanent strain. For rectangular blocks, increases in permanent strain of 81% and 120% were observed for limestone dust and granitic sand respectively when the thickness varied from 25.4 mm to 50.8 mm. As for interlocked blocks, increases of 95% and 50% were observed for limestone dust and granitic sand respectively when the thickness varied from 25.4 mm to 50.8 mm. Table 2 shows the beneficial effect of interlocking. Indeed, when compared with regular blocks, the interlocked blocks show a reduction in permanent strain for an identical material of the same bedding sand thickness, except in the case of the 25.4 mm-thick granitic sand where an increase in permanent strain of 38% was observed. In the three other cases, the decrease in permanent strain observed when interlocked blocks are used remains below 1 mm and varies between 6 and 11%. The type of material seems to be a factor to take into account since, in all cases; the lowest permanent strain is obtained for granitic sand. The plastic behaviour of the limestone dust may explain the results obtained. Nevertheless, granitic sand is an overall better aggregate for this type of application because of its better abrasion resistance which is due to its mineralogy (presence of quartz and feldspar). Permanent strain curves as a function of the number of cycles obtained for the tests carried out are given in Figure 2.

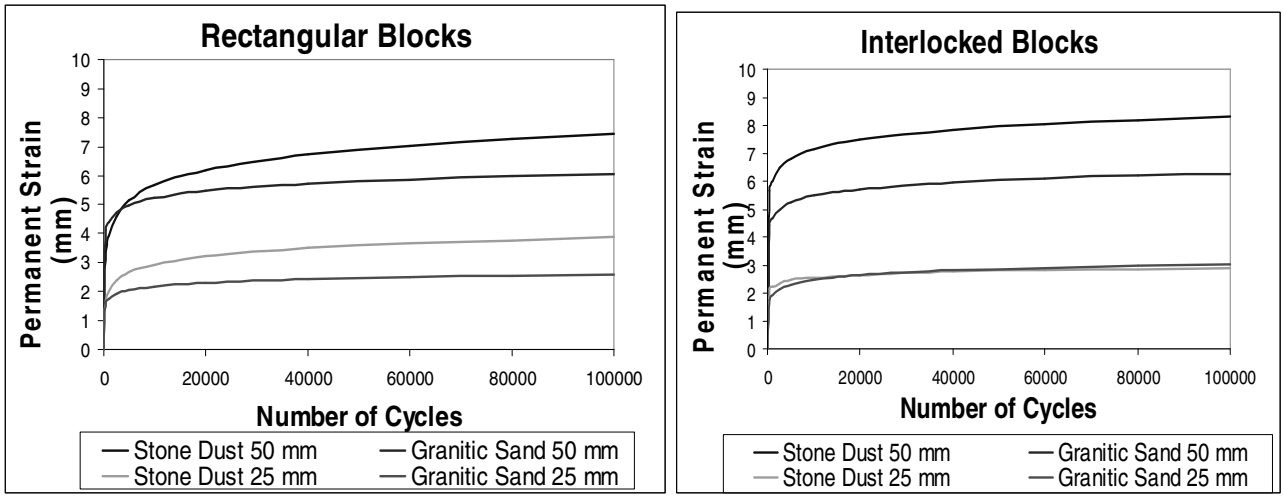

Figure 2. Permanent strain as a function of the number of cycles of applied loads obtained during cyclic laboratory tests carried out on rectangular and on interlocked block.

4. CONCLUSITONS AND PRESENTATION OF THE GLOBAL PROJECT

According to data collected on existing roads, it was observed that the thickness of bedding sand often varies considerably, which can create problems with differential behaviour of pavement. This may result in frost heave and the formation of small indentations in the pavement, which can cause water puddling problems. In terms of bonding and thickness of blocks, the trends observed indicate a certain influence of these two parameters. Among the main degradations observed, the most frequent is rutting. This degradation may be the cause of several failures and it was difficult to identify a common cause to all observed sites. The performance of this type of pavement can also be analyzed using a deflection criterion which might provide interesting results. However, it is more complex and costly to measure deflections on site and therefore the rutting criterion was selected for simplicity purposes.

In general, the objective pursued in selecting several sites distributed in three different cities was to draw a general picture of the performance of interlocking concrete pavement and to identify the main parameters having an overall influence on the behaviour of this type of pavement in a northern environment. However, it is difficult to draw clear conclusions on the in-situ performance of concrete block pavements since too many variables are involved. Good or poor performance is generally related to a combination of factors and it is difficult to isolate the effect of each one. Nevertheless, a few trends were identified which could guide future research. Tests carried out on the cyclic loading press also confirm some of the observations made on site. Laboratory results have thus clearly shown the effect of the bedding sand thickness, of the interlocking of blocks, and of the type of material used as bedding sand and joint-filler on the performance of rutting in concrete block pavement.

The main objective of the global project is to validate solutions that are both economical and adapted for the design of durable and performing interlocking concrete pavements. These solutions will have to be integrated in a global model that can be generalized. The achievement of this research project will be possible through the five following objectives:

- To determinate equivalent elastic modulus of different “concrete blocks – bedding sand” systems and to test them with a previously developed numerical model;
- To define appropriate road structures for each “concrete blocks – bedding sand” systems and to test them using classic design models that consider a continuous pavement layer and decreasing elastic modulus values from top to bottom of the structure;
- To validate in a laboratory the structural behaviour of interlocking concrete blocks pavements using a laboratory load and climate simulator;
- To validate the structural behaviour of the most performing interlocking concrete pavement in real conditions by the construction of interlocking concrete roads in Québec municipalities;
- To elaborate a global model that can be generalized for the construction of roads paved with interlocking concrete blocks in a northern context.

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