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CHALLENGES FOR CONCRETE BLOCK PAVING IN URBAN AREAS OF LATIN AMERICA AND THE CARIBBEAN (DEVELOPING COUNTRIES)

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Summary

The production technology of concrete pavers has been used over 40 years in the Latin America and the Caribbean region with unique technical and socio-economic characteristics. The trend of its development, allows visualizing current and future challenges in terms of quality, development and knowledge that look simple and logical, but not frequently perceived from within the industry. This situation can lead the industry to no longer engage in activities or decisions of great significance for its development, in the same way as the growth of the market entails the need to create and develop supply and service companies, almost as indispensable to climb to a higher level of the technology and the market and to deal with products that compete, especially in the construction of urban public spaces.

1. INTRODUCTION

After 40 years of development of the production of CONCRETE PAVING BLOCKS (CPBs) (*concrete pavers,interlocking concrete pavers, interlocking paving blocks*) and their use for CONCRETE BLOCK PAVING (CBP) in Latin America and The Caribbean, as an alternative to the traditional system, that offers other possibilities of development and well-being for communities, it is possible to review what has been achieved, and to identify some challenges that the PRODUCTION INDUSTRY OF CPB (Industry) may have to face in the near future in this region. These challenges are important and almost universal for all countries and cities of this human and cultural group which, due to their socio-economic characteristics, is far from the first world and their conditions and vision to deal with the day by day, the technological development, the market, competitiveness, service, etc.

This approach is based on referred or direct knowledge of Industry at this regional level, and the experience of their needs. This analysis does not arise with a negative view, but it is intended to highlight what some members of the Industry have developed to conform to what "the state of the art" offers and demands, in the highest circles of production and use.

The growth the industry has had in the region during the last decade, has given a new inertia that could lead not only to increased production but to give a combined strength to make that CPBs and CBP have open prospects necessary for a robust growth, both in the market and in the support of their activities, at all levels.

The challenges that are presented in this document are not to be understood as a finished dissertation but as an incitement to look inside of, and to question, every aspect of the role played by each person, with greater or lesser influence in his future. They are grouped into three themes: Quality, development and knowledge.

2. QUALITY

Quality is understood as the concept that encourages that everything made in order a product or service meets or exceeds the expectations expected by the market, in a proactive way and without causing any harmful effect.

2.1 UNDERSTANDING THE "INTEGRAL QUALITY" OF CPBS

Those who work in the production of CPBs usually know a list of requirements to be met by products, grouped either in a “national” standard or a particular specification, which must comply, at all times or for a particular project. The producers work, then, for compliance with these requirements with some margin, statistically calculated to ensure that the products are within a safe margin, but without exceeding the levels of quality, because a greater investment in materials or processes to achieve them, can make their products less profitable and their continuity in the market less provable.

The problem often appears when competitiveness leads to adjust production costs to a level that may incur risks of "non-compliance" of one or more requirements, with an increased risk of having to address claims and justify changes for newly made products. When this situation becomes common, some producers may try to minimize the effect of "non-compliance", arguing different reasons; and this situation even comes to the point that, if this failure is due, for example, to the high cost of a material or the difficulty to buy it, arguments are made against the parameters required in the standard or specification and they even make efforts for it to change (become more tolerant) rather than improving the product; or it is argued that the use of a standard or specification, impair the product to be competitive or viable in a certain market. Sometimes producers seek that the levels of certain parameters, required within the standard or specification, be those of the Industry’s production or the production of a small group, not those the product should have according to the state of the art, solidly founded in a long time of use and theoretical and experimental, national or foreign, research.

Sometimes producers take the risk of offering a “special” product for unusual applications, when they have no knowledge for its production, so as not to lose a client; or that because of ignorance of the integrity of the product, when they liberalize a requirement some correlated characteristics (which sometimes cannot be assessed either easy or directly) will be affected and as well as the product in unforeseen manners. This is just an example of how the lack of knowledge of the characteristics that must have the product and how they interact, as well as of its fields of application, can damage the product and its market.

That knowledge is an obligation for the producer or his advisors, who must be able to balance the CPB characteristics and how to obtain them, to ensure higher returns but without damaging their performance. As an example, the requirement of a maximum value of water absorption is not critical from the structural point of view nor of durability, for countries where there is no severe conditions of freeze and thaw in winter, presence of salts or organic materials in the sites where CPBs are used; but if this level is very permissive, or is left aside, it is possible to have: presence of moisture in the mass and the surface of the CPBs due to a longer time required to dry after being wet; the appearance of efflorescence and spots due to the growth of biological material or the suction of fines present in saturated bedding and sealing sands; all this when temperature and humidity conditions are favorable to do so, which is frequent, and almost universal, in the tropical or subtropical zones. See Figure 1.

In summary, the producer must know the why and for of concepts and quality requirements, and visualize them in perspective.

2.2 STANDARDIZATION OF PAVERS

In the last two decades of the 20th century, the CBP community understood and defined the parameters that should meet a CPB for the different situations they are used in, and the tests necessary to evaluate those parameters, with some variants and equivalencies according to technologies and standards existing in different countries. This led in many countries (including the European Community, South Africa, Australia and Colombia) to the review of their standards by their standardization institutions and that these standards converge to specific contents to assess the current and potential performance of CPBs (leaving aside the composition requirements as non-normative information) among them:

- Definitions and nomenclature, including the categories of use for CPBs.
- Sampling, testing and compliance, according to the relevant statistical quality practices.
- Dimensional requirements (sizes, levels, tolerances, ranges and their interrelationships).
- Physical requirements (mechanical and abrasion resistance, skidding and sliding resistance, freeze and thaw

behavior, water absorption, among others).
- Appearance requirements (color, roughness, efflorescence, secondary finishes, etc.).

Most of the standardization institutions or Industries, with very good intentions, tend to look into foreign standards or specifications, preceding documents that can serve them to build their own standards, but they often adopt them fully or without consulting the specific conditions of these countries (geographic, climatic, development, market demands, commercial treaties, among many) and the experiences of their Industries or users groups. As a result, it may appear standards or requirements with of parameters that do not have any logic or useful application and testing procedures that cannot be performed in the respective countries or regions. Some experiences follows:

- There must be no reason for countries in the Latin American and The Caribbean zone, to ask for quality requirements dealing with freezing and thaw of superficial and infiltrated water in CPBs, except in regions (very few) with several cycles of freezing and thaw during winter time, due to rain water or snow melting. It is not enough to have temperatures below 0°C for some days during winter, and if the use of the CPBs is not very intense (in terms of wear and tear on the surface (mechanical attack)); the manifestation of the damage will not be significant. Now if there are well-defined enclaves in which these conditions exist, and the extent of the use of the CPBs in them can be assessed, they can protect by lowering the level of the permitted maximum water absorption, which reduces the damage it can cause.
- It is not right to specify various levels of mechanical strength (compression, bending, indirect traction, etc.) for the CPBs according to its use or application, since the required mechanical strength, regardless of the method used for its evaluation, is in third place of relevance as a quality requirement below freezing and thaw resistance and abrasion resistance.
- Many standards used to require the quality control of the mechanical strength of CPBs by testing them under compression, but included, and some still do, limited dimensions and shapes for the CPBs, or included formulas to take into account a shape and size factor, considering length, width and thickness. At this point, it should be clarified that the compressive strength is inversely proportional to the slenderness of the element that fails (the relationship between its length and cross-section; in the case of CPBs, the thickness and the area, defined by the length and the width). If a standard does not restrict the form and dimensions or does not include a shape and size factor, and allows to test different CPB with equal thicknesses, the greater the area of the CPB, the higher the result of the compressive strength, despite having been manufactured with the same mixture and in the same conditions. This phenomenon led to a situation in which some producers used different dosages for every shape and size, so the larger ones may have problems by a higher absorption, stain, discoloration or structural failure.
- Once defined and adopted a standard, it is essential that the Industry deploy a campaign for its acknowledgment and right understanding, explaining the reasons that led to the changes and the imperious need for all to use this new standard and implement it correctly. Not doing so, can cause certain designers or specifiers to continue using the parameters of the previous standard and thereby distort the market by requiring producing CPB for various quality levels and test methods. In this regard, the industry must lead the change of standard and not to accept the production of CPB according to the old standard.
- Another problem appears when a project is designed abroad, to be built in a country without or with different standards for CPB, from the quality level for one or more parameters to the same tests and parameters to be required. One of the drawbacks that entail this situation is that it is possible to end using two standards, one from the designer´s country and another from the site country, with the difficulty or impossibility to perform some test requested in the standard of the designer's country, and the summoning of the designer of being responsible for the design only if "his" standards are met. This situation must lead to an united response of the Industry in order to present technical arguments on the equivalence of standards, the uselessness to comply with certain parameters of the designer's standard or the inability to perform certain tests or to get some materials, without putting the work at risk the work or discrediting the original designs.

2.3 ESTABLISHING A QUALITY CERTIFICATION SYSTEM

One of the main problems of the Industry and its products in this zone is how to "justify quality" before the potential or present users of CPB, when the methods for quality verification inside the projects or works, due to their diverse sizes or professionalism of the construction process and inspection, are more or less deficient in:

- To follow the sampling process with due rigor and advance.
- On-time and comprehensive quality verification of all the parameters required by the relevant standard.
- To accurately and rightly review and apply the quality levels, by the external auditor, inspector or representative of the client.

Although the Industry participate in the standardization processes in each country, the Brazilian and Argentinean ones created a Quality Seal as a guarantee by the Industry for CPB (and for concrete masonry blocks), certifying the suitability of the producers and the quality of products, similar to the Standard Compliance Seals provided by some standardization institutions. One process such as this could be seen as redundant with the work of the standardization institutions, but it obeys to the particular needs of the Industries in both countries (which are not very different from those of other countries in the zone), regarding defense of CPB as a product, facing the proliferation of producers with poor technical and commercial practices, selling non-complying products that damage CPBs global image.

These two cases, developed by the Brazilian Concrete Block Association - BlocoBrasil in Brazil and the Argentinean Concrete Block Association - AABH in Argentina, with the contribution of the corresponding Portland cement associations, other national and international institutions and the members of the associations, are almost unique in the world with Interlocking Concrete Pavement Institute - ICPI's product and installers certification system in the United States and Canada, and have defined the answer that the Industries must give through their trade associations, to the local needs, i.e. those of a city, region or country. Both trade associations, the AABH and BlocoBrasil, are well open to collaborate so that others can begin similar processes in their respective countries.

These particular seals or certificates, at a national or local level, also serve as arguments against the need to comply with certification seals from foreign countries where designs were made.

2.4 DEFINITION AND INCLUSION WITHIN COST, SPECIFICATION, QUALITY AND MANAGEMENT STRUCTURES

Another great problem for the Industry is the inclusion of their products within cost, specification, quality and managing structures of each country, state or city. The official or private structures for cost estimation have items with sub-items involving CPB and CBP, not always adequately calculated or doesn´t include all the resources and procedures that make those items. Accordingly, these items may be over or undervalued, generating a lot of problems and misbalances in the budgets of the works.

In addition, in many laws or practices of tender, it is not very clear who must cover the costs of quality control (processes, essays, reports, etc.). This is the reason why some contractors frequently ask for and use the results of internal quality control tests of the CPB producing companies, to conclude on the compliance of the quality of a production or specific delivery to the site, instead of carrying out the tests on the real product to be supplied the work. This quality control system only causes problems, because standards for precast products are (almost without exception) for the verification of the quality during the commercial process between a buyer and a producer. They are not a guideline for the inner control of a plant or a production company. In addition, the use of such information violates the independence of criterion and action between producer, the external auditor (inspector) and the owner (buyer or contractor), governing the quality system in a construction project.

Another problem concerning the administrative structure of the city, is in the public works offices, or these delegated by local government. These institutions have their internal departments of construction, management and maintenance of roads and public space, with structured operational resources according to the type of works they have to deal with. When a new technology as CBP is introduced, these departments already are structured

for asphalt and/or concrete pavements and floors, but very seldom for CBP. The same is true with those companies providing public services such as water, sewage, telecommunications, gas, etc. when they have to dig pavements and have to follow inter-agency commitments for the reconstruction of the intervened areas as they were before. When CBP is introduced, a different pavement or floor means that all these institutions will have to open a new maintenance line, parallel to the asphalt and concrete ones. They will have to train their staff and have specific materials available for repair activities, and it involves costs and more work. Many of them are not always willing to develop such maintenance lines, leading to a temporal or permanent prohibition of or bad service to CBP, so they become discredited, for an apparent shorter life or a ruinous state due to a lack or poor maintenance.

3. DEVELOPMENT

3.1 EXTENSION OF THE OFFER OF PRODUCTS

The production of gray one-layer pavers is, of course, the first level in the development of a company of CPBs and, consequently, in the development of the Industry. Once the market is saturated with that commodity, it is necessary to pass to the offer of additional colors to the natural grey, with the use of pigments of iron, chromium or cobalt, based on gray or white cement, with different degrees of pigmentation (tones) and shades (blends of colors).

It is common that “color” is seen by producers of CPB as a problem to be solved in the easiest possible way, generally offering only a limited "palette" or series of shades with a definite tone (“I have 10 colors with a single intensity, based either on gray or white cement). But once each producer offers "his" colors (not the same among producers), designers or contractors begin to request different colors for each project (tailor-made), or start to refer colors produced for previous projects or by other producers, not included in the regular palette. As a result, the Industry is forced to give-up its usual position in order to satisfy the costumer’s demands, in order to satisfy them and to retain their loyalty, now extended to the provision of small amounts of products (not considered previously even as a minimal production), comparable in size to an individualized and just-on-time production.

It happens in the same way for roughness, reliefs, performance under of abrasion, use of alternative materials, water absorption, draining properties, etc. of the surface, especially if they can make two-layer CPB, modifying only the characteristics of a thin layer rather than the whole mass of concrete.

3.2 EXTENSION OF THE SUPPLY OF SERVICES

It is common that the supply of services and side products should be expanded, in a similar way the Industry had to expand the n the same way as may have to expand the “palette”. However, the development of trades and markets is not the same in all countries or cities. The creation of professional and dedicated installation of CPBs or the construction of CBPs is not common in developing countries, where professional training certification (such as "CPB contractor”) is poor or non-existent. It makes general construction contractors to subcontract "foremen" for laying CPBs on a base laid by the general contractor or a specialized roads contractor; but this very rarely reaches the professional level this paving technology can give.

Eventually, owners and general contractors get tired of quality problems, and the producers tired of claims for the quality of CPBs. It bring the producers to propose, often by request of the contractors, the sale of the installed product, i.e. the sale of complete surface layer and in some cases of the complete CBP, teaming-up with an earth-moving and a base contractor. This additional complexity that producers have to deal with, may not work as planned, but ends accommodating to the managing of several subcontractors under the liability and image of the producer, without an optimal result due to lack of liaison and unity between the laying contractors and the producer of CPBs.

In very few individual cases of professionalization of a region or country, companies for the laying of CPBs or the construction of CBPs are managed by professionals (engineers or architects) or expert supervisors, as they are in developed countries. This professionalization apparently increases construction costs, but reduces or elimi-

nates quality claims and allows CBPs to offer the best that technology can give. This fact marks the route for the development of programs for the training and certification of labor and contractors for the construction of CBPs, offered by trade associations of CPB producers (such as the ICPI of the United States and Canada) or by private companies (such as Pave Tech's Training School, also from the United States).

Another way to expand the services offered by the producers is the provision of resources necessary for laying CPBs, as an added value to their cost. In the same way as the bathroom tile industry sell adhesive, cleaning and reparation products for the joints and all the piping necessary to install bathroom furniture, paver producers can offer tools, implements for occupational health, cleaners and sealers, sand stabilizers, joint sands, paints, exterior pavement lamps, signaling, and stones for landscaping, etc., and any other product or service that can complement CBPs.

Whatever the type of contract for the construction of CPBs, it can be used to offer the maintenance as a work additional to the construction. It implies to have to make a professional and specialized sale process, no longer for contractors or builders but for owners and managers of properties of different types. This is even more complex if the work is handled by the local governmental administration.

3.3 INVESTMENT ATTRACTION

An obstacle that may find the Industry for a continuous development is the difficulty to have additional big investments in new production plants and service companies that could compete with the existing ones. It is common that a market looks like saturated because a few companies or a business group seem to have the market covered and satisfied. This may be true during the low seasons of the construction cycles, but during in the high seasons it is necessity to have a greater supply of CPBs, special products, a larger construction capacity and more competition.

The reality is that unless the demand is affected by the cycles of the economy, it is always possible to develop new markets from new products (which may be variations of the existing ones), adequately differentiated and justified in costs, and with the technical support and training for the professionals in the position of taking decisions, such that CBPs are clearly differentiated from the existing ones.

Very rarely, the vicious circle "there is not production because it is not demanded, and there is not a demand because it is not produced" is impossible to break by investing in technology, support and the right advertising. Each step made by a producer in a new direction, was apparently considered before by his competitors, but they saw no future in it, when the reality is that they didn´t see a clear need to invest in order to develop a marginal share of the market. In addition, once one producer goes through it, the others follow him.

This phenomenon applies to the zone for which these considerations are made, and could not be strange for others, since it seems to be a current way of thinking. The same applies to the visualization of the possibility of a new development through an investment effort and in individual support, as it was told, a discouragement is felt because after a particular effort, others will profit from it, at least form this effort, although they have to make an investment similar to the initial one.

The investment must be strongly linked to the knowledge of the technology at all levels.

4. KNOWLEDGE

4.1 KNOWLEDGE OF THE PRODUCT

The knowledge of the product CPB should not be limited to technical and commercial aspects. It is essential to understand the role of the producer within a paving system (CBP) and it as an element for the construction of infrastructure and the city.

It is necessary to be clear about the structure of the processes of decision, design, construction, quality control, maintenance, financing, recruitment, outsourcing, innovation, training, etc., governing the pavements of the road

structure and the ones for the floors of the pedestrian network of the public space, which is the most immediate natural market for CPBs.

CPBs cannot develop without first developing CBPs, and those without the development of a network of roads and public space. Therefore, the sale of the final product (CPBs) by the industry is just the top of a pyramid of knowledge, technological and human resources, decisions and investments required to give it a complete support.

An essential part of the knowledge of the product is the knowledge of its characteristics and limitations, i.e. up to where CPBs and CBPs are able to perform in the right way, in order to "exploit" it correctly and not to "risk it" in provision of characteristics and qualities which they may not provide.

4.2 KNOWLEDGE OF THE STATE OF THE ART

It is very difficult to understand the "state of the art" of a product or technology when producers are blocked by the daily production, marketing, sales and administration of a company, and the administrative structure do not allows time to look beyond the area of the natural market for the producer. It is essential to know other industries and products at local and national levels, and what and how is produced internationally, in addition to everything that moves around the CPBs industry, through seminars, conferences, trade fairs and exhibitions.

Every country may have singular developments that could be interesting for a producer, and those occurring in developed countries mark the route of the evolution of the product, even though they obey technical, economic and development conditions with years of advantage over those of the region. Nevertheless, the reality is that the Latin American and the Caribbean producers are shy to participate in international academic and commercial events, and part of the backlog of the industry in the area is due to this apathy for investment in knowledge and the uncertainty of the route to follow.

"Nobody likes to be told what to do". This popular saying has a special value in this region where producers take unnecessary risks and years to develop products or technologies that, in other places are in the lists of products, only for not accepting the knowledge of others and for not having to pay for it, although the self-image of the producers is one of leadership due to a relative dominion of the market and a more or less dominant position in the area of its natural or conquered market.

Participation in events, both academic and commercial, might seem a waste of time and money, or just an excuse for some others to have a few days of vacation or travelling in a city or country other than their own. But the reality is that, although it has been said many times, the assimilation of technologies and the establishment of relationships are not in the same if made by indirect or direct methods, like a personal and face-to-face contact of those involved, especially if the parts involved come from different cultural, economic and technological environments, and it is crucial to establish a relationship of trust from the most basic levels. In addition, the Industry is rarely aware that academic developments very possibly would not be of the desktops of universities or offices if there were no seminars and conferences to present them, and those would be feasible only if there are registered attendants paying for personally attending the events, instead of just reading the book of proceedings or with some papers or articles compiled on the subject. Something similar happens with fairs and exhibitions, since they allow a direct perception of the products and people, beyond the reviewing of a product catalogue, the specifications and the list of prices and marketing requirements.

In summary, the search for the approach to the "state of the art" is the real participation in the development of a global technology, as it could be done through a global association of producers and suppliers; which does not replace the importance of local or zonal groups to advocate for the development of the local industry, in those areas that may be common to all producers and users, without invading the independence and the development of the market in conditions of free competition.

4.3 BASIC RESEARCH FOR THE SUPPORT OF THE TECHNOLOGY

One of the most sensitive problems of the Industry in various countries is the lack of commitment to pursuit the theoretical or experimental developments needed to give itself a stronger support of their products, considering the particular environmental conditions, its economic characteristics, market, climate, materials, etc.

The industry often has problems associated with:

- The availability of the right, substitute or special aggregates.
- Problems of absorption or surface of the finished paver.
- Superficial and inner stain of the products. See Figure 2.
- Difficulty to obtain testing equipment and materials at a local level.
- Need for training of designers and contractors. See Figure 3.
- Requirements to achieve some parameters. See Figure 4
- Inconsistencies between the demands of the market and what the Industry offers or may offer.
- Expectations about behavior of the product beyond the expected time.
- Behavior of alternatives to current products dimensions such as thicknesses, lengths, widths, bevels and spacers; as one-example thin, 40 mm thick pavers. See Figure 5.
- Administrative, maintenance and replacement structure of CBPs, inside public administrations (items, costs, periodicity, structuring of crews and maintenance programs, coordination of all entities involved, etc.).

The reality is that some of these problems can lead to CBP's technology to enter a crisis in a specific market since, no matter the small these problems look like, if they are not resolved quickly and effectively, certain concepts or negative, misleading or false, images related to CPBs can make a career among designers and users, and start rejecting them.

Many of these lines of research or development do not have the large costs of basic research (usually done by developed countries, trade associations and universities) but require some clarity to identify the peculiarities affecting CBPs in an enclave and how to solve the problems that they create, using the state of the art in the rest of the world.

As an example, some markets have decided to not venture into the use of CPBs less than 60 mm thick, i.e. 40 mm or, eventually, 50 mm pavers, fearing that they be used for applications requiring greater thicknesses; but in some markets there are similar "thin", products made with alternate materials, providing the same service and behaving in good way, as some clay or stone pavers, in both cases laid on sand. If the industry do not study this to support "thin" CPBs, to be sure about the uses for which they can sell them (pedestrian, cars, a certain amount of trucks of a certain weight, etc.), and if they do not let this study to be known by the markets, regardless of the outcome, the Industry will continue with the uncertainty of whether there is a potential non-developed or attended market, or if what is offered by intuition or for the translation of the dimensions of applications of parallel materials to concrete, is reliable enough to not jeopardize the image or the capital of the industry.

4.4 EDUCATION AND TRAINING "SPECIALIST" FOR EACH LEVEL

The growth of the market leads inexorably to the need of segmenting the market and to educate it as long as the producer "educates" his product.

Either individually, in a joint work funded by producers through some type of association or a shared project, or by official institutions in charge of the vocational training, it is essential to have training programs for each type and level of education of the "customers", departing from those who work in urban planning to workers who build the pavements and run the maintenance, regardless of the size of the works or projects. Among the scale of levels and types of training there are: Labor; contractors; teachers and professionals; centers for vocational training, universities and specialized education (both teachers and students); developers; structural designers of pavements; architectural and landscape designers; auditors and quality inspectors; planning and public works offices at the municipal, state or national levels, among others. In addition, the Industry may not leave aside the general public that ends-up playing a key role in the correct use and maintenance of CBPs and in their choice within the range of available alternatives.

5. CONCLUSION

The challenges exposed through the considerations on CONCRETE BLOCK PAVEMENTS, grouped under the headings of Quality, Development and Knowledge are an interpretation of the characteristics that this technology has had in Latin America and The Caribbean, as a generalization that may have extreme cases in which the producers can place themselves if they think they are outside the approaches outlined in this document. However, the presence of these singularities do not diminish but increase the value of the comments and characterizations undertaken in this document, which could be extended by entering into details and dealing with other issues that cannot be dealt with due to the format requested for this paper.

Perhaps what is presented here may be partially applicable to other environments but the main purpose is to be useful as a guide to the Industry of the regions of Latin America and The Caribbean, so it can likewise identify and consider alternatives for their individual and joint development through partnerships for processes that cannot be made individually by a producer such as the creation of a quality seal, just to mention only one.



Figure 1.Discoloration of the pavers promoted by highwater absorption.



Figure 2.A bad practice of paver adhesion with mortar in slopes may cause efflorescence.



Figure 3.Need for excellence in the detailing of the design and the construction of the pavement.



Figure 4. Special requisites are required for steep slopes.



Figure 5. Good behavior of 40 mm thick pavers for pedestrian traffic.