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Paving Design: Is Rigid-Fix External Stone Paving the Way to Go?

ABSTRACT: Recent investigations into a number of paving failures in Australia have shown that very little is understood about the many aspects intrinsic to rigid-fix (stuck down) paving. This paper examines and documents some of the factors that can determine the success or failure of paving (assuming a high standard of workmanship). Additionally, it has become clear that most engineers who investigate paving failures fail to fully understand the complexities and interplay of the many factors. Such lack of knowledge leads to poor design, poor supervision, and ultimately poor performance. There are basically three types of paving systems—adhesive/mortar fix, sand-bedded, and setts/cobblestones in a soft mortar. All three systems are being used in Australia but there is undoubtedly an overriding rigid-fixing mentality. By fixing stone to a solid concrete base so that it cannot move is probably seen by most engineers and architects as the most straight-forward and most controllable solution. However, on analysis, it is a system that is subject to numerous potential lines of failure. Not only is there the nature of the stone itself such as the mineral composition, strengths, thermal characteristics, and porosity, but also the environment into which it is placed, the types of loading it is subject to, and how it is fixed. Stability of the base (including shrinkage), expansion/construction joints, size, thickness and shape of the pavers, the laying pattern, type of adhesive, thermal conditions at the time of fixing, influence of salts and water, and sealing, all play a significant role in determining the success or otherwise of rigid-fix paving.

KEYWORDS: stone, paving, failures, external, design

Introduction

Although paving is an important element in modern construction it was an *essential* element in historical times for the movement of people and goods. In more recent times, paving is often ornamental, rounding off the design and complementing the construction. But even today some paving is meant to be functional as well as providing the high aesthetic value afforded by the use of natural stone.

Unlike the historical paving which was often somewhat boring and admittedly a bit rough (in more ways than one) modern processing techniques allow for a much greater range in the type of stone and in the dimensions of the stone paving. Furthermore, there have been many significant advances in bonding media (adhesives, grouts, sealants) and protective coatings. Modern engineering test facilities are available to test stone and computers can be used to simulate load conditions. Yet there have been numerous significant paving failures in the past 20 years all over the world. Usually these failures have been due to a combination of contributing factors—not just a single factor—and some of the failures have been surprisingly elementary.

There are many key factors that need to be considered in the design and successful construction of standard paving. For more demanding paving, involving factors such as exposure to the elements and exposure to complex loadings, the analysis needs to be substantially more rigorous. Stone paving is not just a simple matter of sticking pavers to a prepared concrete bed or placing them onto compressed decomposed sand. Each major application is different and involves a combination of different factors. Expert advice needs to be sought on the stone to be used, how it is to be laid, by what pattern, and on the maintenance of it. Shortcuts cannot be taken and in-house advice is inherently inadequate. Persuasive advertising, extended warranties, long associations with suppliers, and that ever-pressing need to win contracts by those suppliers should not be determining issues.

Manuscript received October 10, 2006; accepted for publication May 16, 2007; published online June 2007. Presented at ASTM Symposium on Dimension Stone Use in Building Construction on 31 October 2007 in Tampa, FL;
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Journal of ASTM International, Vol. 4, No. 6 Special Volume: Dimension Stone Use in Building Construction
Paper ID JAI100843

Recent involvement in a number of paving applications has prompted me to examine and document some of the factors that can determine the success or failure of paving (assuming a high standard of workmanship). Additionally, it has become clear that investigations into paving failures in Australia have failed to fully understand the complexities and interplay of many of the factors.

There are basically three types of paving systems—adhesive fix, sand-bedded, and setts/cobblestones in a soft mortar. All three systems are being used in Australia but there is undoubtedly an overriding rigid-fixing mentality. By fixing stone to a solid concrete base so that it cannot move is probably seen by the engineers and architects as the most straight-forward and most controllable solution. However, on analysis, it is a system that is subject to numerous potential lines of failure. Sand-bedding is a system that relies on a compressed graded sand or deco base upon which are placed smaller and thicker stone pavers in a particular pattern. Special sand is used between narrowly jointed pavers to lock the pavers into place. This is a system that is widely used in Europe and North America. Among the benefits are ready access to underground services, easy replacement in case of failure, and easy maintenance. The sett/cobblestone paving system utilizes small, usually square or cubic units varying in thickness from 30 mm to at least 150 mm. Their use tends to be restricted to areas of limited traffic and they can be laid in a variety of straight and radial patterns. Rectangular block-shaped units are generally deployed for specific applications, particularly where substantial load-bearing is anticipated, e.g., bus-turning areas.

A paving project generally starts with a client's or architect's, or both, vision. The drawings then tend to go to an engineering section and progress to the budgeting section. None of these sections really know much about the performance of any stone and hope that they can get most of the information from a supplier (who hopes to make as much profit as possible, with the least amount of work and commitment, and with fingers crossed that everything will work out). But often the supplier does not know much about the stone (e.g., calling a marble a bluestone or calling a basalt a granite is not unusual) and because most of the stone is now being imported there is quite often a language problem between an Australian buyer and overseas supplier. Surprisingly, many overseas quarries *do* know what they are selling but this is not always conveyed to the purchaser in Australia. Unfortunately, there are also some overseas suppliers who see Australia as a target for dumping inferior material because of a perception that Australians have little expertise with respect to stone.

Assuming the client and architect have agreed on a color and pattern for the stone, and between them the engineers and budgeting section have agreed on a size and quantity they go to tender (unless there is a preferred supplier). Competition is fierce and potential suppliers will break their necks trying to get the contract. This usually means applying financial pressure to the overseas supplier as much as they can get away with. And that is where quality is often compromised, not only in the stone quality but in the quarrying, processing, and delivery.

Once the contract is let how much does the client really know about the quality of the stone that is to be delivered and how can he be assured that delivery will be of the standard expected from the conditions written into the contract? A financial stick is usually successfully applied to the Australian supplier, but what happens when the overseas supplier encounters a change in the type of stone in the quarry, gets into financial trouble, has machinery breakdowns, or demands more money for his product? Some of the human aspects cannot be controlled but at least the quarrying, production, quality control, and shipping of the stone can, and must, be organized *before* supply commences. An experienced stone scientist should be involved in every project dealing with a substantial amount of stone whether it be for paving or for any other application. This will ensure that the stone is available to be quarried, that the quarrier has the capacity and expertise to quarry it, that it can be successfully processed in one or more designated factories, that quality control procedures are put in place and rigorously followed, and that proper, unbiased, and meaningful testing of the stone will be carried out to Australian requirements. So for the small additional expense (in relation to the overall cost of the stone) the client can be assured that he gets delivered the stone at the time required and of the quality required.