Research Paper 12

The Performance of Clay Segmental Pavements

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The Performance of Clay Segmental Pavements

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The author is Head, Civil Engineering in the Department of Transport and Resource Engineering at the Royal Melbourne Institute of Technology. He leads the Pavement Systems Research Group which consists of other academic staff, research assistants and technical staff. The group is involved in major research projects and provide consulting services to the paving industry. This activity generates many benefits to the department, not the least of which are the opportunities available for undergraduate and postgraduate student involvement.

In his early career Mr Mavin worked in local government before joining the Federal Department of Construction in Darwin and subsequently RMIT. His interest in, and involvement with, paving systems began with his first appointment and has continued, with some change of emphasis.

He has been involved in investigations including an assessment of cement stabilised materials, the development of a computer aided design system for highways and an evaluation of a data base for pavement management strategies. His specific interests include the slip/skid resistance of paving materials and the use of alternative materials in road construction. Mr Mavin is also involved in the development of synthetic sporting surface systems and was a member of the Australian Standards committee which produced the first standard on the testing of sporting surfaces.

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Editor's note: The image quality of some figures reflects that of the best available source material.

1.0 Introduction

The pull-out test has been employed for a number of years as a means of assessing the capacity of a segmental pavement. Early work reported in Mavin (1982) demonstrated the 'doming' which occurred when a single block was removed from an interlocking concrete block pavement. This test, which has been adapted to perform *in situ* pull-out of pavers in trafficked pavements, has been used recently to examine the performance of clay pavers. Results are presented from both laboratory and field investigations and conclusions are drawn with regard to the performance of clay segmental pavements.

It appears from these data and from other observations that clay segmental pavements perform under vehicular traffic in a similar manner to interlocking concrete pavements. Segmental pavements constructed strictly according to standards set by the concrete masonry and clay masonry industries will function efficiently with minimum maintenance.

2.0 The performance of CSPs

Clay segmental pavements (CSPS) are designed and constructed in accordance with procedures which are very similar to those used for asphalt pavements. The end product in both cases is a structurally sound pavement with good riding quality and skid resistance.

This can only be achieved if care is taken in the preparation of all layers of the pavement. Each layer contributes to the structural integrity of the whole pavement and a deficiency in any will result in an inferior final product. The materials used in the pavement structure and the quality of the workmanship will determine the useful life of the pavement.

The similarity between CSPs and other pavements also applies to the way in which the pavement performs when trafficked. Clifford (1984) describes tests carried out at the National Institute for Transport and Road Research in South Africa:

These tests have shown that all pavement types, whether concrete, asphalt, tar or earth behave similarly during what might be described as a settling-in period when pavements are subjected to environmental and/or trafficking stresses ...

This author defines the 'settling-in' as the period after which the pavement can support design wheel loads with less accumulated deformation than that which would occur immediately after opening to traffic.

In the case of segmental pavements some of the jointing sand is 'lost' and replaced by a plug of detritus (rubber particles, grit, dust, etc) swept or washed in from the adjacent areas during the 'settling-in'. This period also sees the pavers being forced into the bedding sand.

Thus both the bedding sand and the jointing material develop densities higher than those achieved during construction. In this state, since the joints are almost waterproof, the pavement is structurally very stable.

The stiffening of the surface layer can be monitored by the measurement of the force required to remove a single paver. This 'pull- out' test can be used to assess the condition of a segmental pavement.

3.0 Laboratory pull-out tests

Paver pull-out tests have been carried out in the Royal Melbourne Institute of Technology's Civil Engineering Laboratories by the Pavement Systems Research Group.

The equipment used for the pull-out tests is shown in Figures 1 and 2. These tests were carried out to determine the influence of joint width and paver thickness on the pull-out force for varying values of lateral force.

The procedure which was followed for all tests consisted of the following steps:

1. The bedding sand was spread and leveled.
2. Clay pavers were laid on the bedding sand in a herringbone pattern, the 'target' payer being located in the centre of the area.
3. Joint widths were kept as uniform as possible with particular care being taken to ensure uniform widths around the target paver.
4. Timber packer pieces were placed around the periphery of the paved area.

5. Rectangular steel sections were then placed on the two 'free' sides of the paved area. The steel sections were on the sides facing the hydraulic cylinders.
6. The cylinders were jacked forward sufficiently to hold the steel sections in place.
7. Jointing sand was then spread over the paved area and vibrated into place and the joint spacers were removed. A final spreading and vibration of sand was then carried out.
8. The target paver and those adjacent were then vibrated for some 10 seconds.
9. Excess jointing sand was removed.
10. The lateral horizontal load was then applied to the paved area.
11. The pull-out frame with its equipment and load registering devices were then put into place and the target paver was pulled out.

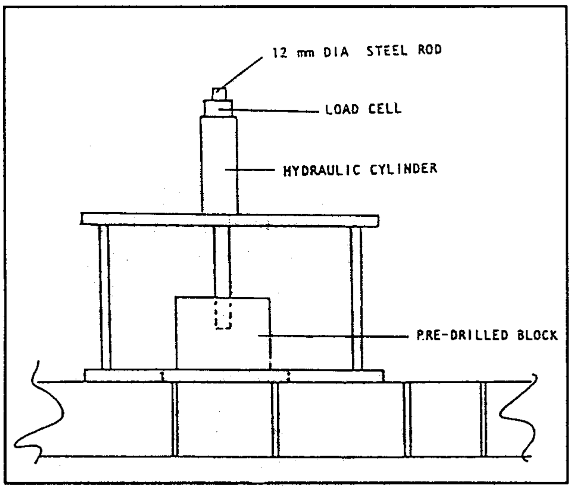


Figure 1. Block pull-out device

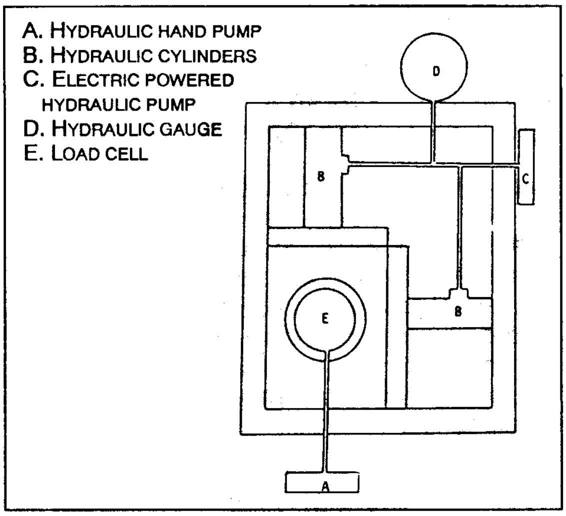


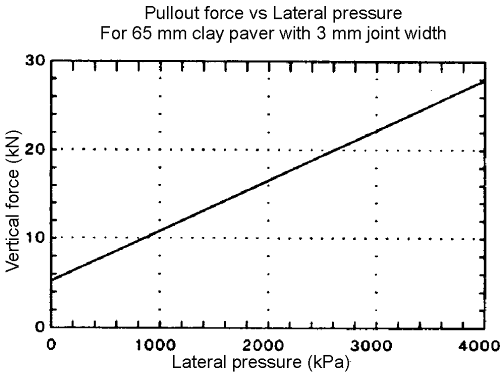
Figure 2. Laboratory test pavement – schematic layout

A comprehensive series of tests (Hocking et al 1988) which, as well as joint and paver thickness, also included different jointing sands, produced the following major conclusions:

1. There is a significant difference between the vertical interlock possible with 65 and 70 mm clay pavers and that achieved by those of 50 mm thickness.
2. The performance of 65 mm clay pavers in the pull-out test deteriorated as the joint width increased beyond 5 mm.
3. As measured in the pull-out test 65 mm clay segmental pavers can develop vertical interlock equivalent to that produced under similar conditions by 80 mm interlocking concrete pavers. See Figure 3 (over page).
4. The most effective jointing sands are those which fall within the grading envelope specified in Table 1 (from Knapton & Mavin 1987). See Figure 4.

Table 1. Jointing sand grading envelope

Sieve size	Percent passing
2.36 mm	100
8 mm	90-100
600 microns	60-90
300 microns	30-60
150 microns	15-30
75 microns	5-10



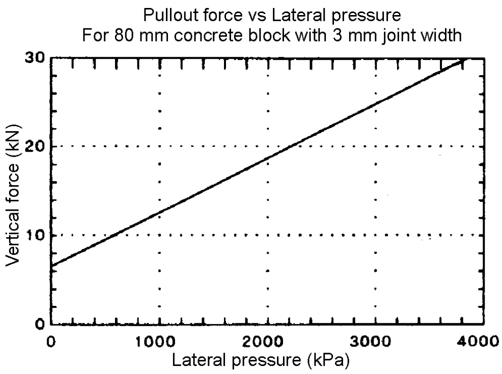


Figure 3. A comparison between a clay paver and an interlocking concrete paver

4.0 Site pull-out tests

The monitoring of the performance of trafficked CSPs by the RMIT Pavement Systems Research Group has included paver pull-out. The laboratory pull-out rig is used on site to remove single pavers from strategic locations within the pavement. This investigation has been restricted to pavements which are subjected to vehicular traffic.

The procedures employed for *in situ* testing were identical to those detailed in Mavin (1984) which describes pull-out tests carried out on the Australian Road Research Board interlocking concrete block test pavement (Sharp 1984).

The maximum pull-out forces recorded for concrete units removed from this test pavement ranged from two to 13 kN for 60 mm block thickness and from four to 16 kN for 80 mm blocks.

The data for concrete blocks can be compared with pull-out forces measured recently for 65 mm clay pavers at sites in Melbourne. The pull-out forces in these cases were in the range six to nine kN.

The fact that higher values of pull-out force (for both clay and concrete) have been measured in the laboratory suggests that jointing sands may have been used which do not conform to the specification grading or that sands which deteriorate under traffic have been used. Monitoring of CSPs will continue to assess the changes which occur in the pull-out force for pavements under a range of trafficking conditions.

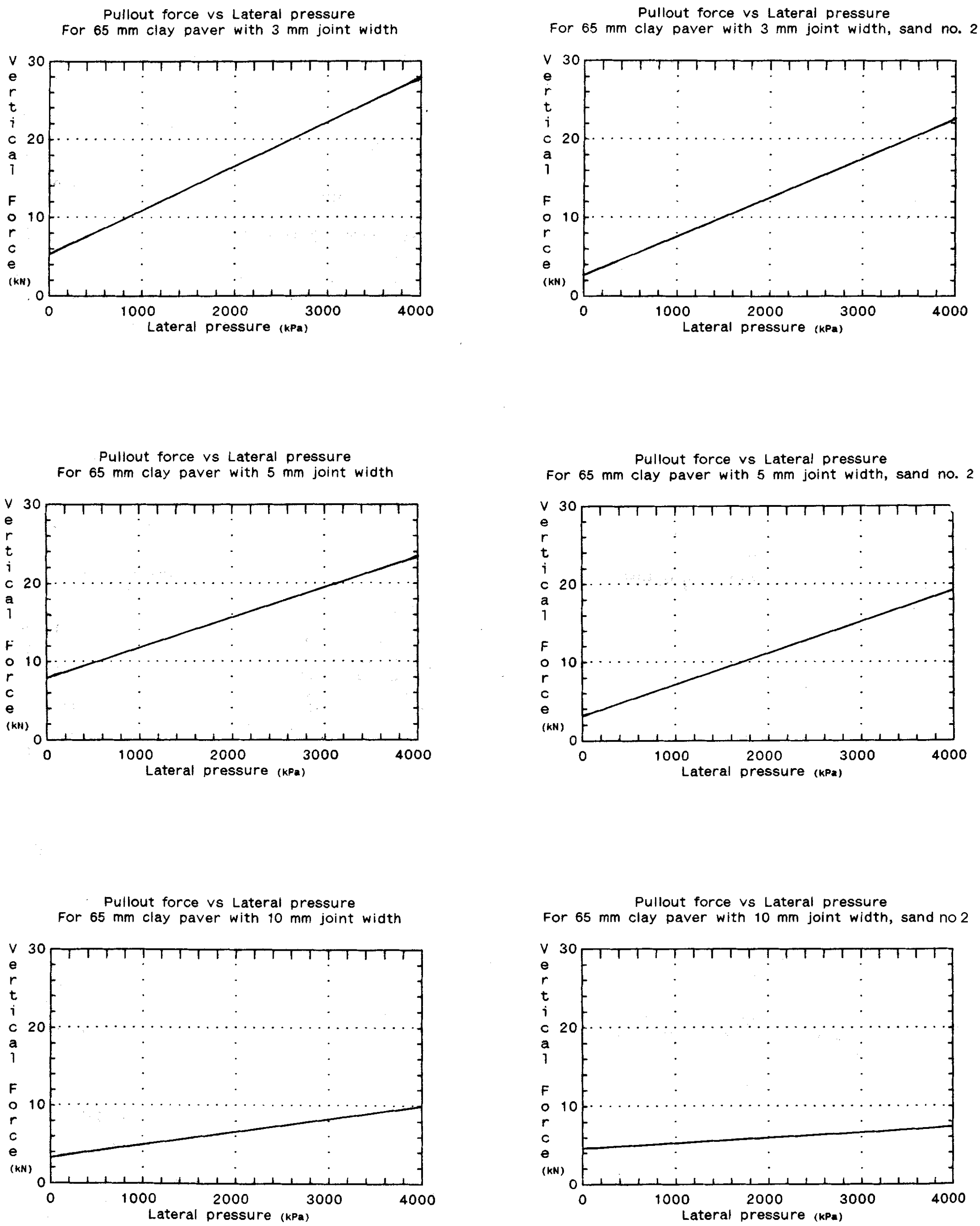


Figure 4. A comparison between a jointing sand conforming with the specified grading

5.0 Conclusion

Laboratory and site investigations have been carried out in an attempt to assess the factors which influence the load bearing capacity of segmental pavements. A pull-out test has been employed to evaluate the importance of joint width, paver thickness and jointing sands. This ‘controlled’ laboratory test program has indicated that the 65 mm clay paver laid in herringbone pattern with a joint width of less than 5 mm (preferably 3 mm) produces a surface capable of supporting vehicular traffic.

Further, the capacity of this surfacing can be maximised by the use of a jointing sand which conforms to a specified grading envelope. The monitoring of trafficked pavements has indicated that CSPs may not be achieving their full potential. Since the laying, in the cases examined, has been to a high standard it appears that inferior jointing sands may be the cause of this deficiency. Either the jointing sand is ill-graded or it may be deteriorating under the action of vehicular traffic.

The successful clay segmental pavement results from a combination of good workmanship and high quality materials. If standards are allowed to fall then the final pavement will be susceptible and premature failure is likely.

Research carried out into the performance of CSPs has indicated that the most likely cause of problems is the jointing sand. Segmental pavements with inferior jointing sands may still function effectively under normal traffic conditions, if all other components are to an acceptable standard. Nevertheless, the pavement with an appropriate jointing sand will be capable of withstanding greater wheel loads, especially after ‘settling-in’ has occurred.

Like any other pavement, the clay segmental pavement requires that all aspects of planning, design and construction are carried out effectively. The components of the total system must interact to achieve the desired final structure. There are now many examples throughout Australia where this has been achieved with clay segmental pavements. Residential streets, car parking areas, multiple use malls, traffic management devices and other trafficked areas are now enhanced by the aesthetics of clay pavers.

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