ADVANCES IN MECHANICALLY LAID PAVERS

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The potential for rapid installation is creating growing interest in mechanically laid concrete pavers for larger projects. This paper examines the importance of paver shape and format in relation to interlock for mechanically laid pavers. New systems which avoid "cluster effect" and offer advanced interlock with improved performance are reviewed, together with opportunities for faster laying rates, reduced manpower and lower supervision requirement.

Specific problems related to airports are discussed together with solutions which retain the benefits of mechanically laid pavers. Recent international demands for water permeable "ecological" paving are examined and new mechanically laid systems which offer advanced surface water handling capabilities without loss of structural performance are reviewed.

Interlock and Paver Performance

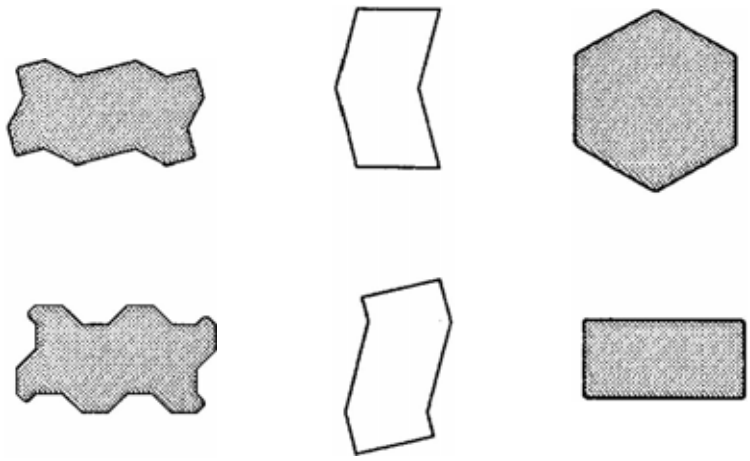
Research from various sources together with operational experience of industrial pavements over a number of years has demonstrated the importance of interlock or “lock-up” in the performance of flexibly bedded concrete pavers under heavy loading and trafficking. Interlock has been defined (1) as the inability of an individual paver to move independently of its neighbours and has been categorised as having three components: horizontal, rotational and vertical.

Interlock is of major importance for the prevention of movement of pavers horizontally when trafficked (known as creep). In addition, important research has been carried out in Australia (2) demonstrating how rotational interlock of each paver in relation to its neighbours "locks up" the surface allowing it to resist vertical loading. This can allow the pavers themselves to be considered as contributing to the loadbearing capabilities of the pavement and design systems are being developed to incorporate this aspect which may offer financial savings and increase the competitiveness of pavers for industrial paving.

Importance of Paver Shape

The Australian research clearly shows that interlock - and hence pavement performance - is influenced by laying patterns and paver shape. Rectangular paving blocks laid in herringbone pattern were seen to perform better than those laid in straight rows whilst dentated shaped blocks performed better still.

As a result, a general classification of block shapes has been devised (3) where 'Category A' pavers are considered as providing the best omni-directional interlock with dentations to all paver faces, contrasting with Category C’ designs which do not key together. Examples of pavers in the three Categories are shown in Fig.l.



Category A Category B Category C

Fig.l

Practical experience in the United Kingdom has also shown that pavers with deeper dentations locking more positively together, for example as shown in Fig.2, offer benefits in terms of self-location, ease of installation, consistent joint widths and maintenance of straight laying lines. Such pavers have been in use for many years without the need for spacer nibs and have demonstrated less reliance on edge restraint.

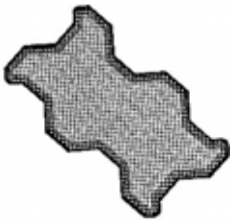


Fig.2

Combining Paver Shape with Non-rectilinear Format

In Australian trials, even better performance was exhibited by pavers with dentated shapes superimposed onto a non-rectilinear L-format, as shown in Fig.3. This improvement can be attributed to the levering action of the additional "arm" protruding from the original rectilinear shape together with the increased size of the paver. The latest developments in high performance pavers seek to improve upon this combination of dentated shape with non-rectilinear profile for advanced interlock.



Fig.3

A completely new concrete paver design has recently been developed along these lines specifically for mechanical laying. Known as the XeneX system, this combines the deep dentated profile of the well-proven rectilinear paver shown in Fig.2 and an overall X-format to give advanced interlock, Fig.4.

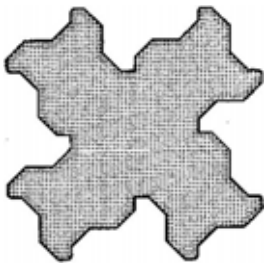
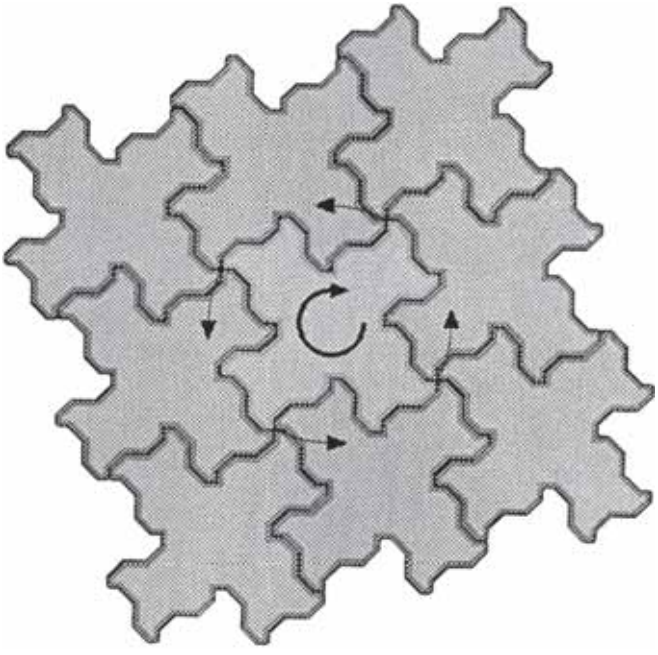


Fig.4

Resisting horizontal forces, the pavers lock up like cogged wheels as they try to rotate, leaving no room for noticeable creep, Fig.5. Vertical loading on any part of the block will be resisted by minute rotational "lock-up", not only of the opposite side of the symmetrical paver, but also by resistance to twisting of the two side aims, Fig 6. This effect is enhanced by the larger size of the paver compared with other designs simply on the basis of disipating loads over a larger surface area (without any additional risk of tensile cracking due to extra length over other pavers). As with the paver shown in Fig.2, there is far less reliance on edge restraint.



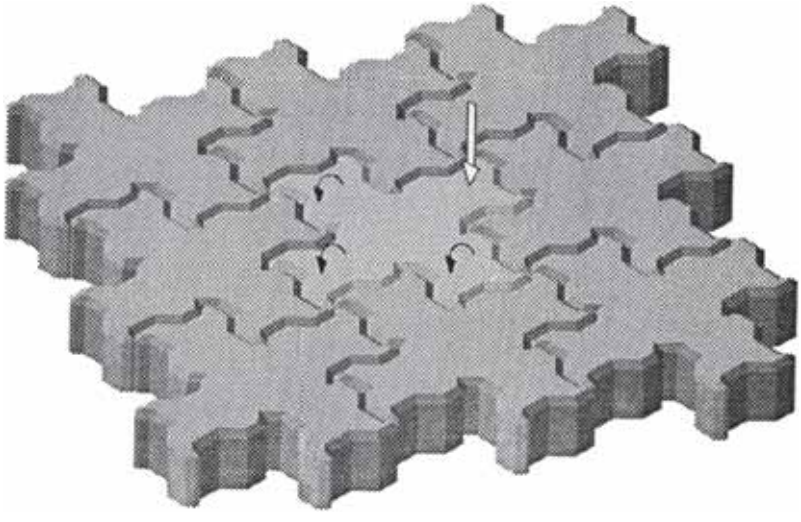


Fig.6

Optimising Mechanical Installation of Pavers

Increasingly, the benefits of high laying rates available with mechanical installation are being recognised for larger projects. But in order to lay rectangular or other non-specialised pavers using machines, additional handling is often required to produce a workable laying pattern (particularly for herringbone, which is essential to prevent creep and other failure in trafficked areas). To improve matters, L and Y format pavers have been used, manufactured in "clusters" ready for laying to reduce handling and the need for complex equipment.

Cluster Effect

However, the generally accepted mode of installation required paver clusters to be installed from the side, "edge to edge", which did not allow for any indentations between clusters in order to maintain interlock. Consequently, effectively straight lines are formed between the clusters, frequently with wider joints than elsewhere in the pavement. Not only can this "cluster effect" present visual problems but also the potential for real structural weakness due to the lack of interlock and wider joints. This problem is particularly relevant at airports (discussed in more detail later).

Maintaining Interlock Between Clusters

To avoid these problems, the new X-format paver is laid in clusters exactly as manufactured, without effectively straight line joints between clusters, Fig 7. No additional handling is required and clamping by standard laying machines provides a tendency for blocks to try to rotate, actually locking them together. The self locating nature of the block shape allows clusters to be quickly and easily positioned from above, minimising adjustment at the laying face.

Increasing Laying Rates and Reducing Manpower

Laying trials indicate that with X-format pavers, consistent joints between clusters, Fig 8, and blocks within clusters, are maintained due to the larger number of pavers surrounding and influencing the position of each individual paver. This allows potential for faster laying rates than are generally attainable with other systems, one man operation (without the need for an operative carrying out manual adjustments at the laying face) and reduced supervision requirement (due to inherently consistent joint widths).

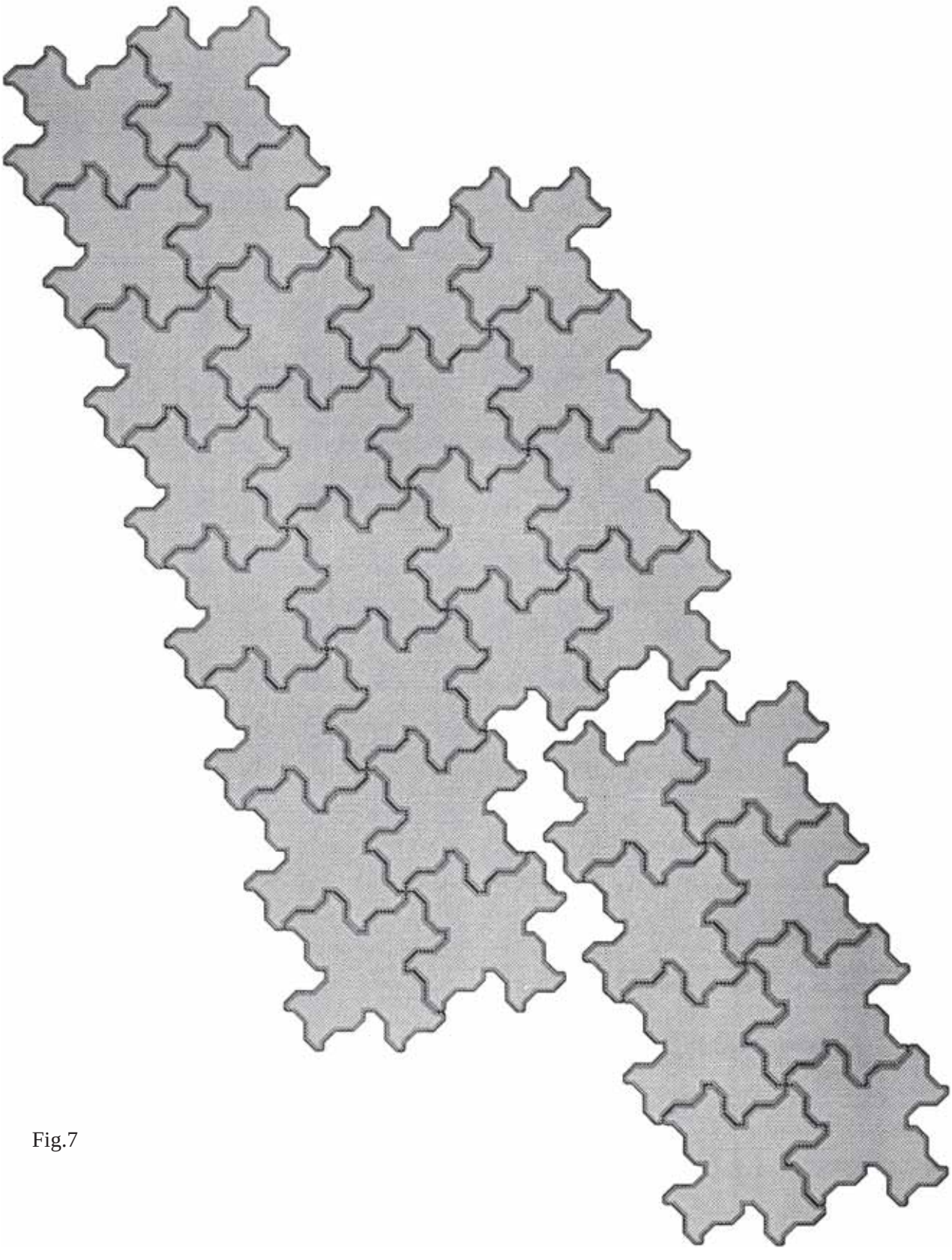


Fig.7

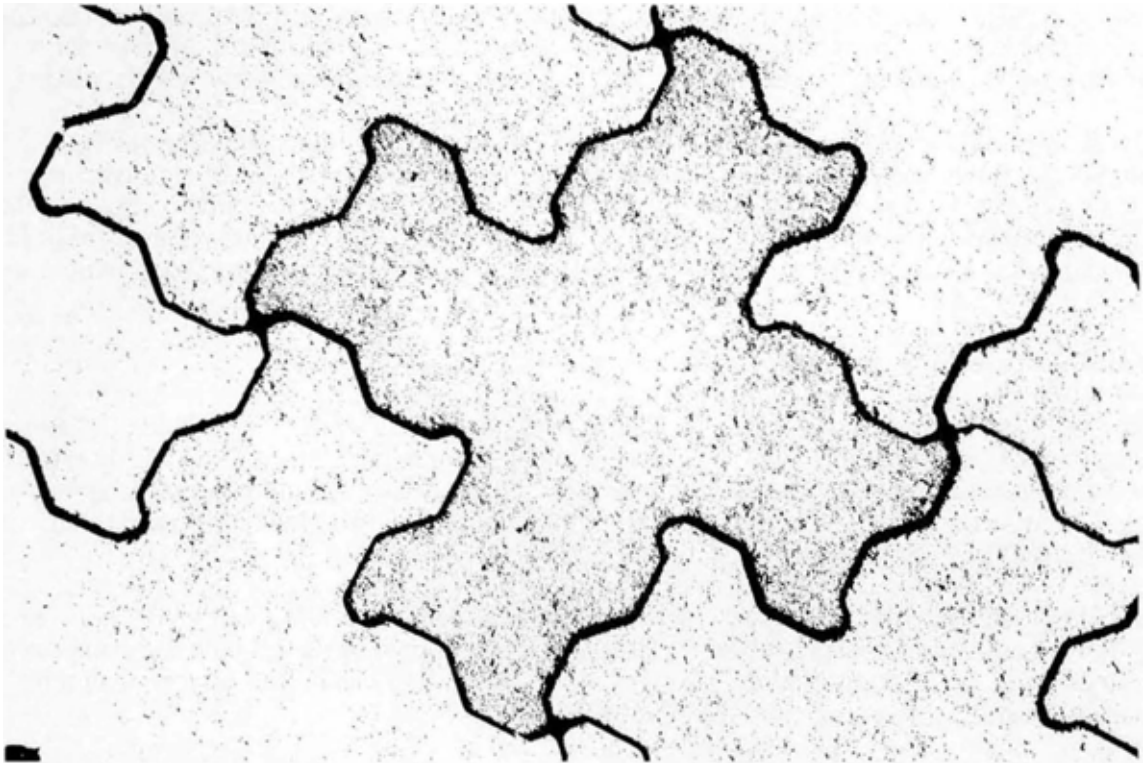


Fig.8

Pavers for Airports

There has been a major growth in the use of pavers for aircraft pavements (4), with their advantages over traditional rigid concrete of no joint maintenance and durability benefits compared with asphalt. In addition, the fast, all-weather, mechanised installation techniques requiring no curing time render concrete pavers a particularly appropriate method of paving around airports to minimise "down time". However, problems have been encountered at airports with removal of jointing material by jet blast and consequent failure of pavements.

An appropriate sealer is essential to help prevent this, but in such cases, over-wide joints have been identified as a major contributor to the problem, notably where "cluster effect" has occured during mechanical installation of particular pavers. The latest recommendations for airport pavements (5) specifically exclude mechanically laid paver systems if they can be subject to this “cluster effect”.

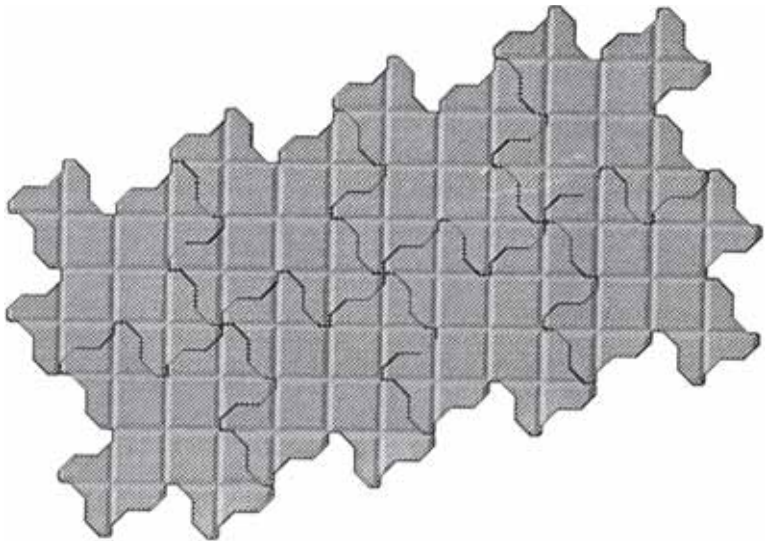
The new X-format paver design has been shown to eliminate cluster effects whilst retaining machine laying capabilities. In addition, preliminary tests earned out at Newcastle University identified that the right angled joints generated by the non-linear format paver effectively arrest the gas flow in joints which causes this problem, whereas all the other pavers tested contributed little to gas flow reduction. The X-fonnat paver is therefore particularly suited to airport pavements.

Maintaining Interlock in Permeable Pavements

There is a growing international demand for loadbearing pavements which are capable of allowing the passage of surface water through the pavement to the sub-base and beyond. In addition to environmental requirements, such systems allow substantially reduced loading of rainwater drainage systems and, in some countries, permit more paving to be installed than would otherwise be possible to comply with current legislation.

Several paver systems exist which can achieve this, essentially by providing voids in or between paving units to allow the passage of water. However, the presence of these voids can compromise the interlock - and, hence, performance - of the pavers whilst water can collect on the pavement itself before draining off through partially filled voids.

The geometry of the new dentated X-format paver allows incorporation of a surface pattern of Channells or "false joints" forming square or linear grids across the paved surface, Fig.9, of various sizes based upon a 40mm module. These surface patterns can be used for visual purposes (disguising the actual shape of the block and giving an impression of square setts) or to generate noise changes with vehicles (for traffic calming). But they are particularly useful in channelling rainwater off the main pavement surface to reduce problems of aquaplaning and improve grip.



Where a permeable "ecological" pavement is required, the X-format paver allows introduction of vertical drainage slots, Fig. 10, which have no detrimental effect upon interlock and structural performance. These slots can collect water from the surface channels to provide a comprehensive, advanced pavement surface water handling system. This allows the X-format paver to be used as a permeable pavement in heavy duty situations.

Conclusion

The growing demand for rapidly installed, mechanically laid pavers has resulted in new product developments to give advanced interlock through dentated block shape combined with a symmetrical X-format. These new pavers demonstrate performance benefits which could have implications for more economic heavy duty pavement design as well as faster laying rates and manpower reductions. The elimination of cluster effect by these pavers ensures optimum performance and allows them to be used for air-port pavements whilst advanced surface water handling techniques can be incorporated where appropriate without loss of structural performance.

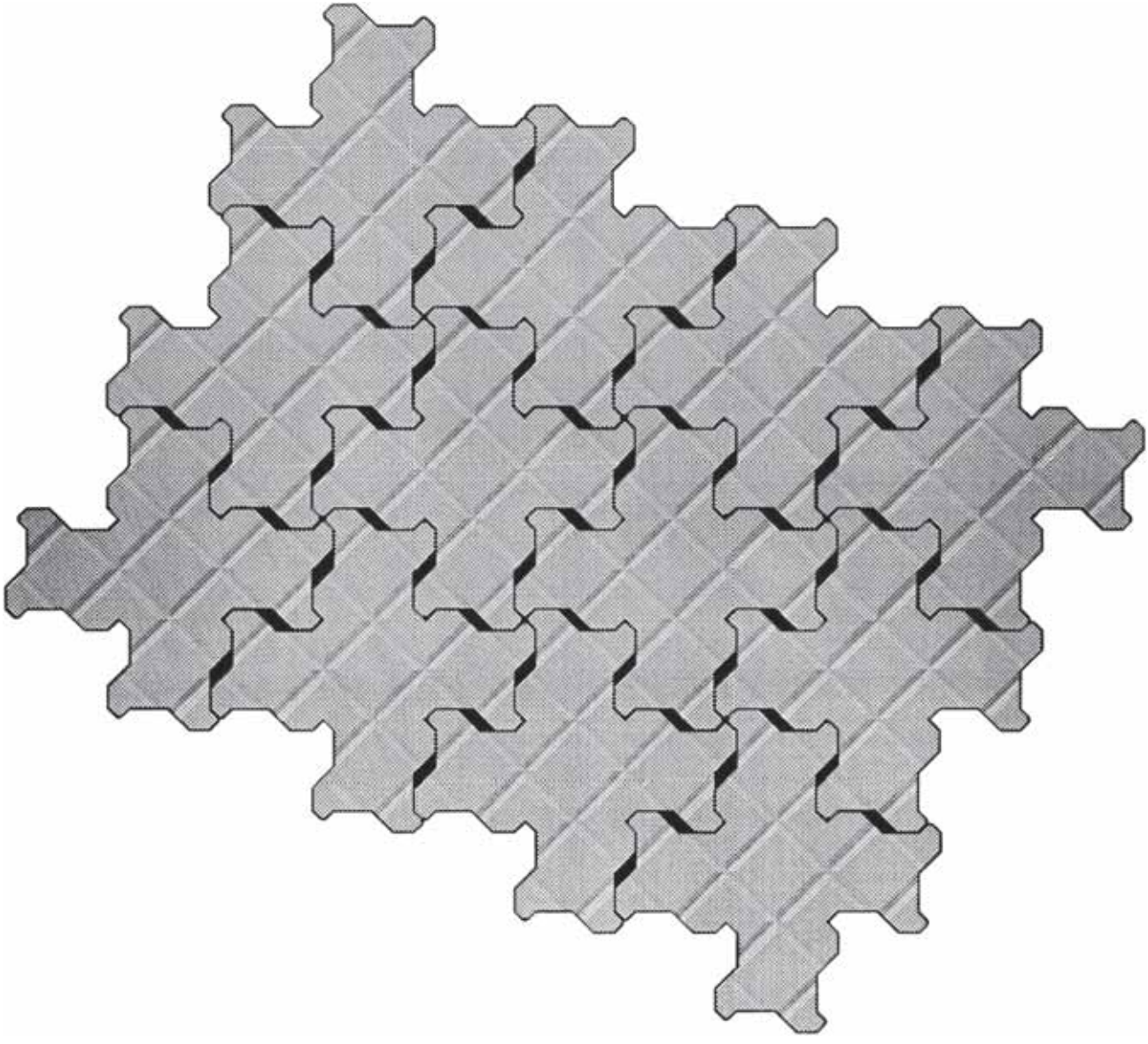


Fig. 10

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