

### Introduction

Concrete segmental pavements share similar thickness design properties to bituminous pavements with the added material durability properties afforded by ordinary Portland cement concrete. This makes concrete segmental pavements a popular paving solution in projects across Australia and the premiere surfacing material in port facilities worldwide.

To extract the most benefit from a concrete segmental pavement system it is important to understand how concrete segmental pavements maintain and develop their strength during their design life through a process known as interlock.

This factsheet aims to define and elaborate on the interlocking process, allowing readers to effectively specify and optimise concrete segmental pavements in their projects.

### Why Do Concrete Segmental Pavements Interlock?

Interlocking is only possible in a concrete segmental pavement due to two fundamental characteristics of the system.

- All units in a properly constructed concrete segmental pavement are able to undergo small rotation when loaded. These rotations are imperceptible to the human eye and are typically measured to be less than a 5 mm displacement at a maximum 10° angle.
- Concrete segmental pavers are manufactured to a high dimensional tolerance and are typically installed with uniform joint widths of 2–4 mm to accommodate the wet cast pavers through spacer nibs, tile spacers or pavers with slightly tapered sides.

This deflection and the uniformly narrow joint spacing allows units to consistently interact with one another, enabling interlock. The loading and reaction forces of a concrete segmental pavement can be seen in Figure 2a and 2b.

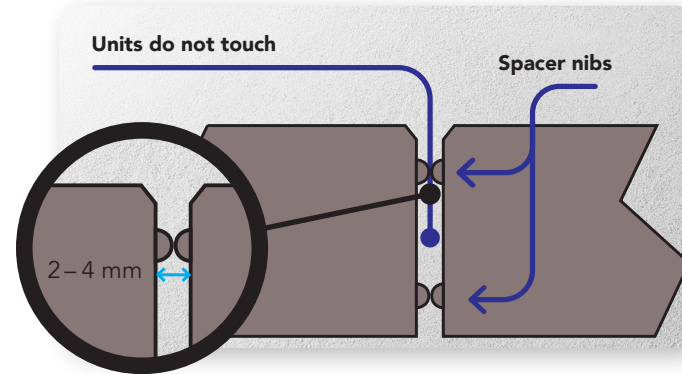


Figure 1: Most pavers are provided with nibs to help maintain uniformity in joints.

### How Does Interlocking Work?

All concrete segmental pavements interlock through frictional and mechanical interlock.

Frictional interlock is provided by the presence of jointing sand between paver units. Without adequate jointing sand, distribution of forces to surrounding units is not possible.

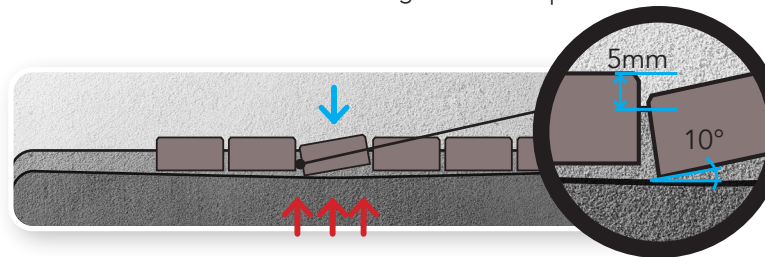


Figure 2a: Loading force localised on individual unit

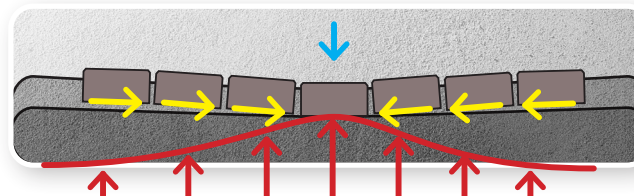


Figure 2b: Loading force shared across paving surface

Mechanical interlock is provided by the units themselves and can be enhanced by the presence of keys in the paver unit. Keyed units lock with other adjacent pavers to provide greater resistance in the lateral direction.

### Factors Affecting Interlocking

#### Laying pattern

Designers have the flexibility of choosing different laying patterns, which can dictate the function of the pavement being designed and overall appearance. Herringbone bond provides the strongest form of interlock, followed by basket-weave and stretcher bond.

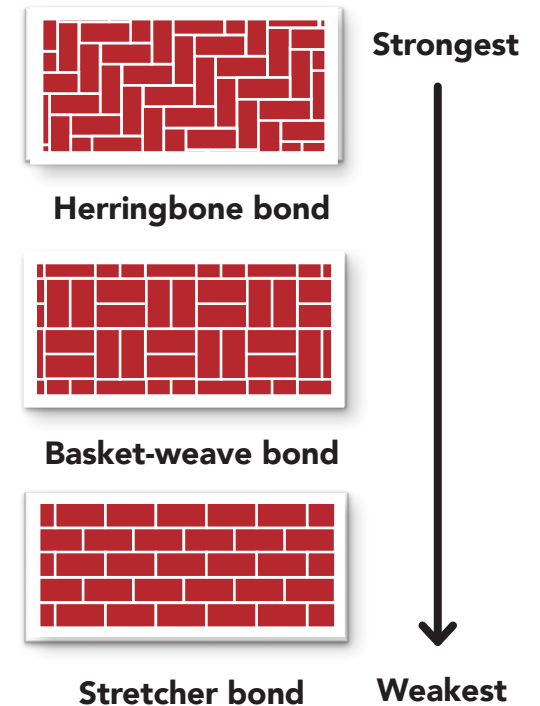


Figure 3: Comparison of laying patterns

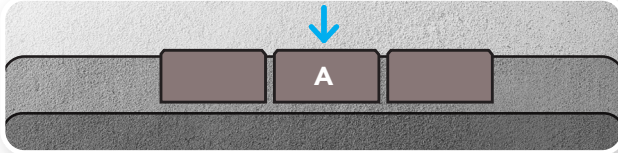
# CONCRETE SEGMENTAL PAVEMENT

## Interlocking Factsheet

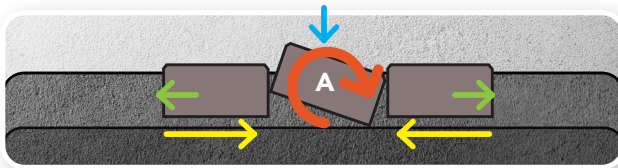
Simplistically interlock may be explained by Newtons Third Law, the law of action and reaction. As forces are exerted on each paver, equivalent reactionary forces are generated to prevent excessive movement. The details of this phenomenon for stretcher and herringbone bond systems are elaborated on below through exaggerated diagrams.

### Stretcher Bond

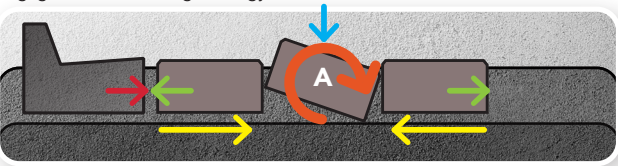
1. Paver A experiences a wheel load, causing the paver to rotate, converting vertical forces into lateral forces.



2. The rotating force induces a wedging force on the adjacent pavers, causing them to shift outwards. The reactionary forces provided by the sand and adjacent pavers locks paver A in place, preventing further displacement.



3. The forces induced by the load and transmitted by pavers continue to travel laterally until a suitable edge restraint is met or the force dissipates to negligible levels through energy loss.



4. As a result, interlock is established throughout the concrete segmental pavement.

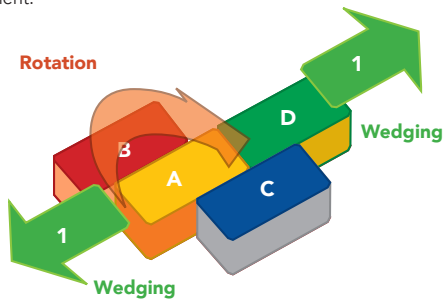
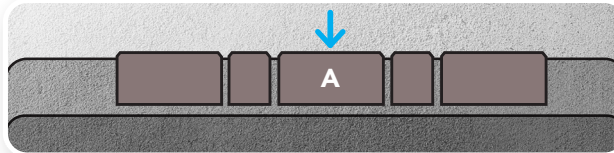


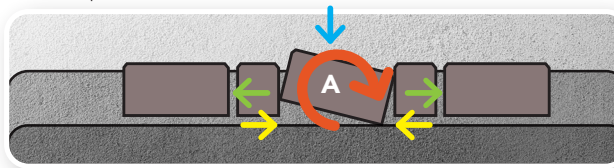
Figure 5: Mechanism of stretcher bond

### Herringbone Bond

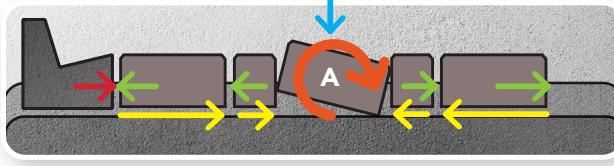
1. Paver A experiences a wheel load, causing the paver to rotate, converting vertical forces into lateral forces.



2. The rotating force induces a wedging and rotation force on the adjacent pavers, causing them to shift and rotate outwards. The reactionary forces provided by the sand and adjacent pavers locks paver A in place, preventing further displacement.



3. The wedging and rotational forces induced by the loads continue to travel laterally until a suitable edge restraint is met or the force dissipates naturally.



4. As a result, herringbone provides a stronger interlock established in the concrete segmental pavement.

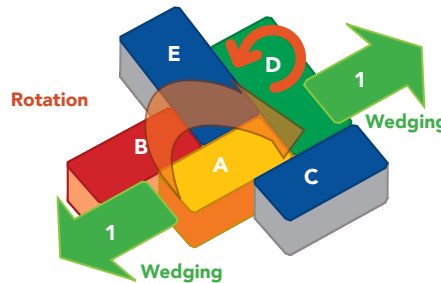


Figure 6: Mechanism of herringbone bond

### Paver shape

Designers have the flexibility of choosing different paver shapes, which can dictate the function of the pavement being designed and overall appearance. While strength is equally important in all pavements, the concept of interlock becomes more critical in heavy duty pavements such as industrial ports and hardstands due to the extreme traffic loadings.

The interlocking of paver units is conservatively considered in the CMAA's thickness design procedures. Although paver units that key into each other facilitate a more effective interlock than those without keys, this benefit is not modelled in design for conservatism. The additional interactions developed between individual units by the presence of keys in paver units is showcased in Figure 4 where additional rotational forces in all surrounding pavers is generated - providing greater interlock to paver A.

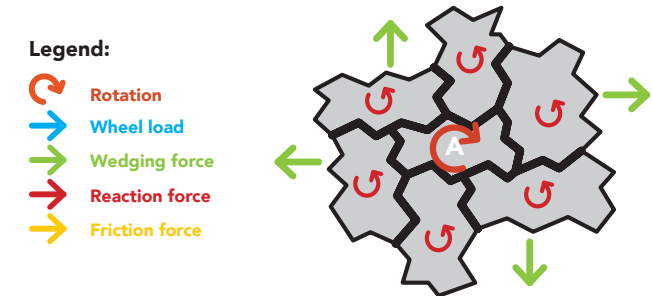


Figure 4: Mechanism of keys

### Traffic loading

Concrete segmental pavements continue to gain interlocking strength over time due to progressive traffic loading. The more vehicle passes the pavement experiences, the stronger the interlocking action within the pavement surface becomes. The CMAA conservatively specifies a minimum design traffic loading of 10,000 ESAs before considering the contribution of interlock.

For thickness design the CMAA recommends adopting the equivalent modulus values provided in Table 1 for the interlocking layer of a concrete segmental pavement.

	Pre-Lockup (≤ 10,000 ESA)	Post-Lockup (> 10,000 ESA)
<b>Modulus</b>	350 MPa	3,200 MPa

Table 1: Recommended moduli for paver layer