PODIUM TILE INSTALLATIONS - POTENTIAL PROBLEMS DUE TO LACK OF APPLICABLE STANDARDS.

Tim Christopher

Principal; Consultile Consulting Australia

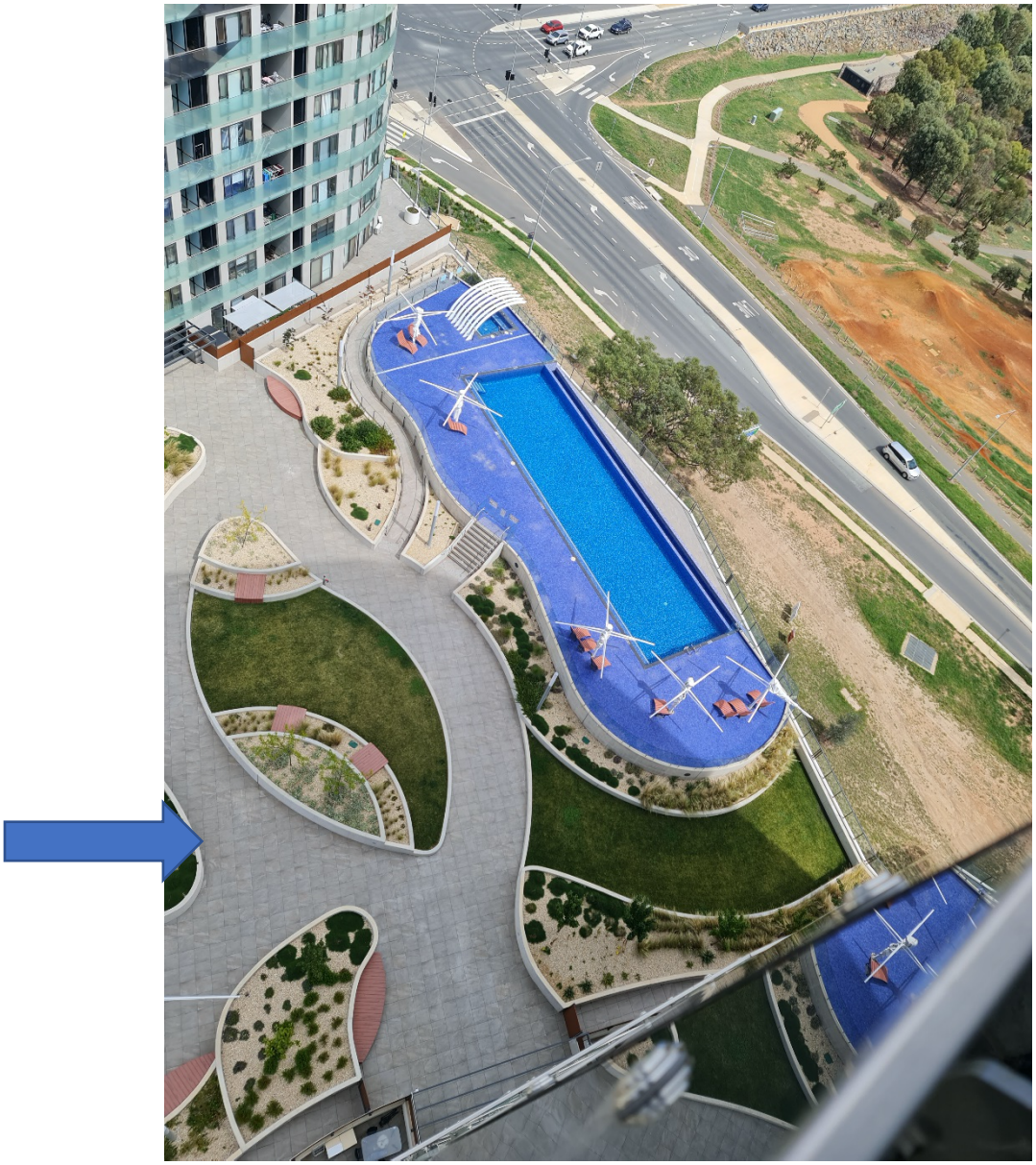
EXECUTIVE SUMMARY

The introduction of Podium tile installation systems represents a forward-thinking development in the tile and building industry. While these systems provide solutions to many building and tile problems, they are not an alternative which can eliminate traditional tile installation methods altogether. Podium tile installations require the accommodation and adaptation of installation and product standards to protect the tile industry from failure, safety, and negative durability impacts. The rigorous adoption of current standards and establishment of new Podium tile specific standards will ensure the continuity of the good reputation of tiles as a quality building element.

Podium tile installations have gained popularity in the recent years. Installing tiles on height adjustable pedestals has eliminated the requirement for traditional sand and cement screed layers and subsequent bonding of tiles to substrates. This new installation practice is used primarily in external installations such as balconies and walkways. I have observed an increased use of Podium or 'Pedestal' tile installations which have also become increasingly ambitious in area and pedestrian intensive scenarios. A typical private balcony installation may be 8-10 m2, (86-107 square feet), however the podium systems are increasingly being utilised for commercial areas such as building entryways and public spaces.

I have commonly seen areas of approximately 500 m2 (5,381 square feet) at apartment blocks as common use areas.

Installing a podium tile installation on an increasingly large and intensive use scale introduces a higher degree of design consideration. Safety, longevity, and serviceability are some aspects to accommodate when specifying a podium tile installation on a construction project. External applications require many functional and environmental use aspects to be accommodated by such a tile installation. Some use aspects and installation characteristics are different to what a traditional tiling installation would experience and be expected to accommodate. Some of these are discussed below.



Photograph 1. *Common Podium Tile installations are used in large public areas such as this 420 unit apartment block 'Sky Park' on level 5*

GENERAL DESIGN CONSIDERATIONS

Any tile installation requires the design to accommodate and consider the relating building elements which may be impacted by it. Waterproofing membranes, storm water drainage configuration and gradient slopes are required by individual National building code boards to be constructed in a way that is suitable to provide functional performance, not just a technical specification.

Insufficient quantity of drainage outlets will require more depth in the substrate to allow adequate fall within the surface to prevent water accumulation. The drainage point will require protection from ingress of debris which will cause blockages. The type of membrane becomes a critical consideration as the determination of trafficable surface through friction and vibration through the pedestals, UV penetration and degradation through retention of surface contaminants are additional characteristics which impact on a podium tile installation. The pedestals themselves also vary greatly in design and manufacture methods and performance recommendations. In my experience, some of these pedestals appear to lose adjustment over time causing tiles to rock and create lips which are a trip hazard. There is little guidance on expected maintenance or intervals requirements for a podium installation.

WIND

Podium tile systems are installed at many different locations globally. Balcony installations which are at elevated positions such as on high-rise apartments are subject to exposure to high wind forces such as those experienced along the sea front or alpine conditions. The force of the wind in these areas is capable of lifting tiles which are installed on a podium/pedestal system if the tiles are not fixed down. In situations I have observed, tiles which are 600mm x 600mm and 20mm (24 x 24 x .78) thick will flip over completely. This leaves a safety hazard where there is effectively a void for pedestrians to fall into.

Common construction standards and guides for wind loadings are written to aid the construction of roofs and wall/truss type junctions which are specific for structural guidance. I examined the Building Code of Australia, Australian and ISO standards relating to the installation of tile and waterproofing design/ installation documents and was unable to find guidance relating to this scenario. Wind related references provide guidance to determine the set down distances for external floor levels in relation to the door sill heights. This guidance is specific to prevent ingress of water aided by wind energy. (See Photograph 2 which depicts mechanical fixings used to restrain tiles which were flipping over in windy conditions.)

Photograph 2. *depicts mechanical fixing sytem to prevent dislogement of tiles that were previosly flipping over in high winds.*

Many manufactures of podium systems provide adaptive fixing systems to anchor tiles down in a way that prevents the installations from allowing the tile to lift and flip. When researching Podium manufacturers installation instructions, I was unable to find information or reference to any guidance documents which provide the technical information on how to determine the wind loads which would dictate the addition of mechanical fixing methods to prevent tiles becoming dislodged. There is no information giving guidance on the extent of mechanical fixing required in each scenario, for example are all tiles required to be fixed down or are several rows closest to the windward face of the installation sufficient? Establishing the applicable wind impact on an individual installation and standards which apply may not be possible to determine in the design stages. There is a lack of available guidance on tile or podium limitations when designing an installation which may be impacted by wind. This problem often only becomes apparent after the installation is completed and the wind impacts are experienced on the site.

MAINTENANCE-TILE LIPPAGE

Higher pedestrian traffic exposes the tiles to a higher friction and differential movement action occurrences on the face of the tiles. A small balcony may limit human and tile movement by its restrictive area; however, a large common area space enables a higher volume of people and more movement. Instances of children being able to run, the introduction of prams, children's bikes and scooters require consideration for the design. Some of these examples may be excessive or outside the suitability of a podium installation, however this guidance is not readily available and not in a calculable format which could be applied to building design.

Multiple pedestrian movements place pressure by foot movement impact which can be projected at varying angles to the tiles. This type of pressure places differential pressure on the installation which in time, can create movement of the pedestals and subsequent loss of adjustment and retention of the tile in its desired plane. This creates problems such as tiles that can rock from side to side and lippage between tiles (see photograph 3 below). This can be addressed by subsequent adjustment of the pedestals but in doing so, creates a maintenance requirement. In the instance of this type of maintenance, there is no guidance on the requirements in relation to intervals, qualifications required of the servicing contractor or expected frequency of such maintenance. One manufacturer of the pedestal systems data sheet states movement in excess of 3mm 91/8 inch) will void the podium system warranty [1].

Photograph 3. *Depicts lippage between tiles subject to foot traffic*

This movement includes wind derived movement. In this scenario which standards are applicable to calculate the expected movement through either wind or pedestrian impacts? These issues should be accommodated with any building design element where safety issues such as trips and falls are possible through lack of maintenance. The information to make informed use decisions based on maintenance requirements is not provided by manufacturers or standardised.

MAINTENANCE- DEBRIS AND SUBSURFACE CONTAMINATION.

The nature of a podium installation provides that there is no requirement for grout between the tiles. Joint size between the tiles is 3-5mm (.11-.19 inch). This gap facilitates drainage, but also allows for a degree of environmental debris to be accumulated beneath the tiles. Where dirt and debris do accumulate on the surface of the tiles, regular sweeping or even vacuuming will not remove all the contaminants and some debris will in time cause an increasing build-up beneath the tiles. The installation of a podium tile system also necessitates adequate room for movement between the tiles and adjacent perimeter walls. Wind driven debris accumulates at this location (see photograph 4).

Photograph 4. *depicts debris under a podium system 2 years after installation.*

When removing tiles which have been in situ for approximately 3- 4 years I have observed a higher amount of dirt, organic matter and dust under tile installations than otherwise expected. This subsequently creates the necessity to clean beneath the tiles to facilitate continuing drainage function and damage to any waterproofing membrane which may be present. Cleaning beneath heavy tiles and/or a large area of tiles is beyond what the typical resident should be expected to carry out. A 600mm (24inch) x 600mm (24 inch) x 20mm (3/4 inch) thick porcelain tile weighs approximately 16.3 kg (36lbs). To lift and replace a tile of this weight is not a practical expectation of a homeowner particularly for a large area of 50-60 m2 (540- 645 square feet). Subsequently a proficient contractor would be required to lift and replace the tiles during cleaning. This process will require some of the reinstalled tile pedestals to be readjusted to maintain a lippage free surface, as once multiple tiles are removed, the tile heights will be out of alignment. This is not a cost or process that is considered in specifying a podium tile installation. In the instance the installation is several hundred square metres (several thousand square feet), this is a major undertaking. This process further risks breakage and damage to tiles as they are subject to manual handling. There is no guidance available on this necessity or frequency of this requirement. The accumulation of debris under the tiles is not necessarily a fault with the installation, it does however introduce additional design considerations.

BREAKAGE/ DURABILITY

The testing of tiles relating to breaking strength is outlined in ISO10545.4 (2020) standards- Method 4 Determination of modulus of rupture and breaking strength [2]. This standard outlines the testing method required to determine breaking characteristics of a tile sample. The test method is applying a force of pressure to the centre of a sample tile which is supported by the two edges of the opposing side of the tile sample. This test method can be used to establish the breaking load which can be placed on the tile before it breaks. A typical 20mm (.78 inch) thick Porcelain tile can have a tensile breaking load of 11000N (newtons) compared to 2500N (newtons of a 10mm (.39-inch-thick tile). This load is measured by applying a consistently increasing amount of pressure on the tile.

The ISO Standard which is currently used to determine the impact resistance of tiles is ISO 10545-5 Ceramic Tiles- Part 5 Determination of impact resistance by measurement of coefficient of restitution. This test method applies to tile samples of 75mm x 75mm (2.9 x 2,9 inch) in size which are adhered to a concrete substrate and consequently supported by epoxy adhesion. This test procedure is effective in measuring the durability of the tile surface in relation to the test. The test constitutes dropping a 20mm steel ball onto the tile surface and subsequently measuring the rebound heights and observing damage to the tile surface due to the impacts.

This test is not used to measure impact and breakage resistance of a large tile such as a common 600mm x 600m x 20mm (24 x 24 x .39inch) in size.

The typical 20mm thick tile installed on a Podium system is marketed to be able to facilitate up to 1500kg of weight in some scenarios [4]. This refers to dead load (fixed) and the as tested 1100 N load capacity of many tiles supports this recommendation. However, the constant dead loading of a tile and pedestal beneath it does not consider sudden impacts which may occur. In the scenario where tiles are 600mm x 600mmx 20mm installed on pedestals which support each corner, there are large unsupported sections of tile. It is possible for the tiles to break when impacted from above with a sudden force.

This sudden impact scenario may seem unlikely; however, I have observed situations where this was occurring. A residential tower complex of twenty floors had pebbles of 20-30mm diameter installed on the roof as ballast to protect the waterproofing membrane beneath. Large birds of the Raven and Cockatoo variety were filmed dropping the pebbles from the 20th floor roof onto a common area with tiles installed on a podium system on the 5th floor below. The impact of these pebbles caused the tiles to break into 2 or 3 pieces. This created a hazard where a drop in the finished floor height of 180mm to the substrate below the tiles was present and pedestrians subsequently exposed to a safety hazard.

The testing of impact resistance is measured using a fully supported and adhered tile sample. Podium installations do not provide equivalent and comparable characteristics. Typically, 20mm thick porcelain tiles are utilised for these applications which are high in load carrying capacity but are still subject to fracture through impact. The information available to calculate suitability and guidance for such an application is not available in the current standards format. Attempting to utilise these standards to determine suitability of a tile for use in a Podium system would be a misuse of these standards. The question is does a tile merely require a thickness of 20mm to be suitable for this type of installation? The industry appears to be currently operating on this assumption. Natural stone and concrete pavers are also not accommodated by any podium manufacturers installation recommendations. Indeed, many natural stones and concrete pavers are unsuitable for installation in a self-supporting system such as podium installations.

FIRE COMPLIANCE

There appears to be a lack of guidance on the suitability of the pedestal supports in relation to suitability to Fire Ratings. Only a few pedestal systems I researched were found to be tested in accordance with the European standard EN 13501-1 which provides the reaction to fire classification procedure for all products and building elements. This standard is used to determine an element performance reaction to heat. According to this Standard, there is a reaction of an element to fire/heat and the response of a product in contributing by its own decomposition to a fire to which it is exposed, under specified conditions (not to be confused with the fire resistance). The podium systems that did have fire test results or classifications are rated as category E in relation to EN 13501. This category definition is '*Class E combustible materials high contribution to a fire and are only able to resist a small contribution to fire.'*

This is an important requirement when considering the need for a floor area to remain stable in a fire to facilitate any evacuation which may be required. By decomposing in the presence of fire, a pedestal floor system would become uneven or collapse completely rendering the floor as a trafficable surface as unusable. It should be considered some pedestal systems can facilitate an elevation of the floor height of up to 600mm above the sub floor below. A floor even partially collapsing in this configuration would restrict and inhibit the egress of an area in the event of a fire and create a significant hazard.

As an example of building requirements in the event of a fire, the Australain Building Code 2019 Vol 1-part CP1, which applies to residential units and other commercial buildings requires, '*a building must have elements which will, to the degree necessary, maintain structural stability during a fire appropriate to the function or the use of a building and the evacuation time*' [6].

When researching podium systems, most manufacturers data sheets did not provide any guidance or test methods in relation to fire ratings or resistance. The implications for lack of consistency relating to any fire rating is a potential fire hazard. While the fire hazard is not one that is present in every scenario where podium systems are used, the accumulation of flammable debris under the tiles and the impact of other flammable building and environmental elements do create the possibility of such a fire hazard. Calculating the risk and specifying a satisfactory system is difficult with the absence of supporting testing or performance standards of these pedestal systems. It was observed the more cost efficient the podium systems were, the less technical supporting information on fire testing or resistance was available. Indeed, many systems had no reference to fire at all.

WATER RETENTION

Podium tile systems necessitate that the tiles are installed in a level plane. Curvature of tiles becomes an issue when an application requires a level installation. When the surface of a large format tile such as 600mm x 600mm is of concave nature, the potential for surface water retention becomes likely (see photograph 5). This subsequently creates slip, health, and maintenance issues. Locations where sub zero temperatures are present, potential slip hazards in relation to ice formation are created. There is no guidance as to limitations of the tile or installation process regarding this issue. Are tiles which exhibit certain concave characteristics unsuitable for use with podium installations due to curvature?

Photograph 5. *Depicts water retention on a podium tile installation during the morning at 10 am after a night of rain.*

Building Codes and standards require falls to be installed on horizontal surfaces to accommodate drainage. The installation of a Podium system relies on the drainage function to be performed underneath the tile surface on the sub floor beneath. The necessity to install tiles in a level plane creates an uncommon situation in general building practice. As there is no facility in the podium tile systems to grade falls on the surface, water retention through surface tension and allowable curvature in the tile manufacturing process occurs.

In the situation where tiled areas are sheltered from winds and the building shadow, this provides an environment where a volume of water is retained on the tile surface for some time. In cold conditions, the surface of the tile may not dry out for a long period. Additionally, potential slip hazards are created if surface water is to freeze and create an icy surface. Surface water retention will exacerbate the retention of dust, promote the growth of moss and or lichen type organisms which create additional pedestrian slip potential and cleaning and maintenance requirements (see photograph 6).

Additional building maintenance adds costs to the residents which may not be considered when considering a podium system in the building design stage.

Photograph 6. *depicts water retention on the surface of a podium tile installation.*

WATERPROOFING COMPATIBILITY

Many Podium tile installations are installed on balconies which require the pedestals to sit upon waterproofing membranes. The types and number of waterproofing membranes suitable for an external balcony installation covers a wide and varying selection range. The utilisation of a membrane under a Podium system requires more consideration than simply being described as suitable for balcony applications by a membrane manufacturer. Some considerations which need to be accommodated are:

I. Does the membrane require a trafficable surface durability requirement to resist friction caused by movement of the pedestals through human activity such as pedestrian movement?

While the individual pedestals are designed by manufacturers to be stable, regularly trafficked public areas are exposed to angular impacts through natural foot traffic. If an individual were to run or jog, this would place further pressure on the tiles. In this instance the base of the pedestal allows slight movement or friction on the surface of the membrane. Many membrane specification sheets list 'balconies' as a suitable application. However, there is no information available on the expected amount of friction likely to be present and which types of membranes are warranted under a Podium tile installation where the possibility of pedestal friction and movement is present. Over time, this may create an abrasive effect on the membrane on which the pedestal sits. This friction is exacerbated by the build up of dirt and debris. The membrane used in this scenario would be required to be resistant to this type of friction and movement.

II. Does the degree of debris which may accumulate under the tiles degrade the membrane and/or affect the suitability of the membrane in the long term?

While researching this paper, I attended several webinars on external waterproofing membranes from several prominent waterproofing manufacturers. On questioning the warranty provided on different types of membranes when exposed to continual dirt and dust exposure and accumulation, it was stated that most waterproofing membranes are not warranted for this scenario and some polyurethane membranes would be expected to break down in the long term in this type of environment (see photograph 7). It is difficult to quantify the level of dirt and debris expected under a podium tile installation and what period of time such a situation might develop.

Photograph 7. *shows dirt and debris accumulated on the waterproofing membrane beneath the tiles after approximately 2 years. In this image, the dirt was cleaned off the membrane to examine a failure in the membrane beneath.*

III. Given the membranes are to be directly in contact with all drainage water, is the surface adequate to ensure drainage without ponding and retaining surface water beneath the tile?

The collaboration of the contractors when designing the waterproofing, sub floor construction and podium systems is essential. Many membranes are unsuitable to be installed where water retention is a regular occurrence (see photograph 11). This necessitates that the entire subfloor falls to the drainage outlets from all the extremities of the floor area. Installing a gradual and consistent gradient during a large concrete placing process is difficult or impossible when considering timing and volume of material to be installed at the concreting stage. Often the concrete slabs which have podium systems installed do not have consistent fall and only drain from limited areas or over a reduced distance as was dictated by the concrete placing process.

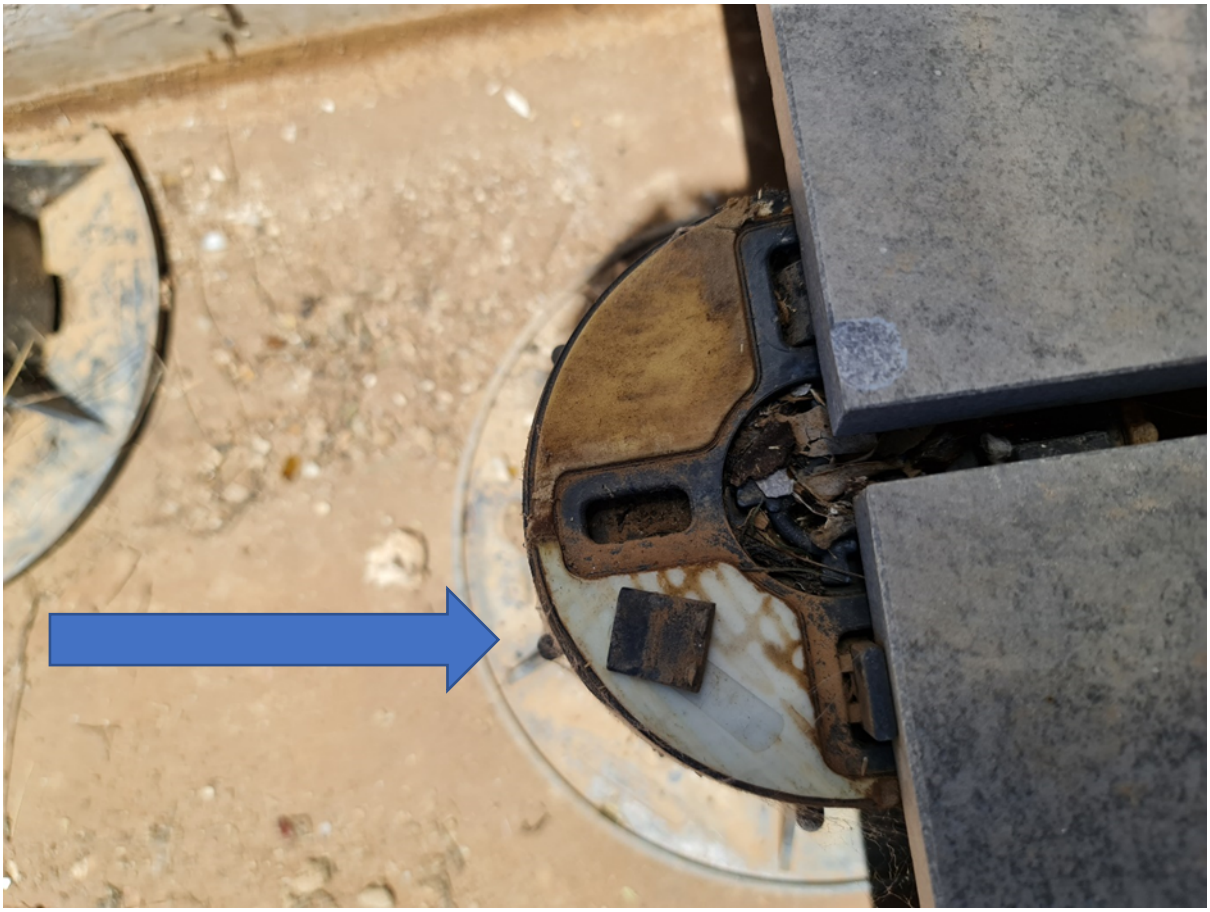
Photgraph 11. *shows water retention beneath the tiles due to insufficient gradients.*

IMPACTS OF ULTRAVIOLET LIGHT.

Although covered by tiles, is this sufficient protection from Ultraviolet (UV) light which can penetrate through the tile joints

While the exposure to UV light to the pedestals themselves is reduced due to the cover of the tiles, I have observed damage to the spacer lugs which keep the individual tiles separated and evenly spaced out. The UV levels in the daytime hours in Australia are some of the strongest globally (up to 15% higher than Europe) [7] and subsequently degrade many plastics through the action of breaking down polymers. The plastic which makes up the pedestal construction are listed in technical data sheets as UV resistant, however there is no accompanying information as to whether this prolongs the time for damage to occur or representative of a consistent high level of protection provided. The damage through this phenomenon is trivial on face value until the resulting tile movement due to broken spacer lugs is considered. Once the spacing between the tiles is absent the tiles move under foot traffic allowing the tile to become chipped (see photograph, 8 9 and 10). The adjustment of the individual pedestals is then knocked out of balance by pedestrian movement, allowing the tiles to rock from side to side and lips to occur. This results in trip hazards occurring between adjacent tiles.

Photograph 8. *shows chipped tile from differential movement.*



Photograph 9. *shows broken spacer lug*

Photograph 10. *shows missing spacer lugs*

CONCLUSION

Podium tile systems provide many solutions to current building problems. Podium tile installations eliminate the requirement for sand and cement screeds layers to achieve substrate drainage as well as the subsequent requirement for the use of tile adhesives. Efflorescence, where salts leach from within the cementitious tile system elements and become a maintenance issue for the tile surface are effectively eliminated. By removing the requirement for a bonded element within the tile installation when cementitious products are not required can have a cost advantage in relation to installation time and material costs. Storm water drainage takes place below the tile surface which negates the problems associated with installing large format tiles and achieving falls to drainage points which may be installed in problematic locations. Traditionally, tiles of 600mm x 600mm in size would be required to be split to 'bend' falls in the substrate and achieve a lip free surface when the drainage point is close to walls or other adjacent building elements. The use of a Podium system facilitates multiple drainage points and can be installed wherever necessary without impacting the subsequent tile installation.

These advantages have opened the way for various Building Code committees to consider Podium tile installations as a solution to many current building failures. Balcony tile failures have many causes such as:

I. Insufficient set down of the balcony substrate in relation to internal floor heights to allow for falls in the substrate to be achieved without creating height issues at external doorways. The further the drainage point is from a location such as a doorway, the more depth is required to apply a sand and cement screed to achieve a continual gradient such as 1cm in 1m (.39 inch in 3.2 ft).
II. Some polyurethane and Torch-on waterproofing membranes are often not compatible with tiling systems and cannot be bonded with tiling adhesives. This subsequently requires the use of unbonded systems which require greater set down heights at door threshold to maintain tiling system strength to support itself in an unbonded application.
III. Efflorescence and latex leeching from cementitious products, curing and setting times are eliminated by the removal of adhesives, grouts, and screeds.
IV. Workmanship error and subsequent installation problems are reduced.

These advantages are attractive and currently used as a justification to mount an argument in Australia to eliminate external adhesive and screed tile installations.

However, the issues outlined in this paper suggest there are more considerations which need to be accommodated for this type of conclusion to be reached. Podium tile installations are useful alternatives to traditional sand and cement/ adhesive installations, but the issues outlined above suggest Podium tile installations are not necessarily a substitute which can apply in all building situations.

Building designers and tile installers require adequate standards and codes to establish the suitability and situational requirements to make informed decisions on the tile installation and performance suitability.

While there are currently Podium installations which are performing as intended, what available standards and documentation is available to consistently design a long-lasting installation? Specific environmental and maintenance issues are unable to be consistently and accurately evaluated by using the Standards which are currently available. It is not possible to utilise existing standards, such as ISO (International Standards Organization) standards, to specify an application that provides indemnity for the building designers and subsequent building owners involved on a performance basis. The individuals responsible for design and installation cannot provide a measurable or expected performance time frame. In the long term this has potential to cause damage to the tile industry though significant insurance and compensation claims, personal injury accidents, unexpected maintenance, and failure.

RECOMMENDATIONS

There are five recommendations that can be made in relation to the installation of Podium systems. These are not necessarily solutions available for all the problems outlined above. Water retention on the tile surface is a consideration that can only be addressed when considering each and every installation, scenario and environment. Some suggestions for standards are:

- Installation standards to set the minimum acceptable installation requirements. These could consider tolerances of finished surfaces and substrates which require minimum and maximum slopes to remain stable, the quantity of pedestals required per tile size and expected foot traffic present after installing the tiles. The qualifications for the contractor who installs the system needs to be stipulated, for example some data sheet advice ranges from a requirement for '3-years building experience of the installation contractor' to no advice at all [8].
- A manufacturing standard for the individual pedestals which includes fire rating, durability, point loading capability and UV stability. These characteristics can all be defined to give some guidance. The expected lifespan of a pedestal before it is not warrantable to perform in accordance with the performance standard could also be implemented to provide a continuing safety performance level
- Tile standards could be related to the suitability for use in a Podium installation. Minimum thicknesses may be defined to provide the durability and safety performance expected. Currently 20mm (78 inch), appears to be the accepted thickness for tiles (however it is not stipulated as a minimum nor is the existence of any parameters to determine suitability.
- The waterporoofing membrane compatibility element is critical to consider when specifying which membranes are suitable. It is not possible to establish this by using the standards available and requires a manufacturer input to establish which membranes are suitable. This also includes concrete subfloor construction for the gradients to allow drainage.
- Maintenance intervals required for inspection under tiles for debris and cleaning, adjustment intervals. The stipulation of what qualifications are required for the individuals who are performing this work should be provided. These issues need to be clearly defined by manufacturers of National standards committees to provide adequate maintenance and lifespan of the installation as it relates to the respective Building Codes.

The introduction of Podium tile installation systems represents a forward-thinking development in the tile and building industry. While these systems provide solutions to many building and tile problems, they are not an alternative which can eliminate traditional tile installation methods altogether. Podium tile installations require the accommodation and adaptation of installation and product standards to protect the tile industry from failure, safety, and negative durability impacts. The rigorous adoption of current standards and establishment of new Podium tile specific standards will ensure the continuity of the good reputation of tiles as a quality building element.

REFERENCES

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