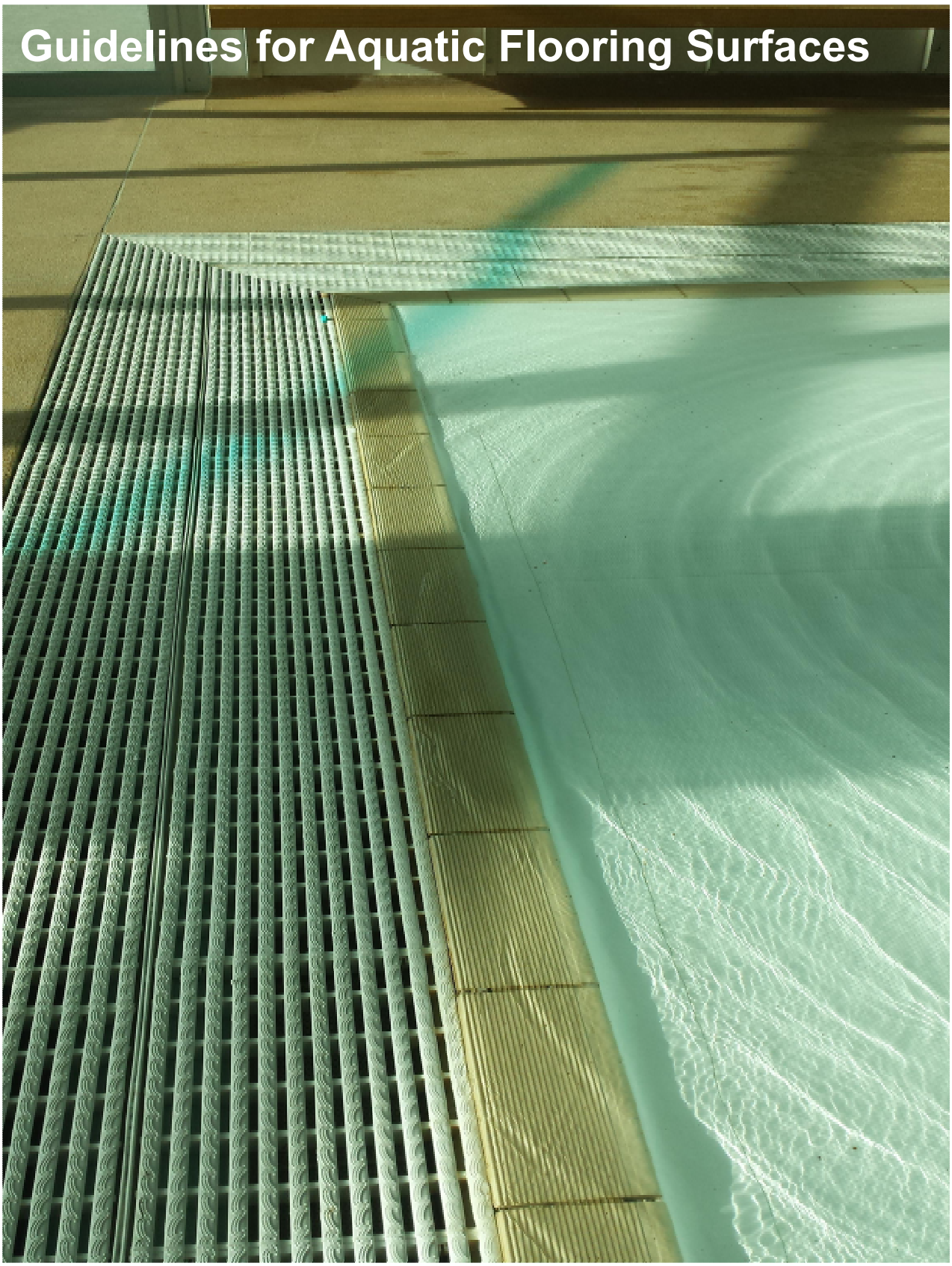
Guidelines for Aquatic Flooring Surfaces



SPORT NEW ZEALAND

NZRA NEW ZEALAND recreation ASSOCIATION

ARCHITECTURE HDT

Contents

Executive Summary

The aim of this report is to provide guidelines to the aquatic industry in order that sound and well informed decisions are made by local councils, designers and pool operators in the specification, installation, cleaning and maintenance of aquatic surfaces. The report primarily considers aquatic flooring surfaces, but also touches on pool tank surfaces. This research has been commissioned by Sport NZ in association with the New Zealand Recreation Association (NZRA).

The cost of building and/or refurbishing community aquatic facilities is significant. These facilities are used by a wide cross section of the community for an increasingly wide range of aquatic activities. The selection, design, installation, cleaning and maintenance of flooring surfaces in and around pools is critical to the safety of pool patrons and staff. Aquatic facility users have varying degrees of physical ability, ranging from elite athletes to those who by virtue of age, temporary or permanent disability have restricted mobility. Key points from this report;

- The variety of aquatic experience and the range in physical ability of pool patrons and staff requires products be selected for specific circumstances- there is no risk free 'perfect' aquatic surface suitable for all applications. All products contain some degree of risk, whether this be in the specification, installation, maintenance or use of the product.
- Successful outcomes are the product of a shared risk approach between clients, designers, contractors and facility operators. All parties have a part to play, and it is important that clear project processes and awareness of project roles and responsibilities are understood.
- The best performance indicator is in-use history of the product in the same environment. Critically, it was noted that products proven to be unsuccessful in some facilities were continuing to be specified and used elsewhere. It is recommended that a central database of aquatic facilities be set up which includes specifics about surface type, cleaning methods and maintenance costs used in New Zealand facilities. This should include key contacts relevant to these facilities so that this knowledge can be readily shared amongst the aquatic industry.
- It is not easy to use current New Zealand standards to establish compliance of aquatic surfaces with the New Zealand Building Code. This report recommends that further research be undertaken and that New Zealand standards be updated so as to provide specific guidance to designers and Territorial Authorities regarding aquatic surfaces. This information would be best found within the NZS 4441 Swimming Pool Design Standard, with other industry standards for slip resistance referencing it.
- The use of experienced consultants and contractors is critical to successful outcomes. Investment at the start of the project pays dividends when considering 'all of life' costs.

It should be noted that this publication provides general guidelines only. It is issued for the purpose of raising awareness around the product selection, installation and use of surface finishes within aquatic facilities. As such, conformance with the guidelines and recommendations within this report should reduce, but not eliminate, the many risks inherent in aquatic surface finishes. NZRA and Architecture HDT Ltd do not accept any liability from use of this report. It is recommended that this document be reviewed and updated on a 3-5 year cycle.

Report Structure and Methodology

A. REPORT STRUCTURE

Section 1. Factors Affecting Aquatic Surface Performance

This section provides an outline of the issues faced by the aquatic industry in the design, specification, installation and management of aquatic surface performance. It identifies the operational issues faced by facility managers such as slip resistance, drainage and cleaning associated with both pool concourse and pool floor surfaces, and references case studies undertaken in the preparation of these guidelines.

Section 2. Regulatory and Legislative Requirements

This section details the regulatory and legislative requirements governing aquatic surfaces. Non mandatory guidelines are also referenced.

Section 3. Risk Management

This section gives guidelines on aquatic surface risk management. It explores steps that can be taken throughout the briefing, consultant engagement, design construction and operation of aquatic facilities to minimise the risk of substandard performance.

Section 4. Aquatic Surface Types

This section provides a database on available aquatic surface types. It gives typical characteristics of each type and makes comment on the advantages and disadvantages of each type. It references data obtained from the aquatic facility survey in establishing the popularity of each surface type.

B. METHODOLGY

The information presented within this report was obtained in the following manner;

1. An online survey was conducted of facility operators (refer appended survey results). The survey was issued to 134 likely participants, from which 58 responses were received. The survey identified the most common surfaces used in the industry and the issues associated with them. Investigation work was then targeted towards the most common surfaces and issues faced. A summary of the survey results is appended to this report, and where necessary referred to within the body of the report.
2. Site visits to the following facilities to investigate the condition of various aquatic flooring surfaces-Jellie Park Aquatic Centre and Graham Condon Pool (Christchurch), Wellington Regional Aquatic Centre, Karori Pool, Keith Spry and Freyberg Pools (Wellington), Waterworld (Hamilton), and Massey Park Aquatic Centre (Auckland). Visits to Hamilton, Christchurch and Wellington coincided with NZRA Lifeguard Assessor's Forums in these cities, and valuable information from pool operators at other facilities around the country was gained.
3. A study of the legislative and regulatory requirements relating to aquatic flooring surfaces. This involved research into New Zealand Building Code and Australian and New Zealand Standards and Guidebooks.
4. Manufacturer's literature relating to different products was researched.

Section 1. Factors Affecting Aquatic Surface Performance

This section identifies the factors affecting the performance of aquatic surfaces. Factors affecting surface performance are found right from initial briefing phases through to the completed installation, use and maintenance of the surface. All project participants, be they clients, designer/architects, contractors and pool operators have a stake in achieving a successful outcome.

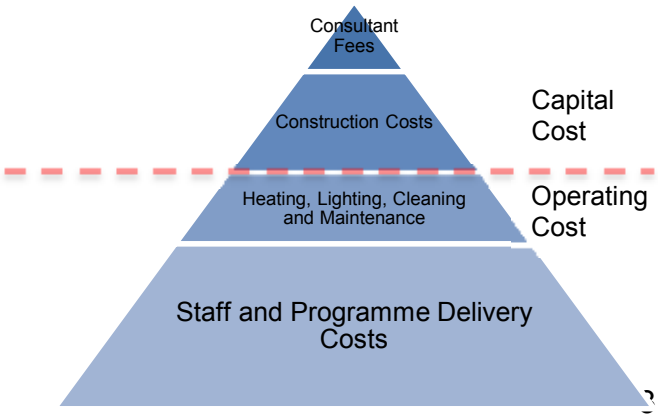
A. INITIAL DESIGN BRIEF/FEASIBILITY STUDY

The ability to influence project outcome is greatest at the beginning of the project, and progressively less so as time goes on. By the time an aquatic surface has been installed, all decisions regarding cost, product suitability and performance have been made, and it is left to the pool operator and the facility owner to deal with the on-going use and maintenance of the product. Early project phase factors affecting performance;

- Inadequate brief preparation. While project briefs are necessarily high level documents, they need to clearly set out the expectations of the client with regards to the cost, quality and programme parameters of the project.
- Valuable lessons learnt by experienced clients and operators often do not find their way into comprehensive briefing documentation. An example of this was noted during facility visits where one particular resin product exhibited the same unsightly rust staining in three different facilities; however the respective operators were unaware these issues were being experienced at other facilities. Having a central database (surface type, application, cleaning methods, contact details) of what products are used at various aquatic facilities will allow better knowledge distribution. It is important that facility managers and operators are involved in the briefing phases and have input throughout the design development and construction phases so that critical information regarding the selection and use of these products is transferred to the design team.
- Often little consideration is given within the brief to factors affecting the on-going operation of the facility. Understanding who will be responsible for cleaning, what equipment will be required and where will it be stored, how often will cleaning be required and the operational budget needed for upkeep are important considerations.
- Budgets set early in the project often get constrained as the project develops. Surface products, installed late in the construction phase, can be easy targets for value engineering. Costs associated with the on-going use and maintenance of the product fall on the operator and/or the client and are often not considered.

B. CONSULTANT SELECTION

An important factor in achieving a successful outcome is the establishment of an experienced consultant team. Cost is often a determining factor in consultant selection, but can have a disproportionate effect on the life cycle costs. The consultant team plays a critical role in all phases of



the design, specification and observation of the contract works.

C. DESIGN and DOCUMENTATION

1. Pool Use

A wide range of activities are undertaken within aquatic facilities. Activities such as lane swimming, hydrotherapy and programmes use, team sports (water polo, underwater hockey, Flippaball, canoe polo), and recreational uses such as splash pads and spray parks all place different demands on aquatic surfaces. Flooring surfaces out of the water have different requirements than those within the pool itself.

It is therefore important that the range of activities to be catered for is clearly communicated by the client, understood by the design team and followed through by the pool operator. Pool equipment such as lane rope trolleys, polo nets and underwater hockey barriers can cause damage to surfaces in and adjacent to the pool.

Splash pads and beach entrances used by children require special attention. It is critical to get these areas right, to avoid excitable children rushing into shallow water where they can easily slip backwards and hit their heads with little water to cushion their fall.

Figure 1 Beach entrances are hazardous and require careful thought in surface selection

One facility visited had glazed floor tiles used on the beach entrance. At the very least a proven non slip surface needs to be used, and serious consideration should be given to the use of a soft fall surfaces. With the exception of PVC membrane, other flooring surfaces used as soft fall in these situations are notably porous. This creates cleaning challenges, particularly in shallow transition areas where the treated water is not continuously flushing the surface.

2. Circulation Patterns

Poor consideration of circulation patterns throughout the facility can greatly increase cleaning demand. While European aquatic facilities actively discourage pool concourse access by anyone other than active patrons, New Zealand facilities generally allow concourse access for both swimmers and the general public at the same time. Careful planning can minimise cross circulation of wet and dry foot traffic. For example, bleacher seating located remote from the main entrance and from toilet facilities may greatly increase cleaning demand as a result of this cross circulation. Likewise a clear separation between those toilet and change facilities provided for swimmers and those provided for the general public will decrease cleaning demand.

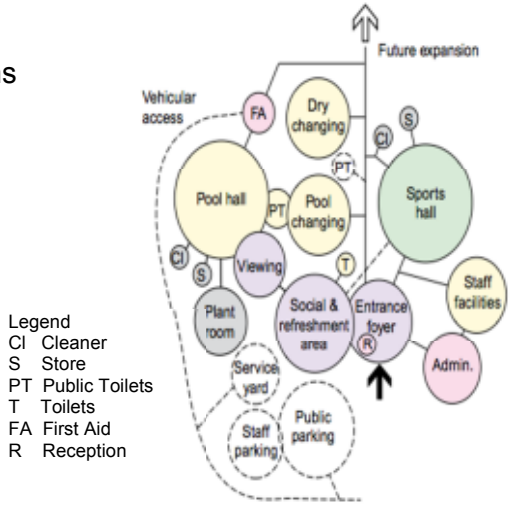


Figure 2. Clearly defined circulation and separation of wet and dry foot activities can increase surface performance

3. Drainage

A number of facilities visited had inadequate pool concourse and change room drainage, with areas of ponding clearly visible. Apart from causing unsightly staining of the floor surface, inadequate drainage increases the likelihood of slips and falls and provides the opportunity for bacteria and mould to thrive in the damp humid conditions unless a regular maintenance and replacement cycle is undertaken. Inadequate drainage affects the durability of surrounding surfaces.

Figure 3 Inadequate drainage greatly increases cleaning demand and slip potential

A common sight in the pools visited was the use of rubber safety matting. In many cases the matting was providing a safer surface for walking than the original flooring surface, however matting creates cleaning challenges and increases the health and safety risks for staff having to move or lift the mats to facilitate cleaning.

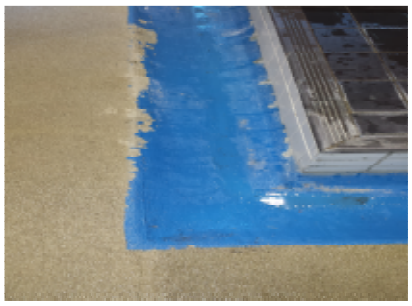


Figure 4 Open channels, even when clearly marked, create tripping hazards

Drainage falls which confine wet areas to be adjacent to the pool where most water is expected, allows a 'dry foot zone' away from concourse surface water. This helps prevent contaminants from footwear being tracked through the facility. When organising floor gradients, consideration of the flooring product being used is important. Products such as tiles allow drainage in the grouted joints but are harder to form valleys and ridges without cutting tiles, whereas products such as resin coatings may demand a slightly steeper fall to encourage drainage. It is critical that finished floor gradients are correctly specified, and that there is a quality assurance process in place for supervision of the contractor to achieve the stated gradients. Uniform cross fall gradients are encouraged as these provide a predictable surface for patrons, and in particular partially sighted users. Open drains and channels create tripping hazards, and should be avoided in favour of grated channels.

4. Product Selection

The selection of a suitable aquatic surface material can be fraught with difficulty. The increasing variety of aquatic experience available demands that different products are used in different situations, and as yet there is no magic surface available able to satisfy all criteria. The surface used for a 2 metre deep pool floor is unlikely to be suitable for a beach entrance shallow water pool.

- As explored in section 2, there are a number of methods of determining and rating slip resistance, few of which have direct applicability to the aquatic environment.
- Aquatic environments are particularly demanding and manufacturers slip resistance ratings should be viewed with caution. ***Proven in-use history of the product in aquatic environments is critical.***
- Products need to be fit for purpose within the pool environment. This means they need to be able to withstand the upper ranges of pool water chemistry included within NZS 5826 Pool Water Quality (ie calcium hardness 100-300 gm/m3, Alkalinity 100-150 gm/m3, FAC 10 gm/m3).

- It is important to keep in mind that data provided by flooring manufacturers is based on the testing of new (ex-factory) products and that the performance of the floor can be critically affected during the installation process (i.e. grouting and initial cleaning) and after short periods of use.
- Finding the right balance between a flooring product that has adequate slip resistance but is still able to be successfully cleaned is difficult to achieve. Simply increasing slip resistance is likely to introduce cleaning challenges, which in the long term may negatively affect slip resistance and produce an unsightly and unhygienic flooring surface. Rougher, more slip resistant surfaces can cause serious abrasion if falls do occur.
- The selection of flooring colour is important. Too light and the product is likely to easily show dirt and require excessive cleaning to maintain. Too dark and the product may show body fat, chloride stains and other contaminants.
- Different manufacturing methods produce different results in terms of product accuracy, colour and fitness for purpose. This is particularly true for tiled surfaces, and understanding which products work best is important.
- How the products accommodate normal building movement needs to be considered. It was interesting to note resin flooring in one facility having no movement control joints at all. As such, subsequent cracking of the concrete substrate was directly transferred to the flooring surface. Sealant selection for movement control joints needs to consider the chemical resistance (pool and cleaning chemicals), mould resistance, is soft enough to accomodate expected movement while at the same time hard enough to resist mechanical damage from cleaning actions and normal use.
- The compatibility of adjacent products needs to be carefully reviewed. This is particularly important for tiling adhesives, grouts and sealants.
- With regards to tiled flooring surfaces, different tile types and surface finishes are available and are applicable to very specific areas of the pool. For example, grit finish tiles may not be appropriate for a pool concourse due to cleaning difficulties, but are perfectly suited for use in lane pool ends to facilitate tumble turning.
- Consideration needs to be given to how the product is treated at floor/wall junctions and at junctions with adjacent materials. Differential movement at these junctions needs to be accommodated. Aesthetic considerations, i.e. matching skirting tile modules with floor tiles, or how resin floor coves are detailed is important.

Figure 5. Allowance for movement and correct sealant selection is critical. Note damage to exposed tile edges also

Figure 6. Cracking in a resin surface as a result of no movement control joints

Figure 7. Excessive movement causing cracking immediately adjacent to a movement control joint

Once a product has been selected, ***the construction documentation prepared by the consultant team needs to clearly define product quality expectations and how these will be achieved and monitored.*** This might include requesting such things as methodology statements, sample installations of the chosen product and the defining of QA processes.

D. CONSTRUCTION FACTORS

The high wear nature of aquatic facilities demands that chosen products are installed with great care. The reality is that constrained budgets, contractor inexperience and compressed construction programmes mean that installation quality may be compromised. Aquatic surfaces are often installed late in the construction process when the pressure to complete the project is on.

1. Contractor Experience

Reputable contractors who are familiar and experienced with the challenges posed by aquatic environments are key to successful outcomes. The benefit of having such contractors on board the construction team cannot be overstated, and is important that once such contractors are on the construction team their work is not subcontracted out to less experienced parties.

This is particularly true of tiling in and around the pool tank, where a number of factors need careful consideration-

Figure 8 Sharp tile ends should b avoided within pool tanks

- Pool users have skin softened by submersion in water and are therefore more susceptible to cuts from sharp tile edges. Care needs to be taken to ensure that tile edges are ground and kicked edges are minimised. Sharp tile ends need to be avoided.
- Substrate preparation is critical to the success of all aquatic surfaces, and particularly so with tiling. The removal of contaminants such as formwork release oils from the concrete and preparation by grinding and/or blasting of the concrete are important to obtain a good key for tile adhesives.
- Tile set out and coordination with movement joints is critical to minimise cut tile joints.
- The correct application of adhesive to ensure the tiles are fully bedded without voids behind, (which can create stagnant pockets of water behind the tile and increase the potential for tiles to pop when the pool is emptied).
- Tight tolerances are required, particularly along rollout channel edges to ensure skimming action and where FINA compliance for pool lane length is required.

2. Construction Programme

The construction programme needs to provide sufficient allowance for long lead-time supply items such as tiles. Aquatic flooring surfaces are most often installed towards the end of the construction programme, when the pressure to complete is greatest and there are a number of contractors on site all trying to complete their own work. Not only is the potential for contamination of the flooring surface high (dust, filings), but shortcuts may be taken in substrate preparation. Curing times for elements such as sealants and adhesives are critical but can be compromised. It is critical that the

finished surface is protected by the contractor to prevent damage by construction activity until practical completion is achieved.

3. Construction Observation

Some of the issues noted during facility visits were clearly the result of poor installation practices and poor preparation of the immediate substrate. The use of experienced contractors as noted above will minimise these risks, however the consultant team and the main contractor have an equally important role during the construction phase. These parties need to be actively involved in establishing and observing construction processes to minimise the risk of failure. It is vital that quality assurance procedures and requirements set up in the construction documentation are instigated by the contractor and actively monitored by the consultant team. ***Observation and involvement by the consultant team during the construction phase is a critical component in achieving a successful outcome.***

E. PRODUCT IN-USE CONSIDERATIONS

The survey work undertaken to inform these guidelines identifies the key pool concourse operational issues experienced within New Zealand aquatic facilities. Of primary importance to facility operators were the slip resistance of the flooring surface and the ability to keep it clean.

1. Product Maintenance

Inappropriate maintenance adversely affects surface performance and durability. Surfaces need to be maintained in accordance with the manufacturer's recommendations in order to maintain their warranty and on-going surface performance.

Robust specification documentation should require that maintenance and cleaning instructions are included within operating manuals required from the contractor at practical completion, and handover requirements should include the need for staff training in the required cleaning methods. The design team needs to ensure that this information is passed on from the contractor to the facility operator.

Further compounding the issue of product maintenance is the high proportion of casual staff working within aquatic facilities. The high staff turnover means that there is little retention of knowledge, making the operational manuals noted above all the more important.

2. Cleaning

The research undertaken indicates that most facilities had procedures in place for regular day to day cleaning. Typically this involved daily hosing down of the surface and periodic deeper cleaning using chemicals and/or mechanical means. It is important that facility operating budgets have sufficient money to provide for the necessary upkeep of the surface, both short and long term.

3. Contamination

Aquatic surfaces are contaminated by body oils, food, foot fungi, dirt and bacteria caused from shoes, blood, vomit and urine. As noted earlier, consideration of circulation routes through aquatic facilities is not often given the attention it deserves, and the effective separation of wet (pool users) and dry foot (spectators, non-pool users) traffic can reduce cleaning demand. This is an operational issue as much as it is a design issue, requiring clear directional signage and operational procedures to deal with the differing modes of activity within the facility (i.e. competition use v recreational use).

4. Surface Damage

Surfaces may be damaged by impact (underwater hockey pucks, water polo goals, and metal fire hose nozzles), ultraviolet light, regular wear (table legs, circulation, cleaning machines) and chemical action (pool and cleaning chemicals).

Figure 9. Thoughtfully placed edge protection to exposed corners limits surface damage

Impact damage can be mitigated by thoughtfully placed edge protection, but is equally an operational issue in the control and tolerance for activities within the pool likely to cause damage. The use of plastic hose nozzles in lieu of brass fittings reduces damage to surface finishes.

Facility staff need to be aware that pool chemicals may have a detrimental effect on movement sealants, grouts, resin and concrete surfaces. A minimum calcium hardness of 100 gm/m3 should be adopted by pool operators in order to reduce longer term failure of these products.

KEY POINTS FROM THIS SECTION

- The variety of aquatic experience and the range in physical ability of pool patrons and staff requires products be selected for specific circumstances- there is no risk free 'perfect' aquatic surface suitable for all applications. All products contain some degree of risk.
- There are many reasons for inadequate surface performance. It can be the result of decisions or actions taken at any stage throughout the briefing, design + documentation and construction process. Equally it can be the result of unintended product use or inadequate maintenance.
- The key to minimising the risk of inadequate surface performance is the use of products with an established in-use history, and utilising the considerable knowledge of experienced clients, facility operators, contractors and consultants. It is recommended that a central database of aquatic facilities be set up which includes specifics about surface type, cleaning methods and maintenance costs used in New Zealand facilities in order that this knowledge is shared.

Section 2 Legislative and Regulatory Requirements

This section provides an overview of the various legislative and regulatory requirements applicable to aquatic flooring surfaces. Non Mandatory guidelines are also explored.

MANDATORY REQUIREMENTS-NZ BUILDING REGULATIONS

Building regulations in New Zealand are made under and in accordance with the Building Act 2004. The Building Code is a performance-based code and sets out the standards that all new building work must meet. The Building Code includes acceptable solutions that provide a method of establishing compliance with the Building Act. The code also allows alternative solutions to be offered, provided that these can be shown to comply with the objectives and functional requirements of the Code.

Of relevance to aquatic surfaces are the following sections of the Building Code-

- **NZBC C1-C6 Fire Requirements** The New Zealand Building Code clauses C1 to C6 may impact aquatic surface finish options, as requirements for egress may dictate materials to have a maximum flammability index. This is unlikely to affect finishes such as tiles, but may limit selections such as vinyl, rubber and resin compounds which can burn at high temperature and produce toxic smoke. It is recommended that surface finish options be discussed and agreed with the Territorial Authority and a fire engineer early in the design process.
- **NZBC D1 Access Routes**. The objective of D1 Access Routes is to safeguard people from injury during movement within, into and out of buildings as well as ensuring that people with disabilities are able to enter and carry out normal activities and functions within buildings. ***Slip Resistance*** and ***Accessibility*** are the key elements of NZBC D1 relative to aquatic surfaces.

A. SLIP RESISTANCE

Establishing compliance with the slip resistant performance requirements of NZBC D1/AS1 is not easy when considering aquatic surfaces. Compliance with D1/AS1 can be demonstrated to Territorial Authorities using Verification Method D1/VM1, or by showing that the product meets the requirements of one of the following NZ Standards deemed to be acceptable solutions-

- AS/NZS 3661 part 1 Slip Resistance of Pedestrian Surfaces.
- AS/NZS 3661 part 2 Slip Resistance of Pedestrian Surfaces.
- AS/NZS 4586:2004 Slip Resistance Classification of New Pedestrian Surface Materials
- AS/NZS 4663:2004 Slip Resistance of Existing Pedestrian Surfaces

The following table explores the requirements of these standards and verification methods.

Standard/ Verification Method	Requirement	Comment
Verification Method D1/VM1	Requires testing in accordance with *AS/NZS 3661.1 Slip Resistance of Pedestrian Surfaces* to confirm that the surface ***under expected conditions of use*** have a coefficient of friction no less than 0.4+0.0125S , where S is the slope of the walking surface expressed as a percentage. NZBC D1/AS1 Table 2 gives acceptable wet slip resistance ranges for common surfaces using coefficient of friction format.	AS/NZS 3661.1 has been incorporated within AS/NZS 4586:2004 Slip Resistance Classification of new pedestrian surface materials. Verification Method D1 does not provide a viable method of establishing compliance for aquatic facilities. It references coefficient of friction (COF), which is a dry surface test (refer further comment below). D1/AS1 notes that consideration be given to the slip resistance of surfaces when worn or wet. Building Consent Authorities (BCA's) generally review the slip resistance of specified products only during the building consent process, so there is no ongoing verification of a products slip resistance other than the 'in-use' experience of the particular products.
AS/NZS 3661 part 1 Slip Resistance of Pedestrian Surfaces.	Incorporated within AS/NZS 4586:2004-refer below	
AS/NZS 3661.2:1994 Slip Resistance of Pedestrian Surfaces	Part two of AS/NZS 3661 gives a guide to the reduction of slip hazards. Prior to it being superseded by AS/NZS 4586, AS/NZS 3661.1 specified minimum coefficient values for pedestrian surfaces. Part 2 of AS/NZS 3661 recognises that other factors such as footwear, circumstances of use and contamination affect the slip resistance, and provides guidelines for the selection, installation and improvement of existing surfaces.	Table 1 within AS/NZS 3661 provides methods of improving the slip resistance of existing flooring by methods such as acid etching, sand blasting and grinding. Some of the methods given in table 1 may be applicable to repair of existing aquatic surfaces but should be used with care given the demanding aquatic environment. As with the selection of new surface materials, proven use is the best test of fitness for purpose.
AS/NZS 4586:2004 Slip Resistance Classification of New Pedestrian Surface Materials	NZS/AS 4586 defines the test methods and classification for new pedestrian surface materials. Four methods are defined, as follows- **Wet Pendulum Test Method**- A flooring sample is tested using a pendulum friction tester. The tester measures the friction on the sample and thereby determines a slip resistance rating. Samples are given a rating between V(less slip resistant) to Z (more slip resistant)	The classifications of slip resistance arising from the different tests are all different, and cannot be correlated with each other unless the surface sample has been tested using different test methods. The wet pendulum test method gives the wet dynamic friction between the concourse and a pendulum slider, however the rubber surface used on the pendulum slider does not accurately replicate human skin. The surface on the bottom of the pendulum needs to replicate human skin, and the possibility of using synthetic skin to give a more

AS/NZS 4586:2004 Slip Resistance Classification of New Pedestrian Surface Materials (continued)	**Dry Floor Friction Test** The coefficient of friction of the sample is measured by determining the dynamic friction between the specimen and a slider moving at a constant speed across the sample using a friction floor tester. Gives a classification F (COF greater than or equal to 0.40) or G (COF less than 0.4) **Wet Barefoot Ramp Test** Two test persons are used to determine the angle of inclination at which safe walking can no longer be undertaken. The sample being tested is continuously wetted and test persons move backwards and forwards with an upright posture and bare feet at increasing angles of inclination until they can no longer reach their safe limit of walking. Samples are rated A (inclination angle greater 12 degrees), B (angle greater than 18 degrees) or C (inclination angle greater than 24 degrees) **Oil-Wet Ramp Test** Two test persons wearing standard test shoes move backwards and forwards across the test sample coated with engine lubricating oil with an upright posture at increasing angles of inclination until they can no longer reach their safe limit of walking. Samples are rated between R9 and R13	realistic outcome for pool use should be investigated further. As this is an insitu method of testing, it has the advantage of being able to test both newly installed surfaces and used surfaces. As such, it could be used to establish the on-going performance of the surfaces. Samples from a number of locations need to be taken in order that a representative sample is taken, particularly where the surface type has variance in the surface due to the application method (ie resin flooring) The dry floor friction test is the only test that provides a coefficient of friction that can be related back to building code requirements. The dry floor test is not directly applicable to the wet pool environment. The wet barefoot ramp test appears to be the most relevant test for use on pool surfaces, but even this test has limitations. The test requires a uniform stream of water over the surface of the test sample which again does not accurately replicate the water that might be present on aquatic surfaces, particularly on the pool concourse areas. Furthermore, the test requires the test persons to take steps on the ramp which are half the length of their foot and is therefore not representative of how people move in aquatic facilities. The presence of footwear and engine oil gives conditions unlikely to be replicated within aquatic facilities.
AS/NZS 4663:2004 Slip Resistance of Existing Pedestrian Surfaces	This standard sets out means of testing the slip resistance of existing pedestrian surfaces. It defines the two tests (wet pendulum and dry floor friction test) that can be used to determine the slip performance of existing surfaces.	Tests are the same as defined within AS/NZS 4586. Comments made above regarding the applicability of these tests apply.

In summary, the wet barefoot test is the most relevant of the various methods of establishing slip resistance compliance with NZBC D1/AS1 Access Routes, and even this has limitations when considering the aquatic environment.

A number of publications reference ***HB 197:1999 An Introductory Guide to the Slip Resistance of Pedestrian Surface Materials.*** This handbook provides additional guidelines in the use of AS/NZS 4586. Whereas the superseded standard AS/NZS 3661.1 established the concept of a minimum slip resistance threshold value that is safe, AS/NZS 4586 and HB 197 recognise that the slip potential is a function of footwear, activities, gait, contamination and other factors. It contains the German requirements[1] for the specification of surfaces in wet barefoot areas, and contains specific guidance for swimming pool situations.

HB 197 is a handbook only and its status is secondary to that of the standards referred to in New Zealand Building Code Acceptable Solution D1/AS1. Whether Territorial Authorities will accept it as a means of compliance with NZBC D1 should be discussed early in the project with them, but in the absence of other information applicable to aquatic facilities it is the most relevant guide for both designers and the Territorial Authority in establishing suitable products for use.

TABLE 4

CLASSIFICATION GUIDE FOR PUBLIC WET BAREFOOT AREAS

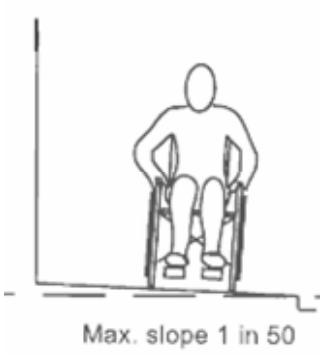
Classification	Minimum angle	Areas of application
A	12°	- barefoot passages (mostly dry)
		- individual and communal changing and locker rooms
		- swimming pool floors in non-swimmer areas, if the water depth in the entire area (of a pool) is more than 80 cm
B	18°	- barefoot passages not classified in group A
		- shower rooms
		- pool surrounds
		- in the vicinity of disinfecting spray facilities
		- swimming pool floors in the non-swimmer areas, where the water depth is less than 80 cm
		- non-swimmer sections of wave-action pools
		- lifting platforms
		- toddler's paddling pools
		- ladders leading into the water
		- stairs leading into the water with a maximum width of 1 m and handrails on both sides
		- ladders and stairs outside the pool area
		- seating and resting steps and benches
C	24°	- stairs leading into the water, if not classified in group B
		- walk-through wading pools
		- sloping pool edges

NOTE: Classifications as per Table 4 in AS/NZS 4586.

[1] *(GUV 26.17, 17 April 1996, Code of Practice for Floor Coverings in Barefoot Areas under Wet Conditions)*

B ACCESSIBILITY

Compliance with NZBC D1 Access Routes can be undertaken by reference to the Acceptable Solution D1/AS1 or by reference to NZS 4121 Design for Access and Use of Buildings and Facilities by Disabled Persons which is deemed an acceptable method of establishing compliance with NZBC D1.

Standard/ Verification Method	Requirement	Comment
D1/AS1 Accessibility Requirements	The key concept within D1 is that public buildings are required to have an ***accessible route.*** An accessible route is defined as a continuous route that can be negotiated unaided by a wheelchair user. The route extends to those spaces within the building required to be accessible to enable people with disabilities to carry out ***normal activities and processes*** within the building	The requirement within aquatic facilities to deal with surface water means that a strictly complying accessible route as defined in NZBC D1/AS1 is difficult to achieve. Special thought needs to be given to drainage design to minimise where possible changing gradients, and detailing at drainage channels needs to acknowledge that open channels create hazards for all pool users and partially sighted patrons in particular.
NZS 4121	NZS4121 requires that footpaths, ramps and landings comply with the requirements given in rule 6.1. Of relevance to aquatic surfaces are requirements (b) and (f) 6.1 (b*) The transverse gradient of crowned or banked footpaths or ramps shall not exceed 1 in 50.*  	Transverse gradients and cross falls pull wheelchairs to one side, and may cause blind or partially sighted people to veer in the direction of the fall. The standard notes that a gradient flatter than the minimum of 1 in 50 is preferred. Pool concourse drainage is typically in the range of a 1: 30 to 1: 60 fall in order to remove water from the surface so may well not strictly comply with this NZS 4121 requirement. It is recommended that early discussion by the design team with the Territorial Authority be undertaken to resolve this. A surface which complies fully with NZS4121 with respect to cross falls but fails to adequately drain is arguably more hazardous than a dryer but slightly steeper cross fall, and given that pool facilities are inherently hazardous areas Territorial Authorities are typically amenable to discussions around this issue.
	(f) The surfaces of footpaths ramps and landings on accessible routes shall be slip resistant with a texture that is usable by all people with disabilities.	This is in line with the general requirements of accessible routes given in NZS 4121 clause 4.6.1, which requires that surface finishes shall be *'stable, firm and slip resistant under all normal environmental conditions'* It references Building Code Acceptable Solution D1/AS1 and AS/NZS 4586. The key requirement given in 6.1 (f) is that it is *…usable by all people with disabilities*'
	NZS 4121 13.4.5.2 requires the use of tactile surfaces or colour strips to signify where the gradient changes	Finding a tactile surface that creates enough of a difference between a studded non slip concourse surface is impractical, particularly when considering a pool concourse that requires many changes in level. Early meetings with the Territorial Authority by the Design Team are recommended in order that a practical approach is taken.

C HEALTH AND SAFETY IN EMPLOYMENT ACT 1992

The HSE Act came into force into 1993 with the primary aim of preventing harm to employees at work by promoting the management of health and safety by employers. Like the building code, it is performance based legislation which sets the standards required of (primarily) employers, rather than any specific details of how to achieve it.

Of relevance to aquatic surfaces, the HSE act requires employers to;

- take all practicable steps to ensure the safety of employees and of other people in the vicinity
- To systematically identify hazards, particularly those which are deemed to be significant and likely to cause serious harm.
- To eliminate, isolate or minimise the effects of significant hazards

Aquatic surfaces represent a significant hazard. Slips are the obvious hazard, but other hazards such as the presence of bacteria in a warm moist environment need to be considered also. It is not possible to eliminate or isolate these hazards, but minimising the hazards posed by aquatic surfaces falls on councils and other organisations that operate aquatic facilities.

NON MANDATORY GUIDELINES

The following non mandatory guidelines contain useful information for clients, designers and pool operators considering aquatic surfaces.

A. NZS 4441:2008 Swimming Pool Design Standard

NZS 4441 provides guidelines for the operational management of pools and for pool design in order that minimum health and safety standards are met. It is used by Territorial Authorities as a model acceptable solution for reviewing and approving pool facility designs, and in the absence of other NZ Standards relating to pool design should be considered mandatory. NZS 4441 contains the following requirements relevant to aquatic flooring-

NZS4441	Requirement	Comment
3.3.2	*The maximum slope of the pool bottom shall be* *a) Where the water depth does not exceed 900mm and the pool bottom has an antislip surface (minimum coefficient of friction measured wet of 0.50)-1 in 12.* *b) Where the water depth does not exceed 1650mm-1 in 15* *c) Where the water depth of water exceeds 1650-no restriction*	Refer above. It is difficult to establish the coefficient of friction for a wet surface using the test methods defined in AS/NZS 4586
Section 5 Pool Surfaces and Surrounds	Section 5 gives guidelines on the typical internal pool surface finishes (wall and floor) such as concrete, paint, plaster, tiles, vinyl and fibreglass.	Guidelines for internal pool finishes are general in nature.
	5.3.1 Separation of pool surrounds from other areas. *To reduce the amount of dirt carried into the pool on bathers' feet and to lower the risk of contamination of the pool water with soil and dust-borne disease organisms all of the following precautions should be considered.* *(a) Spectators should not have access to the immediate pool surround. Areas for spectators should be separated from the pool surround by means or barriers or other devices.* *(b) Bathers should not have direct access to grassed areas* *(c) Lawns should be separated from paved pool surrounds by fences or other barriers.*	As noted in section 1, New Zealand facilities generally allow concourse access for both swimmers and the general public far more than European pools where circulation within aquatic facilities is more tightly controlled. Thoughtfully designed circulation can greatly reduce cleaning demand.
	5.3.3 *'…All pool surrounds, including the tops of pool walls, shall have antislip surfaces. All pool surrounds shall be finished to a minimum fall of 1:50 towards the drains'*	This should be viewed in the context of NZS 4121 requirements given above with regards to concourse drainage falls. Note here that a **minimum** fall of 1:50 is required, whereas NZS4121 requires a **maximum** of 1:50 cross fall

B. Royal Life Saving Society of Australia Facility Design Guidelines

The RLSSAus Guidelines for Safe Pool Operation are voluntary guidelines prepared primarily for Australian facilities, but equally applicable to New Zealand. They are a comprehensive set of guidelines covering all aspects of pool facility operation and design, but have no formal, legal or regulatory status.

Reference is made within the RLSSA guidelines to the HB197 handbook noted above, as the most relevant standard to establishing suitable materials for aquatic facility use.

Relevant guidelines included within the RLSSA Facility Design Guidelines are summarised below.

Clause	**Guideline**
	FD 1 Design of Pool Tank
FD1 4.3.1	Notes that areas where bathers enter the pool or congregate during activities need to be slip resistive and non-abrasive, including steps and ramps, beach entry, pool areas where bathers are able to stand, learners and toddlers pools.
FD1 4.3.2	Refers to the HB 197 An introductory Guide to the Slip Resistance of Pedestrian Surface Materials as a suitable reference for slip resistant characteristics in various pool locations.
FD1 4.7	Gives requirements for wet deck systems, noting that grating should be slip resistant, flush fitting and not allow water to flow onto the pool concourse.
FD2	**Design of Pool Concourse**
FD2 4.2.1	Notes that abrupt changes in floor level in the wet concourse should be avoided, handrails and slip resistive surfaces should be provided, and that ramps on concourses should be limited to 1:14 gradient. *(Note that the NZ building Code allows 1: 12 gradient)*
FD2 4.2.2	Refers to HB 197 as a suitable reference for slip resistant characteristics in various pool locations.
FD2 4.2.3	The concourse should be constructed to facilitate drainage or water flow to prevent the pooling of water.
FD 5	**Design of Pool Access**
4.3.4	Steps should have rise and tread conforming with building regulations and have slip resistive and non-abrasive finishes
4.4.2	Beach entries should be flush with pool concourse or wet deck, and where not flush a contrasting colour band and appropriate signage should be used to warn the public.
4.5	Ramp requirements as given in FD2 are repeated.
FD13	**Interactive Water Play Equipment**
5.4.3	**Zero Depth Splash/Spray Grounds** Soft fall surfacing shall be installed. Surfacing to be finished with an AS/NZ compliant 'solid surfacing compound' rather than a loose fill product. Refers to AS/NZS 4486.1 1997 'Playgrounds and Play equipment'

KEY POINTS FROM THIS SECTION

- It is not easy to use current New Zealand standards to establish compliance of aquatic flooring surfaces with the New Zealand Building Code. This report recommends that further research be undertaken and that New Zealand standards be updated so as to provide specific guidance to designers and Territorial Authorities regarding aquatic surfaces.
- There are four different methods of determining the slip resistance of flooring products defined within AS/NZS 4586. None of the test methods are directly compatible with the conditions experienced in aquatic facilities. The most relevant test method is the use of the Wet Barefoot Test.
- Further development of the Wet Pendulum test method using synthetic skin as a substitute on the pendulum surface may allow this method to be more applicable to aquatic facility conditions. The advantage of the Wet Pendulum methods is that it allows insitu testing of both new and used surfaces and could be used to establish the on-going performance of the product with regards to slip resistance.
- Handbook HB 97 contains wet barefoot rating guidelines from German Standards which directly relate to aquatic facilities.
- Competing requirements within New Zealand Standards, ie regarding gradients to accessible routes and the need for adequate drainage, need to be discussed and agreed early in the design process with the Territorial Authority.

Section 3

Risk Management

Successful outcomes are the product of a shared risk approach between clients, designers, contractors and facility operators. All parties have a part to play, and it is important that clear project processes and awareness of project roles and responsibilities are understood. It is important that the project objectives are clearly defined, shared, understood and ultimately acted upon.

The risk is best placed on those parties able to control the outcome. While the consequences of poor product performance ultimately rest with facility owners and operators, this risk can be mitigated by these parties clearly defining project expectations and outcomes in the design brief. An experienced design team is therefore informed and is best placed in the design and documentation phase to control the risk of poor product performance by diligent investigation, specification and design of the facility. The specification and drawings are key contractual documents prepared by the design team which, where appropriate, transfer the risk to contractors undertaking the installation of aquatic surfaces.

Note that the following risk matrix is adapted from, and expands upon, the matrix included in *'Pool Concourse Guidelines-Design, Construction, Management and Maintenance Considerations'* prepared by Aquatics and Recreation Victoria.

Stage	Action O Principle Responsibility O Secondary Responsibility	Responsibility: Client	Designer	Contractor	Operator	Comment	Importance
Project Inception Feasibility Studies and Preparation of Design Brief	Develop a client team with a proven history and experience in the operation, management and procurement of aquatic facilities	O			O	A lack of knowledge in the client team may set poor expectations for the remainder of the project.	CRITICAL
	Establish a clear quality expectation from project inception	O					CRITICAL
	Develop a design brief which clearly states- -Preferred aquatic surface materials for different locations in the facility with reference to relevant design standards. -How the facility is to be cleaned (external cleaners or staff?) -Space requirements and storage for cleaning equipment identified	O				Poor information directed at the design team increases the likelihood of a poor quality outcome.	CRITICAL
	Clearly establish and document the intended uses of the pool	O				Ongoing lifecycle costs can result from damage to selected finishes from unanticipated use	CRITICAL
	Develop a clear overall budget by using Quantity Surveyors with proven experience in aquatic facilities.	O				Unrealistic budgets put pressure on decision making throughout the project.	CRITICAL
	Involve the pool operator in the preparation of the design brief where possible.	O			O	The pool operator's expectations about the performance and maintenance aquatic surfaces are not met.	HIGH
Design Team Selection	The client team based on the aquatic facility experience should prepare a shortlist of possible consultants.	O				Often the difference in fee value between competing firms is relatively low compared with ongoing life cycle costs associated with poor design decisions made by inexperienced consultants.	CRITICAL
	Contact references and other facility owners and operators regarding the suitability of prospective consultants.	O			O	Inexperienced consultants may be engaged	CRITICAL
	Establish a clear scope of service for the consultant team. Ensure that the scope defines construction-monitoring expectations for inspections of risk items.	O	O			Undefined scope allows consultants to limit fee value to the scope of service noted in the brief. This may put pressure on time and resources later in the project, leading to poorly resolved design and documentation.	HIGH
	Ensure that the consultant team is engaged for the duration of the project.	O				An approach to encouraging fee competitiveness is to engage consultants for early phase concept design/master planning services, then retender services for the remainder of the project. 'Project knowledge' is lost for the sake of relatively small fee difference with this approach, increasing the likelihood of poor outcomes.	HIGH

Stage	Action	Responsibility				Comment	Importance
		Client	Designer	Contractor	Operator		
Early Design Phase	The design team should engage with the pool operators and other stakeholders so that their requirements are clearly understood.	○	●		○	Having a clear understanding of user requirements means that stakeholder concerns can be addressed and responded to.	CRITICAL
	The Design Team should consider the separation of wet and dry foot traffic within the functional planning of the facility. This separation should be demonstrated to the Client Team by way of circulation diagrams.	○	●			Separation of wet and dry foot traffic decreases the potential for contamination and thereby reduces cleaning demand.	HIGH
	The Design Team should present the client with Design Reports at the completion of the various design stages (Concept, Preliminary and Developed Design phases). Design reports should include investigations into flooring options. Minimum information to include- • Indicative costs/m2 • Summary of in-use history • Recommended cleaning requirements • Warranties • Slip resistance • Ease of cleaning • Colour range • Advantages and disadvantage • Typical details. • High-risk areas for flooring surfaces should be clearly identified.	○	●			The production of design reports is an important part of the communication between the client team and the design team. It provides a formal basis for the sharing of important information at the various design stages, and for this information to be updated as the project develops so that there is a shared and recorded understanding of the decisions made. The client team should be asked to 'sign-off' on the design reports prior to proceeding to the next design stage.	CRITICAL
	The intended uses of the facility need to be clearly understood between the Client Team and the Design Team.	●	●		○	Understanding how the facility is to be used is critical to the Design Team, particularly in addressing matters such as edge protection to surfaces for activities such as canoe polo, scuba diving instruction and underwater hockey. The proposed facility uses should be formally agreed within the Design Reports between the client and design teams.	CRITICAL
	The client team should continue to engage with others in the aquatic network regarding suitable products.		●		○	The most reliable test of product performance is its performance 'in use'.	CRITICAL
	The client team and design team should arrange to visit comparable facilities and agree on a 'benchmark' for aquatic surface based on in service use.	●	●		○	A shared understanding of in-use issues allows these issues to be addressed in the design and documentation as the project develops.	CRITICAL
	Project costs should be updated at the completion of each design stage with sufficient contingency included to allow flexibility		●			Regular monitoring of project costs at the completion of design stages allows the client team to regularly assess aquatic flooring costs in relation to overall budget and required performance.	CRITICAL

Stage	Action	Responsibility				Comment	Importance
		Client	Designer	Contractor	Operator		
	The design of floor falls and drainage should be undertaken early in the design process. The design of concourse falls should consider- -Type of drainage outlet (point drainage or channel) -How falls will be formed -Accessibility -Proposed surface material -High risk areas such as beach entry, ramps -Junctions with walls and other adjacent materials -How movement will be accommodated		○			The early design of floor drainage and falls allows critical coordination to be undertaken within the design team. For example, the structural engineer needs to be involved in discussions around how falls will be formed and how building movement will be accommodated. It allows discussions to be undertaken with the Territorial Authority (see below)	HIGH
	The design team should engage with the Territorial Authority, discuss and agree the approaches taken with accessibility and pool access, particularly in regard to competing requirements in building standards regarding accessibility and the need to provide adequate drainage.		○			Territorial Authorities typically take a reasonable approach with regards to competing building standard requirements. It is important that the agreed approach is recorded between the design team and the TA in a formal manner.	CRITICAL
	The design team should review samples of the selected products with the client team. Agree acceptable products and colour range and make sure that maintenance requirements (both short and long term) are clearly understood.	○	○			Cleaning and maintenance will ultimately fall on the client and the operator. Understanding the expected lifespan of the flooring and cleaning regime allows these parties to allow sufficient funding to cover life cycle costs.	CRITICAL
Design Documentation Phase	**PROJECT DRAWINGS**						
	Projects should clearly detail- • Typical installation details • Required drainage falls • Junctions with adjacent materials, finishes and building elements such as coving details, drainage channels and the like. • Construction and movement joint details		○			Poor or incomplete documentation gives little definition to the required outcomes and how these are to be achieved. Poor documentation provides little basis for the Design Team to challenge the contractor on matters of quality or installation procedure. This increases the client's risk and likelihood of a poor outcome.	CRITICAL
	PROJECT SPECIFICATION						
	The product specification is the key contract document describing product requirements and quality expectations. It should clearly define the responsibilities of the contractor with respect to aquatic surfaces. Key requirements of the specification- • Project specific • Clearly identify selected material, colour, thickness, substrate preparation, installation requirements • Nominated installers/suppliers • Required adherence to relevant New Zealand/Australian and international standards and non-mandatory guidelines where applicable		○				CRITICAL

Stage	Action	Responsibility				Comment	Importance
		Client	Designer	Contractor	Operator		
Design Documentation Phase	• Warranty requirements • Clearly identify requirements for information to be provided to the client post construction regarding cleaning and maintenance. • Clearly identify processes and QA procedures required through the construction period. • Identify the defects liability period • Clearly identify procedures and responsibilities associated with remedial work (if required), and who is to be responsible for costs.		O			Note that default periods in NZ building contracts typically call for 3-month defect liability. This is often not long enough to establish whether the performance of the surface is 'fit for purpose'. Consideration can be given to increasing the defect liability period out to 12 months for the aquatic surfaces.	CRITICAL
	The specification should identify the following processes-						
	• Require statements of experience from subcontractors and installers.		O			Statements of experience are particularly important in identifying whether the proposed contractor has sufficient expertise to undertake the works. The tiling of pool tanks for example takes skill and care.	HIGH
	• Provision of control samples and sample installation areas		O			Control samples are important in defining the expected result. They provide a consistent reference throughout the construction period as to the expected result and are a valuable resource if issues occur during use.	CRITICAL
	• Methodology statement describing the product, preparation of substrate, expected installation programme, confirmation of products (adhesives, grouts, sealants), proposed installation procedures.		O			Methodology statements allow the Design Team an early review of the contractor's attention to detail in respect of the requirements of the specification. Where a specialist contractor has knowledge based on experience (and possibly at variance with the specification), these statements allow information to be shared in the common interest of a positive outcome. Such statements should be requested and reviewed at Tender, and again prior to works starting on site.	CRITICAL
	• Identify hold points such as pre-installation meetings during the construction period where critical elements of the installation can be discussed and agreed between all parties		O			Hold points allow the Design Team to review installation at critical times, (i.e. prior to installation, following substrate preparation for example) to ensure that the requirements of the specification are being met.	CRITICAL

Stage	Action	Responsibility				Comment	Importance
		Client	Designer	Contractor	Operator		
Design Documentation Phase	Require warranty and maintenance instructions be provided to the client and pool operator as part of the facility operating and maintenance manuals. The specification may include the requirement for the contractor to provide a demonstration in the correct cleaning method to the client		O			This documentation is vital to the ongoing use and operation of the surface.	CRITICAL
	The specification should clearly state whether alternative products can be offered by the Tenderer/Contractor. If so, the specification should be clear on how alternatives will be assessed and the information required form the Tender/Contractor		O			The use of alternative products can increase the risk to the client. Often these are offered for cost reasons and not for any performance benefit to the client. Assessment of alternatives should be undertaken with great care. Assessment of alternatives is often required over a comparatively short period of time during tender review, and therefore does not get equal consideration to the earlier assessments and information prepared by the Design Team.	CRITICAL
	The specification should clearly identify expectations around final cleaning prior at handover.		O			Surface performance is likely to be compromised if construction residue and waste is not thoroughly cleaned from the surface prior to handover.	CRITICAL
	The specification should clearly identify known long lead-time supply items and require that these be identified in the contractors programme. A preliminary programme should be requested from the contractor at tender, and then regularly updated during the construction phase.		O			The supply of items such as tiles are often on long lead times. It is important that the Contractor understands this and makes sufficient allowance in the programme for procurement. Rushed construction, particularly with tile installation, greatly increases the likelihood of failure.	HIGH
	The specification should clearly identify contract requirements for spares. Requirements for spares need to be discussed between the Client and Design Teams.		O			Products such as tiles are produced in batches. Having matching spare tiles is important for future maintenance, particularly if a brand/type of tile is to be discontinued.	HIGH
	The contract used should be specific about responsibility for liability resulting from non-performance.		O			Costs associated with remedial work can be significant, particularly when pool closure costs are required to undertake it. For example, the need to drain the pool to reinstate tiles may require a significant closure period to suit adhesive and silicone curing times and the need to reheat/treat pool water.	CRITICAL

Stage	Action	Responsibility				Comment	Importance
		Client	Designer	Contractor	Operator		
	A final estimate of cost should be prepared by the Quantity Surveyor.		○			A final estimate of cost allows a basis for the analysis of tender results, and provides the client with an updated assessment of cost.	CRITICAL
Contractor Selection	Contract selection should be on the basis of a prequalification process. Submissions from prospective contractors need to demonstrate experience in aquatic environments, as well as key personnel, QA procedures.		○	○		As with Consultant selection, Contractors engaged on the basis of price alone without proven experience in aquatic facilities increases the likelihood of a substandard outcome.	HIGH
	Tender documentation should request tenderers identify key subcontractors and suppliers proposed for aquatic surfaces, and to establish their installation experience in aquatic environments		○	○		Tender documentation should require references and referees from previous aquatic facility projects.	HIGH
	Documentation requested from the Tenderer (refer above) should be reviewed thoroughly by the Design Team. This documentation to include- -Tender programme (incl identification of long lead time supply items) -Methodology statements Capability statements form the contractor/subcontractors involved in aquatic surface installation. -Assessment of alternative products (if permitted)	○	○	○		The review of this documentation at tender stage sets an example for monitoring processes later in the construction phase.	CRITICAL
Construction Phase	The Design Team should monitor the contractor's programme at regular site meetings, and ensure that it allows for long lead-time items and sufficient float to ensure quality result.		○	○		Rushed construction programmes are likely to compromise the end result.	HIGH
	The Design Team should review control samples jointly with the Contractor and the Client and agree on acceptance.	○	○	○		Control samples allow the accepted standard of installation to be enforced.	CRITICAL
	The Design Team should engage in the pre-installation meetings with the Contractor and relevant subcontractors, and conduct inspections during installation at critical points to ensure that the requirements of the documentation are being met.		○	○			CRITICAL
	The Contractor should be responsible for overseeing the works to ensure that they are being constructed to the standard required of the documentation.		○	○		It is important that the Contractor understands their role as being responsible for QA procedures and achieving the requirements of the specification, and for monitoring subcontractor performance.	CRITICAL
	The Contractor is responsible for the protection of aquatic surfaces from installation through to practical completion			○		Standard NZ Building contracts require the contractor to adequately protect the work during the construction phase.	CRITICAL

Stage	Action	Responsibility				Comment	Importance
		Client	Designer	Contractor	Operator		
Construction Phase	The Contractor should undertake a thorough clean prior to handover.			O		Inadequate cleaning may compromise surface performance. Localised cleaning of the substrate immediately prior to product installation minimizes the likelihood of product failure.	CRITICAL
	The designer and the contractor should inspect the works on completion and agree critical remedial work prior to practical completion.		O	O			CRITICAL
	The designer should ensure that the contractor provides the spares required of the selected surface product prior to handover.		O	O			CRITICAL
	The designer should ensure that completion documentation (cleaning and maintenance manuals of the product, product warranties etc) is provided by the contractor prior to completion, reviewed and passed on to the client prior to facility operation	O	O	O	O		CRITICAL
Product in Use	The design team should ensure that the contractor meets the contractual obligations regarding the defects liability period.		O	O			CRITICAL
	The client needs to ensure that there is sufficient time and operational budget to undertake the maintenance and cleaning requirements.	O			O		CRITICAL
	Regular maintenance closures (every 3-5 years) should be instigated to maintain surface performance.	O		O	O	Regular maintenance closure may require repair and/or replacement of the surface.	HIGH
	The client and pool operator should monitor the use of the facility and ensure that it is in accordance with uses agreed, and that cleaning and maintenance is in accordance with manufacturer's instructions.	O			O	Unintended use can cause damage and greatly compromise surface performance.	CRITICAL

KEY POINTS FROM THIS SECTION

- Successful outcomes are the product of a shared risk approach between clients, designers, contractors and facility operators. All parties have a part to play, and it is important that clear project processes and awareness of project roles and responsibilities is understood.

Section 4

Guide to Aquatic Surface Products

This section provides a database on available aquatic surface types. It is intended to provide a reference point for designers, clients and pool operators when considering the type of aquatic surface to be used.

It is by necessity general and summarises the commonly used surfaces without reference to particular product lines or manufacturers. Those parties selecting and specifying aquatic surfaces will need to satisfy themselves regarding the suitability of products to project specific applications.

The following matrix provides a quick reference for product selection.

Legend

✔ Product technically suitable, subject to notes and clarifications given below and within detailed product descriptions on the following pages

✔ Product technically suitable, cost may prohibit use in given application

✖ Product not recommended

	Resin Flooring	Studded tile	Structured tile	Glazed tile	Grip tile	Ribbed pool tile	Monolithic Concrete	Painted Concrete smooth	Painted concrete grip	Studded rubber tile	Gran. Polymer	Rubber sheet	Gran. Rubber	PVC Membrane	Vinyl Sheet
Indoor pool concourse	✔	✔	✖	✖	✖	✖	✔	✖	✖	✖	✔ (1)	✖	✔ (1)	✖	✖
Outdoor pool concourse	✔	✔	✖	✖	✖	✖	✔	✖	✖	✖	✔ (1)	✖	✔ (1)	✖	✖
Change rooms	✔	✔	✖	✖	✔ (7)	✖	✔	✖	✖	✔	✖	✖	✖	✖	✔
Pool access ramps	✖	✖	✖	✖	✔ (6)	✔	✖	✖	✔ (2)	✖	✖	✖	✖	✔ (3)	✖
Pool stairs	✖	✖	✖	✖	✔ (6)	✔	✖	✖	✔ (2)	✖	✖	✖	✖	✔ (3)	✖
Pool Floors <1400 deep	✖	✖	✖	✖	✔	✖	✖	✖	✔	✖	✖	✖	✖	✔ (3)	✖
Pool Floors >1400 deep	✖	✖	✖	✔	✔	✖	✖	✔	✔	✖	✖	✖	✖	✔	✖
Pool walls	✖	✖	✖	✔	✔ (4)	✖	✖	✔	✔ (4)	✖	✖	✖	✖	✔	✖
Shallow water leisure pools <500mm deep	✖	✖	✖	✖	✔ (5) (6)	✔ (5)	✖	✖	✔	✖	✔	✖	✔ (1)	✔	✖
Beach entrances	✖	✖	✖	✖	✔ (6)	✔	✖	✖	✔ (2)	✖	✔	✔ (1)	✔ (1)	✔	✖
Splash pads	✖	✖	✖	✖	✔ (5)	✔ (5)	✔ (5)	✖	✔ (5)	✖	✔	✔ (1)	✔ (1)	✔	✖

Notes/Clarifications

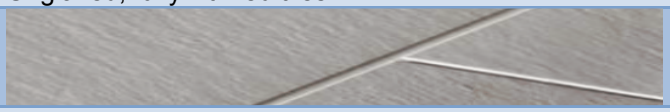
1. Non-porous products are recommended for pool concourse applications for maintenance reasons. Porous products such as those noted have been used, but special consideration needs to be given to the cleaning regimes, methodology and operational cost associated with keeping porous products hygienic.
2. Where used as part of a painted pool tank system. Care is needed to achieve suitable slip resistant finish.
3. Non-slip membrane finish required, and requires the product to be 'double-stuck'
4. Non-slip or grip finish required to lane pool tumble turn ends.
5. Products can and have been used in this application, however soft fall surfaces preferred.
6. Grip tiles are regularly used in this application; however ribbed tiles generally provide better slip resistance.
7. Grip tiles can be used in out of water flooring applications subject to having an appropriate rating, but can be difficult to keep clean.

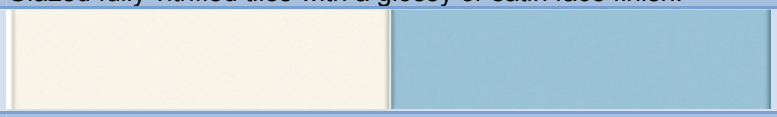
Follows are data sheets for the generic product types.

Surface Material	**Resin Flooring**
Material Description	Methylinethacrylate resin flooring system over concrete substrate
Photo	
Suggested Applications	Aquatic facility concourses and change rooms, including out of water ramps. Resin flooring has been used within shallow pool areas but can discolour in this application. Suitable for both indoor and outdoor applications, but more typically used for indoor facilities due to cost and larger concourse areas associated with outdoor facilities.
Popularity	Used in approximately 25% of aquatic facilities surveyed, primarily on the pool concourse. Little use within 'in-pool' situations
Slip Resistance	High slip resistance R12 rated (Oil Wet Ramp Test) Uniformity of slip resistance can be affected by installation method.
Appearance	Uniform appearance, with a wide range of colours and available
Indicative Cost	High
Warranty	Typical 3-5 years material warranty, 1-3 years execution.
Durability	High chemical, impact and ultraviolet resistance
Cleaning	From survey results, cleaning within aquatic centres tends to involve daily wash down with water, regular deep clean with water-blaster with patio scrubber attachment. Manufacturers suggest the use of a neutral or mildly alkaline detergent to aid in stubborn dirt removal. A water blaster with patio cleaning head was recently used to deep clean a section of resin flooring at the Wellington Regional Aquatic Surface. The floor was restored to an almost as new appearance after 5 years use. This contrasts with the experience of Jellie Park, where the use of a water blaster damaged a resin floor.
Ease of Maintenance Replacement	Relatively easy to replace and seamlessly 'cut in' larger sections of flooring.
Advantages	• The number of resin coats applied over the grit layer determines the finished slip resistance. Care needs to be taken in the specification of the product to ensure that the required slip resistance is achieved. • Compatible resin screeds can be used to create additional falls to drain outlets within existing facilities. • Programme advantages compared with tiled concourse installation • Different colours can be used to decorative affect • Colour fade noticed where the product is used immediately adjacent to or submerged in chlorinated pool water. • Able to be coved up the walls and run into drains and channels
Disadvantages	• The product has an unpleasant chemical odour during installation. • Abrasive-can cause serious abrasion if falls do occur. • Care needs to be taken with direct cleaning with a water blaster.
Product Watchpoints	• There are a number of suppliers of resin flooring products. Selecting those that have an established in use history. • The product has a waxy coating when first installed which adversely affects the slip resistance. Needs to be thoroughly cleaned on completion with a mechanical scrubber to remove. • Slightly steeper falls need to be considered with resin flooring in order that standing water overcomes the surface friction.

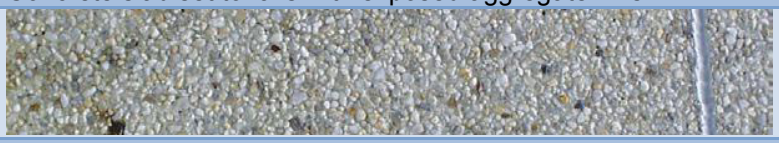
Surface Material	**Studded Tiles**
Material Description	Unglazed, fully vitrified tiles with a studded finish
Photo	
Suggested Applications	Aquatic facility concourses and change rooms, including out of water ramps. Resin flooring has been used within shallow pool areas but can discolour in this application. Suitable for both indoor and outdoor applications, but more typically used for indoor facilities due to cost and larger concourse areas associated with outdoor facilities.
Slip Resistance	R12 (Oil Wet Ramp Test), C (Wet Barefoot Ramp Test) when new
Popularity	The most popular pool concourse flooring, used in approximately 35% of aquatic facilities. Little use in 'in-pool' applications
Appearance	Good appearance when newly installed (subject to workmanship and tile selection)
Cost	High
Warranty	2-5 years materials warranty, 1-3 years execution.
Durability	High chemical and ultraviolet resistance Limited resistance to direct impact.
Cleaning	From survey results, cleaning within aquatic centres tends to involve daily wash down with water, regular periodic deep clean with water-blaster and acidic cleaning detergent.
Ease of Maintenance Replacement	Damaged tiles can relatively easily be removed and replaced
Advantages	• High quality appearance • Tile surface readily cleaned • Allows water to run in tile joints and below tread level. • Typically come with a range of skirting and/or channel tile accessories.
Disadvantages	• Installation of new tiled concourses takes a long time when compared with other flooring options • It can be difficult to form sloped 'valleys' with studded tiles. • Studs can become worn over time with mechanical cleaning methods, leading to a loss of slip resistance • Easily chipped by impact which can create sharp edges. Requires edge protection to critical areas. Sharp edges require urgent attention to prevent hazard to pool patrons. • Long lead times associated with tile supply.
Product Watchpoints	• A high degree of skill is required to install tiles. • Tiles are manufactured using a number of methods, and dimensional accuracy can differ between products depending on whether tile is a pressed or extruded type.

Surface Material	**Ribbed Pool Tiles**
Material Description	Unglazed or glazed, fully vitrified tiles with a ribbed finish
Photo	
Suggested Applications	Pool ramps and stairs. The tops of pool nibs and bulkheads that may be walked on.
Slip Resistance	R12-R13 (Oil Wet Ramp Test), C (Wet Barefoot Ramp Test) when new
Popularity	Used in and around many tiled pool tanks.
Appearance	Good appearance when newly installed (subject to workmanship and tile selection)
Cost	High
Warranty	2-5 years materials warranty, 1-3 years execution.
Durability	High chemical and ultraviolet resistance Limited resistance to direct impact.
Cleaning	Limited cleaning required in for 'in-pool' applications
Ease of Maintenance Replacement	Damaged tiles within the pool are not easily replaced. Tiles out of water relatively easily replaced.
Advantages	• High quality appearance • Available in glazed and unglazed. Unglazed type preferred so that chips and surface damage not easily broadcast. • Typically come with a range of edge types including bullnose and finger grip type for rollout channel edges.
Disadvantages	• Easily chipped by impact which can create sharp edges. Requires edge protection to critical areas. Sharp edges require urgent attention to prevent hazard to pool patrons. • Long lead times associated with tile supply.
Product Watchpoints	• A high degree of skill is required to install tiles. • Tiles are manufactured using a number of methods, and dimensional accuracy can differ between products depending on whether tile is a pressed or extruded type.

Surface Material	**Structured Tiles**
Material Description	Structured tile finish
Description	Unglazed, fully vitrified tiles
Photo	
Suggested Applications	While this tile type has been used for pool concourse areas, it is not recommended for any aquatic facility situation due to the high degree of maintenance required to keep it clean, and when not clean the slip resistance of the product is compromised. As with studded tiles, this product is suitable for both indoor and outdoor applications.
Slip Resistance	R12 (Oil Wet Ramp Test) B (Wet Barefoot Ramp Test) when new.
Popularity	Approx 10% of aquatic facilities use structured tiles on their pool concourse. 5% of aquatic facilities surveyed reported having this tile in shallow areas of the pool (<1200mm deep)
Appearance	Good appearance when newly installed (subject to workmanship and tile selection), and the finished product does not have the 'industrial look' of studded tiles.
Cost	High
Warranty	2-5 years materials warranty, 1-3 years execution.
Durability	High chemical and ultraviolet resistance Limited resistance to direct impact.
Cleaning	Extremely difficult to clean. Requires regular cleaning with mechanical scrubbers and acid based cleaning agents to keep clean. Cleaning with a water blaster with a patio cleaning head achieves moderate success, however this method is labour intensive and tiles rapidly collect dirt.
Ease of Maintenance Replacement	Damaged tiles can relatively easily be removed and replaced
Advantages	• Good quality appearance when new
Disadvantages	• Tiles are extremely difficult to keep clean. High maintenance costs. • Acid based cleaning agents used to keep tiles looking good pose a health and safety risk to pool staff required to use them. • Slip resistance compromised by the difficulty in cleaning • Installation of new tiled concourses takes a long time when compared with other flooring options • Easily chipped by impact which can create sharp edges. Requires edge protection to critical areas. Sharp edges require urgent attention to prevent hazard to pool patrons. • Long lead times associated with tile supply. • In pool tiling required to have a water absorption rate of less than 3%

Surface Material	**Glazed Tiles**
Material Description	Glazed fully vitrified tiles with a glossy or satin face finish.
Photo	
Suggested Applications	Suggested for use on pool walls and on pool floors only where water depth is great enough to inhibit walking/running. Not suggested for lane pool ends where tumble turning is required.
Slip Resistance	Little or no slip resistance.
Popularity	50% of facilities surveyed reported having glazed tiles on pool floors where the water depth is greater than 1200mm deep. 10% of pools surveyed reported use on pool floors where pool depth is less than 1200mm deep. One facility was noted as having glazed tiles installed at a beach entrance situation!
Appearance	Uniform appearance and available in many different colours.
Cost	High
Warranty	2-5 years materials warranty, 1-3 years execution.
Durability	High chemical and ultraviolet resistance Limited resistance to direct impact. Chips to glazed tile surface easily visible. Tile surface etches over time in chlorinated water.
Cleaning	Little cleaning required for in pool applications. Cleaning with the use of mildy acidic cleaners may be required at maintenance closures to strip off accumulated tile face deposits.
Ease of Maintenance Replacement	Damaged tiles within the pool are not easily replaced. Temporary repair can be undertaken using a suitable epoxy putty product. Short term maintenance can be undertaken by replacing whole tiles with new ones installed using scuba equipment and the use of a submergible silicon adhesive.
Advantages	• Relatively easy to keep clean
Disadvantages	• Requires edge protection to critical areas as tiles are easily chipped by direct impact. Sharp edges require urgent attention to prevent hazard to pool patrons. • Long lead times associated with tile supply. • Little or no slip resistance when used in out of pool flooring applications.
Product Watch Points	• In pool tiling requires a great deal of skill • In pool tiling required to have a water absorption rate of less than 3% • Tiles are manufactured using a number of methods, and dimensional accuracy can differ between products depending on whether tile is a pressed or extruded type.

Surface Material	**Glazed Grip Tiles**
Material Description	Glazed fully vitrified tiles with a grip (sandpaper) finish
Photo	
Suggested Applications	Suggested for use on pool floors up to 1400mm deep (glazed tiles can be used where pool depth exceeds this as noted above) Used for pool walls where nonslip finish is required for lane swim tumble turning. Not recommended for pool ramp, concourse or beach entrance applications.
Slip Resistance	R10-R11 (Oil Wet Ramp Test) A-B (Wet Barefoot Ramp Test) when new.
Popularity	No use recorded as a pool concourse material Approximately 25% of facilities surveyed use these tiles for pool floor tiling where pool depth is no greater than 1200mm.
Appearance	Uniform appearance and available in different colours.
Cost	High
Warranty	2-5 years materials warranty, 1-3 years execution.
Durability	High chemical and ultraviolet resistance Limited resistance to direct impact. Chips to glazed tile surface easily visible.
Cleaning	Little cleaning required for in pool applications. Regular maintenance
Ease of Maintenance Replacement	Damaged tiles within the pool are not easily replaced. Temporary repair can be undertaken using a suitable epoxy putty product. Short term maintenance can be undertaken by replacing whole tiles with new ones installed using scuba equipment and the use of a submergible silicon adhesive.
Advantages	• Relatively easy to keep clean
Disadvantages	• Requires edge protection to critical areas as tiles are easily chipped by direct impact. Sharp edges require urgent attention to prevent hazard to pool patrons. • Long lead times associated with tile supply. • Little or no slip resistance where used in the wrong application.
Product Watch Points	• In pool tiling requires a great deal of skill • In pool tiling required to have a water absorption rate of less than 3%

Surface Material	**Monolithic Concrete (Exposed Aggregate Finish)**
Material Description	Concrete slab set to falls with exposed aggregate finish
Photo	
Suggested Applications	Indoor and outdoor pool concourse areas.
Slip Resistance	Medium to high slip resistance. Not possible to define slip resistance unless tested in place.
Popularity	Concrete (both broom finish and exposed aggregate) used as a pool concourse material in approximately 20% of aquatic facilities surveyed.
Appearance	Good appearance with large variation in colour and texture possible. Appearance can be inconsistent, as it is difficult to control the distribution of aggregate (depending on installation method and contractor skill level)
Cost	Medium
Warranty	Not typically provided. Warranties may be available on sealer products.
Durability	Medium to high durability if used with a penetrating sealer applied to concrete surface. If no sealer durability is low to medium.
Cleaning	From survey results, cleaning involves daily wash-down with periodic deeper water blast clean.
Ease of Maintenance Replacement	Difficult to patch in matching areas of concrete if the surface is damaged.
Advantages	• Relatively low cost compared with other surface options
Disadvantages	• Control skill needed to achieve uniform surface finish. • Care needs to be taken to protect finish during construction. Slabs are typically installed early in the construction process-as the slab is the finished product also there is limited ability to 'hide' or repair damage. • Aggregate can become dislodged with aggressive cleaning methods, creating pockets for water and dirt to sit.
Product Watch Points	• Control samples of the exposed aggregate concrete finish are required during construction to control quality. • Sealers affect the colour of the finished product. Ensure early samples prepared include the sealer coat so that the effect on colour is known. • Care needs to be taken in the specification of the aggregate in order to achieve slip resistance without the finished product being too abrasive. • Check to ensure that penetrating sealers and colour tints are compatible. Shrinkage needs to be carefully controlled so as cracking does not occur in the surface finish

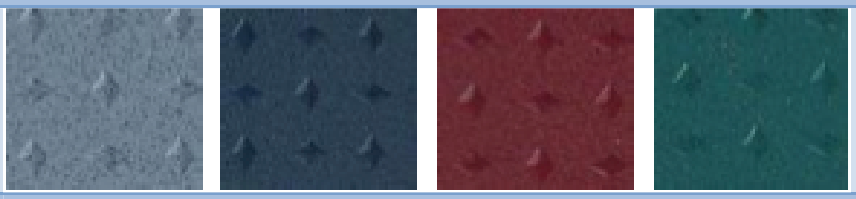
Surface Material	**Monolithic Concrete (Broom/Blasted Surface Finish)**
Material Description	Concrete slab set to falls with either broom or blasted finish to achieve slip resistance
Photo	
Suggested Applications	Indoor and outdoor pool concourse areas.
Slip Resistance	Medium to high slip resistance. Difficult to achieve uniform surface texture and slip resistance, particularly with broom finish. Carborundum can be applied to the concrete surface prior to setting to give better slip resistance. Slip resistance can only been confirmed on completion.
Popularity	Concrete (both broom finish and exposed aggregate) used as a pool concourse material in approximately 20% of aquatic facilities surveyed.
Appearance	Average appearance. Appearance can be inconsistent, as it is difficult to control factors such as the brooming consistency and cure strength of concrete (brooming is undertaken before slab has fully cured)
Cost	Medium
Warranty	Not typically provided. Warranties may be available on sealer products.
Durability	Medium to high durability if used with a penetrating sealer applied to concrete surface. If no sealer durability is low to medium. Surface sealers should be avoided as these tend to reduce slip resistance and can be damaged by cleaning methods.
Cleaning	From survey results, cleaning involves daily wash-down with periodic deeper water blast clean. Poorly finished surfaces can be very difficult to keep clean as contaminants are easily trapped in surface grooves (similar to structured tile finish)
Ease of Maintenance Replacement	Difficult to patch in matching areas of concrete if the surface is damaged.
Advantages	• Relatively low cost compared with other surface options
Disadvantages	• Extremely difficult to clean • Perceived as a lower quality option when compared with applied surface finishes. • Difficult to achieve uniform surface finish. • Care needs to be taken to protect finish during construction. Slabs are typically installed early in the construction process-as the slab is the finished product also there is limited ability to 'hide' or repair damage. • Aggressive cleaning can lead to further inconsistency in the finish.
Product Watch Points	• Sealers affect the colour of the finished product. Ensure early samples prepared include the sealer coat so that the effect on colour is known. Check to ensure that penetrating sealers and colour tints are compatible with chlorinated water. • Shrinkage needs to be carefully controlled so as cracking does not occur in the surface finish

Surface Material	**Painted Concrete (epoxy and chlorinated rubber)**
Material Description	Concrete with an applied paint finish
Photo	
Suggested Applications	Painted pool walls and floors. Grit finish suggested where water depth is less than 1400m deep and for lane pool end walls where tumble turning is required. Not recommended for concourse surfaces
Slip Resistance	Sand can be incorporated between paint coats to provide slip resistance. Slip resistance classification only possible with on-site testing.
Popularity	Painted concrete finishes reported in approximately 40% of aquatic facilities surveyed for use in the pool (includes the use of both smooth and textured paint finishes). One facility surveyed reported the use of painted concrete on the concourse.
Appearance	Good even appearance. Chlorinated rubber products typically available in narrow colour range (2-3 colours). Wider range available with epoxy paint products.
Cost	Low-Medium
Warranty	No warranties offered on materials or execution
Durability	Medium durability when compared with other surface finish options. (3-5 year expected lifespan for chlorinated rubber, 5-10 years for epoxy paint systems)
Cleaning	In pool applications require little day to day cleaning. Cleaning problems experienced with pool concourse applications suggest that painted concrete (specifically epoxy) surfaces should not be used in pool concourse applications.
Ease of Maintenance Replacement	Painted surfaces easily recoated and/or repaired if damaged (but require pool to be drained)
Advantages	• Low cost when compared with tiled pool finishes. • Relatively quick installation. • Different patterns and shapes can be easily included to add interest of for practical reasons (i.e. lane markings)
Disadvantages	• Relatively easily damaged • Shorted lifespan when compared with tiled pool finishes • Painted pool finishes can appear ‘chalky’ after 2-3 years use.
Product Watch Points	• Compatibility with pool sealant systems needs to be carefully established • Care is needed in the preparation of the concrete surface prior to painting. Acid washing, grinding and/or blasting of the concrete surface may be required. Refer to manufacturer’s literature.

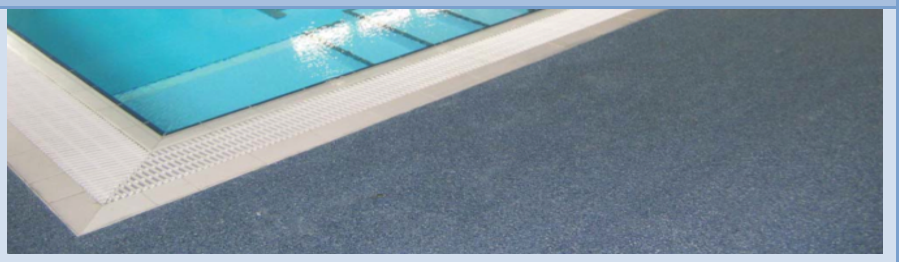
Surface Material	**Studded Rubber Tiles**
Material Description	Rubber tiles with circular studs
Photo	
Suggested Applications	This product should be used with care due to slip resistance not confirming to HB 197 requirements. Not recommended for 'in pool' applications.
Slip Resistance	R9-R10 (Oil Wet Ramp Test). Note that earlier product lines were available with higher studs if ordered in bulk which improved slip resistance. Evidence from Huia Pool experience suggests that slip resistance was satisfactory unless soap or other contaminants were present.
Popularity	No survey respondents recorded using this product. Has been used in the past for pool concourse use (e.g. Huia Pool). Is currently used in the reception areas of H20 Xtream and Massey Park Aquatic Centre.
Appearance	Good appearance with reasonable colour range.
Cost	Medium-High
Warranty	Limited warranty available under strict conditions from the manufacturer
Durability	Good durability. Some colour fading reported from UV and from exposure to chlorinated water. Numerous tile joints provide opportunity for water penetration under the tile. Manufacturer's literature suggests that tile joints can be heat welded.
Cleaning	Generally easy cleaning. Huia Pool required daily hosing with deeper cleaning requiring buffer machine and the use of chlorine. Manufacturer's recommendations involve the use of a low speed mono brush buffer equipped with light abrasive disc and neutral or slightly alkaline detergent.
Ease of Maintenance Replacement	Relatively easy to replace individual tiles if damaged
Advantages	• Relatively easy clean • Flexible product is able to tolerate limited substrate movement without the need to broadcast construction joints. • Relatively soft and non-abrasive compared with other surface options, limiting injury if falls do occur. • Soft surface may have acoustic benefits (reported 10dBa reduction in ambient noise level)
Disadvantages	• Slip resistance low compared with other product options. • Numerous tile joints provide opportunity for joint failure and water penetration under the tile, leading to unhealthy (and smelly) conditions. Water penetration under tile can affect adhesion in the tile, which can cause tile edges to kick up.
Product Watchpoints	• Substrate preparation and environmental conditions need to be carefully controlled during laying.

Surface Material	**Granulated Polymer Flooring**
Material Description	Coloured polymer pebbles held together by polyurethane binder
Photo	
Suggested Applications	Pool concourses, splash pads, beach entrances. Use in pool concourses and out of water areas needs to acknowledge the need for chemical and/or steam cleaning required to clean a porous product.
Slip Resistance	W (Wet Pendulum Test) C (Wet barefoot ramp test) R12 (Oil wet ramp test)
Popularity	Limited in-use history within this country. Used as a pool concourse material at Te Rapa Waterworld.
Appearance	Good appearance with a wide range of colour options. Patterns and logos can be formed with the product.
Cost	High
Warranty	3 year warranty offered on materials and execution
Durability	High chemical, impact and UV resistance. Longer term durability unknown due to limited in use history.
Cleaning	**Pool concourse use**-Cleaning undertaken with daily hosing. Deeper clean undertaken at Waterworld using a water blaster and hypochlorite solution. Manufacturer's recommendations suggest that water blasting (up to 2000psi) may be undertaken with a neutral cleaner, and that a steam vacuum machine is an ideal maintenance method. **In-Pool use-**Limited day to day cleaning required.
Ease of Maintenance Replacement	Easy to seamlessly cut in replacement sections of flooring
Advantages	• Flexible product is able to accommodate substrate movement without the need to broadcast construction joints. This has a downside also, as construction and movement joint sealants are not able to be easily inspected and replaced if necessary. • Good slip resistance with good slip test data is available. • Soft product-limits injury if falls do occur. • Soft product has acoustic advantages. Noise within Te Rapa Waterworld noticeably less reverberant when compared with tiled or resin concourses.
Disadvantages	• Pebbles can become dislodged in the cleaning process, clogging drainage points. • Limited applicators in this country. Experience at Waterworld suggests the skill and care of the applicator is critical to the durability of the final product. • Porous-use out of pool water requires the use of chemical cleaners to maintain hygienic conditions. • Can stain when in contact with rubber products, and rust stains are difficult to remove.

Surface Material	**PVC Membrane**
Material Description	Welded PVC membrane sheet with welded joints over a concrete or proprietary stainless steel panel (wall applications) substrate. Available in smooth and non-slip varieties.
Photo	
Suggested Applications	In pool applications only. Particularly good for splash pads and beach entrances when used with a soft foam underlay.
Slip Resistance	C (Wet barefoot ramp test)
Popularity	Approximately 7% of respondents reported using PVC membranes for in pool applications.
Appearance	Good appearance. Small range of colours available.
Cost	High
Warranty	Standard manufacturers 10 year warranty on materials, with conditions.
Durability	Fades over time with exposure to UV. Easily damaged by deliberate vandalism. Shallow Leisure pools at the Wellington Regional Aquatic Centre are requiring significant replacement after 5 years heavy use.
Cleaning	Limited cleaning required for in pool applications. Transition areas (i.e. at beach entrance points) may require periodic cleaning with cleaning solution recommended by the manufacturer.
Ease of Maintenance Replacement	Old sections of membrane can be cut out and replacement sections relatively easily welded in.
Advantages	• Impervious • The use of the antislip version of the membrane with a foam underlay provides a safe non slip product for beach entrances and shallow leisure pool applications. The foam is fixed to the concrete floor substrate and the membrane welded to this. • Flexible product is able to accommodate substrate movement without the need to broadcast construction joints. This has a downside also, as construction and movement joint sealants are not able to be easily inspected and replaced if necessary.
Disadvantages	• Limited agents and installers within New Zealand • The membranes typically come as part of a system, with prefabricated channel and wall assemblies. • Where the membrane is used for pool water retention, penetrations such floor inlets and water feature points provide the opportunity for leaks at gasket seals. • Standard installation procedure in deeper pools is for the floor to be loose-laid, with the weight of the water holding the membrane in place. This is not recommended for pools less than 1400mm deep where walking on the surface without the buoyancy of the water can cause rippling of the membrane. • Long lead times associated with material delivery • Membrane can be easily damaged by deliberate vandalism
Product Watchpoints	• The membrane is impervious and can be used to provide the waterproof integrity of the pool tank. A decision needs to be made early in the design process whether the membrane is to be the sole method of water retaining, or whether a secondary water retaining structure is required below with the membrane forming a 'pool carpet' only. This affects the fundamental detailing of the product.

Surface Material	**Vinyl Sheeting**
Material Description	2-3mm thick vinyl with a textured surface pattern
	
Suggested Applications	Not suggested for use 'in-pool' or to pool concourses. Could be considered for secondary spaces such as change rooms and reception areas with care.
Slip Resistance	0.70 (COF when dry) 0.60 (CoF when wet)
Popularity	Limited in-use history within NZ, and typically for secondary spaces as noted above.
Appearance	Good-wide range of colours and surface textures.
Cost	Medium
Warranty	Varies-Typically 2-5 years available on materials and 1-3 years on installation.
Durability	Medium to high durability depending on quality selection and installation. Good chemical, impact and UV resistance.
Cleaning	Cleaned by sweeping and/or wet vacuum and mop and bucket with detergent. Deeper clean may require the use of machine scrubbers using synthetic brushes. Refer to manufacturer's instructions.
Ease of Maintenance Replacement	Small tears can be re-welded. Whole sections can be removed and replaced if necessary; however removal of adhesive and preparation of substrate may make this difficult and costly.
Advantages	• Impervious • Can be coved at wall junctions. • Flexible product is able to accommodate substrate movement without the need to broadcast construction joints.
Disadvantages	• Can be easily damaged during construction.

Surface Material	**Applied Rubber**
Material Description	EPDM granules bonded to slab substrate
Suggested Applications	Pool concourses, splash pads, beach entrances. Use in pool concourses and out of water areas needs to acknowledge the need for chemical and/or steam cleaning required to clean a porous product. Both indoor and outdoor applications.
Slip Resistance	Not stated for wet laid granule form, but likely to be similar as for EPDM sheet product, i.e. C (Wet Barefoot Ramp Test) R10 (Oil Wet Ramp Test)
Popularity	Limited use of this product in NZ based on survey information, with one survey respondent recording the use of it in their facility.
Appearance	Good appearance with wide range of colours available.
Cost	Medium-High
Warranty	Typically 3-5 years materials, 1-3 years installation.
Durability	Medium durability. Good UV and chemical resistance
Cleaning	Limited cleaning required for in pool applications. Porosity makes cleaning difficult, particularly in transition areas (i.e. at beach entrance points) where periodic deeper cleaning using chemicals and/or mechanical cleaning methods may be required. Refer to the manufacturer's instructions.
Ease of Maintenance Replacement	Easy to seamlessly 'cut in' replacement sections of flooring
Advantages	• Good noise absorption properties • Reasonable slip resistance and provides a soft fall surface.
Disadvantages	• As with granulated polymer products, the porosity of the product makes it difficult to flush out stale water and control bacteria growth. This makes the product less suitable for indoor applications, where there is a lack of UV light to assist in reducing bacterial growth.

Surface Material	**Rubber Sheet Flooring**
Material Description	EPDM synthetic rubber sheeting
Photo	
Suggested Applications	Pool concourses, splash pads, beach entrances. Use in pool concourses and out of water areas needs to acknowledge the need for chemical and/or steam cleaning required to clean a porous product. Both indoor and outdoor applications.
Slip Resistance	C (Wet Barefoot Ramp Test) R10 (Oil Wet Ramp Test)
Popularity	Limited use of this product in NZ, with one survey respondent recording the use of it in their facility.
Appearance	Good appearance with wide range of colours available.
Cost	Medium-High
Warranty	Typically 3-5 years materials, 1-3 years installation.
Durability	Medium durability. Good UV and chemical resistance
Cleaning	Limited cleaning required for in pool applications. Porosity makes cleaning difficult, particularly in transition areas (i.e. at beach entrance points) where periodic deeper cleaning using chemicals and/or mechanical cleaning methods may be required. Refer to the manufacturer's instructions.
Ease of Maintenance Replacement	Small areas are not easy to repair. Whole sections can be removed and replaced if necessary; however removal of adhesive and preparation of substrate may make this difficult and costly.
Advantages	• Good noise absorption properties • Reasonable slip resistance and provides a soft fall surface.
Disadvantages	• The porosity of the product makes it difficult to flush out stale water and control bacteria growth. This makes the product less suitable for indoor applications, where there is a lack of UV light to assist in reducing bacterial growth. • Experience of use at Waterworld suggests that product is subject to movement which affects sheet joints. Loose edges can create a trip hazard.

Appendix A

References

Australian and New Zealand Standards

AS/NZS 1884	Floor coverings-Resilient sheet and tiles, laying and maintenance practices
HB 197:1999	An Introductory Guide to the Slip Resistance of Pedestrian Surface Materials
AS/NZS 3661.2:1994	Slip Resistance of Pedestrian Surfaces: Guide to the reduction of slip hazards
NZS 4121:2001	Design for Access and Mobility-Buildings and Associated facilities
NZS 4441:2008	Swimming Pool Design Standard
AS/NZS 4586:2004	Slip Resistance classification of new pedestrian surface materials
AS/NZS 4663:2004	Slip Resistance Measurement of existing pedestrian surfaces
NZS 5826:2000	Pool Water Quality

Royal Life Saving Society of Australia Guidelines for Safe Pool Operation

Managing Health and Safety in Swimming Pools, by Sport England and the Health and Safety Commission, 2007

Guidelines for Safe Recreational Environments Vol 2. Swimming Pools and Similar Environments, by the World Health Organisation

Assessing the slip resistance of flooring. Technical information sheet
http://www.hse.gov.uk/pubns/web/slips01.pdf

The ABC of Barefoot Slip Resistance www.metz.net.au

BRANZ Good Tiling Guide

The New Zealand Building Code

New Zealand Aquatic Facility Review, by John McGuinness

British Columbia Guidelines for Swimming Pool Design April; 2011

Code of Practice for the Design, Construction, Operation and Management of Aquatic Facilities, Western Australia May 2007

Pool Concourse Guidelines; Design, Construction, Management, Maintenance Considerations, by Aquatics and Recreation Victoria July 2011

Swimming Pools Design Guidance Note, by Sport England February 2011

Manufacturers Data

Appendix B

Summary of Survey Data

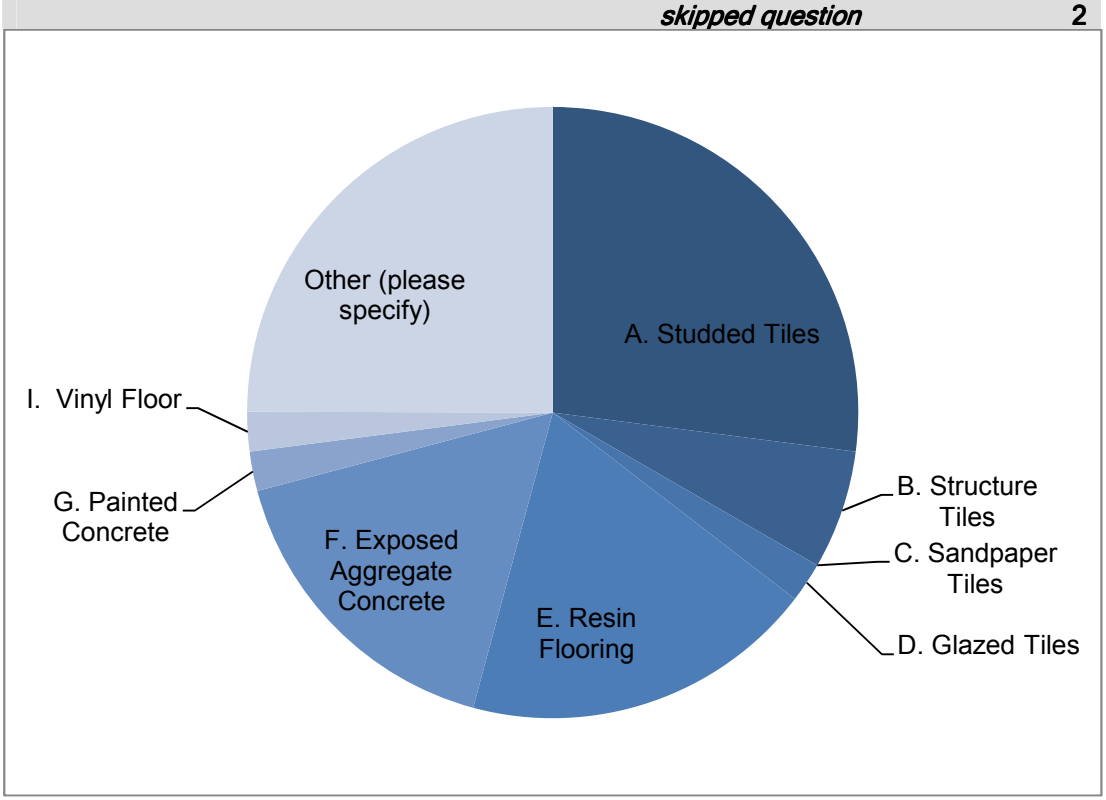
Early in the research process, an online survey was conducted of facility operators. The principle aim of this survey was to identify the most common surfaces used in the industry and the issues associated with them, in order that the report could be targeted towards these.

The survey was issued to 134 likely participants, from which 58 responses were received. The relatively small sample size makes drawing any concrete conclusions difficult. There were a variety of other factors influencing the survey results (for example distinctions between whether the facility was an indoor or outdoor facility, size of facility and patronage), however some general trends were observed in the results.

A brief summary of the survey results follows.

A. Pool Concourse Surface Material

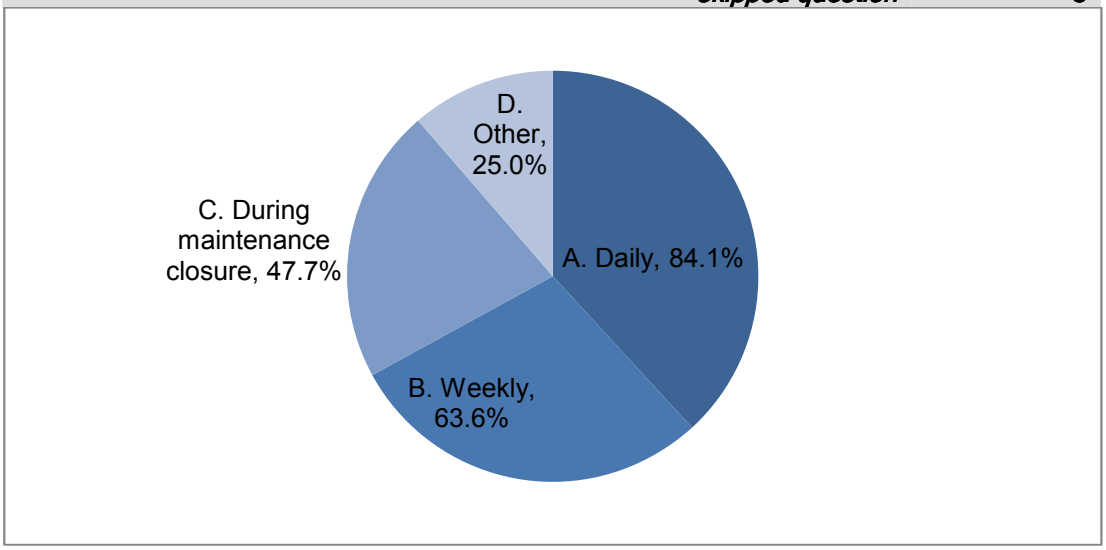
Question 1. What is the pool concourse floor material?		
Answer Options	**Response Percent**	**Response Count**
A. Studded Tiles	27.1%	15
B. Structure Tiles	6.3%	2
C. Sandpaper Tiles	0.0%	0
D. Glazed Tiles	2.1%	2
E. Resin Flooring	18.8%	11
F. Exposed Aggregate Concrete	16.7%	10
G. Painted Concrete	2.1%	1
H. Rubber Floor	0.0%	0
I. Vinyl Floor	2.1%	1
Other (please specify)	25.0%	12
	answered question	**56**
	skipped question	**2**



Comment
The most common surface types recorded were resin floors and studded tiles. Exposed aggregate concrete is common also, however as there was no distinction between indoor and outdoor facilities in the questionnaire it is not possible to understand how these results may have varied if confined to indoor facilities only. Note that one respondent reported glazed tiles on the concourse, and it is unclear whether this is accurate or in error.

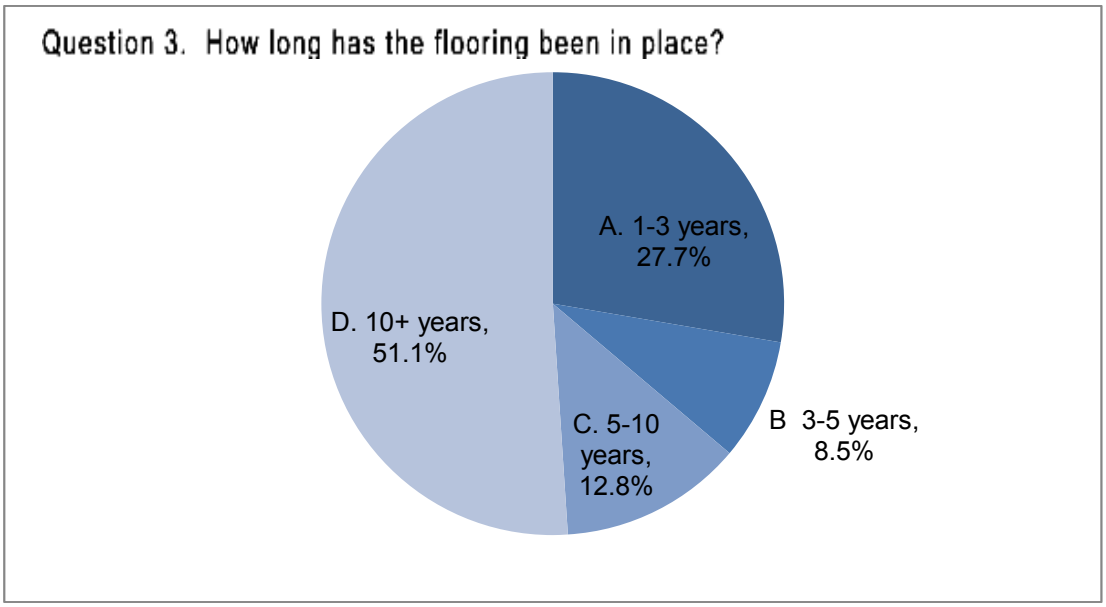
Few respondents who recorded 'other' specified what surface material was used. Those that did recorded cobblestones and concrete pavers.

Question 2. Concourse floor cleaning regime? (Describe method)		
Answer Options	**Response Percent**	**Response Count**
A. Daily	84.1%	39
B. Weekly	63.6%	32
C. During maintenance closure	47.7%	21
D. Other	25.0%	11
	answered question	50
	skipped question	8



Comment
As expected, most facilities have a regular cleaning regime.
Daily cleaning-Where respondents described the method, the most common was a daily hose down or water blast. Of these, only four recorded the use of chemical cleaners also.
Weekly cleaning-Where weekly cleaning was undertaken, respondents reported using deeper cleaning methods such as chemical cleaners/degreasers and the use of mechanical scrubbers. Water blasting was also a popular deeper cleaning method.
Maintenance Closure- Deeper cleaning methods were employed at maintenance closure such as the use of weak sodium hypochlorite solution/acid washing, and the use of mechanical scrubbers. Resurfacing was also reported as being undertaken during maintenance closure in three of the facilities surveyed.

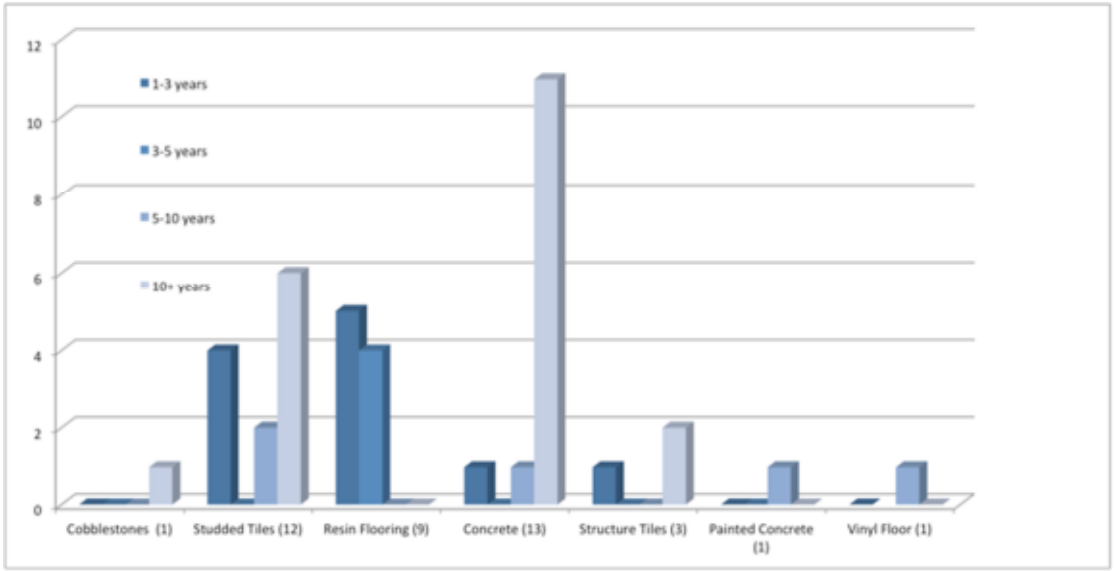
Question 3. How long has the flooring been in place?		
Answer Options	**Response Percent**	**Response Count**
A. 1-3 years	27.7%	16
B 3-5 years	8.5%	5
C. 5-10 years	12.8%	7
D. 10+ years	51.1%	27
	answered question	55
	skipped question	3



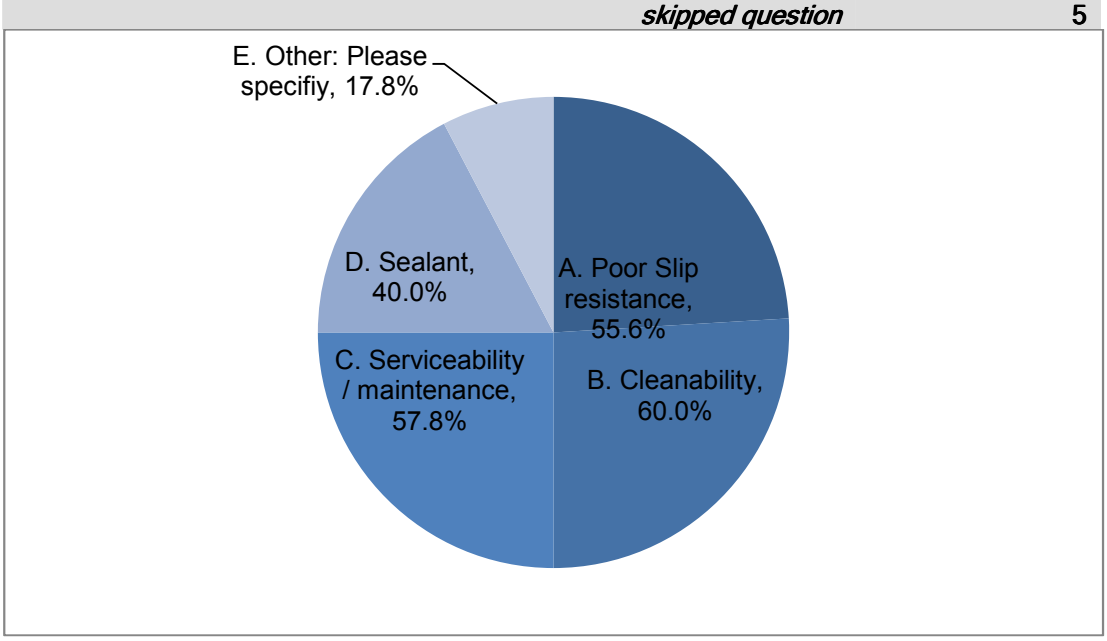
Comment

The table below cross matches data from question 1 (Surface type) with question 3 to get an idea of which surface type is the longest lasting.

Concrete would appear to be the longest lasting surface. As with question 1, there was no distinction in the survey between indoor and outdoor facilities. Studded tiles also rate as one of the more durable surfaces. Resin surfaces do not rate highly when considering the 10+ time period, however as these surfaces have become more popular only in recent years it is expected that there may not be the longer term history of this product to allow a useful comparison with other products.



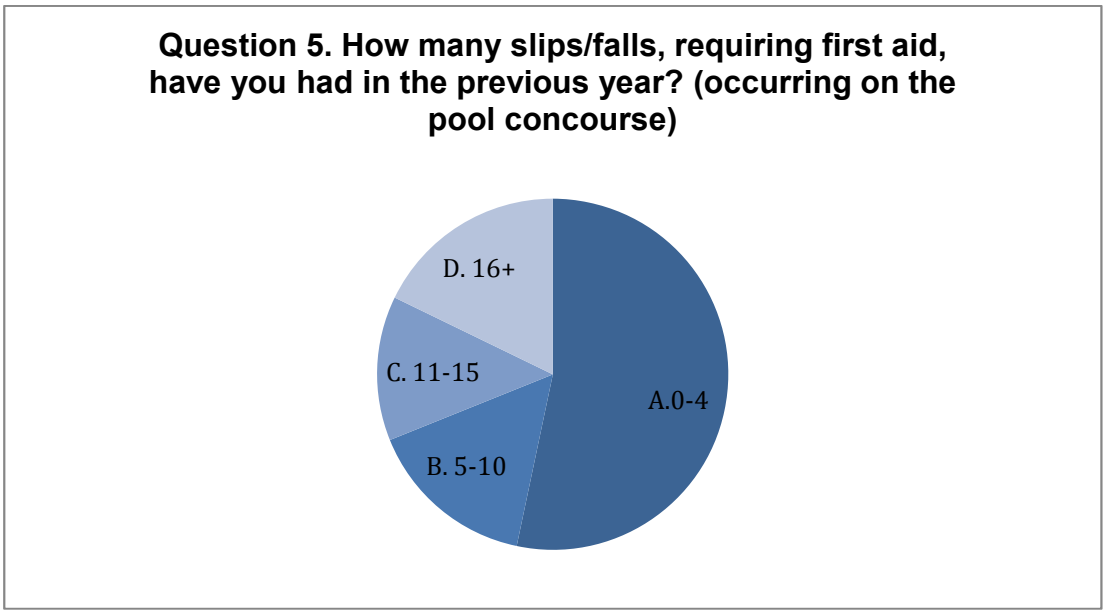
Question 4 Issues associated with the concourse floor? (describe all that apply)		
Answer Options	**Response Percent**	**Response Count**
A. Poor Slip resistance	55.6%	25
B. Cleanability	60.0%	27
C. Serviceability / maintenance	57.8%	26
D. Sealant	40.0%	18
E. Other: Please specify	17.8%	8
	answered question	**45**
	skipped question	**5**



Comment
Results from this question were variable, and for some reasons fewer respondents replied to this question.

Of the 'other', a common issue reported was cracking of the concrete/resin surface (3 respondents). Key considerations for facility operators appear to be the cleanability, slip resistance and serviceability in equal measure.

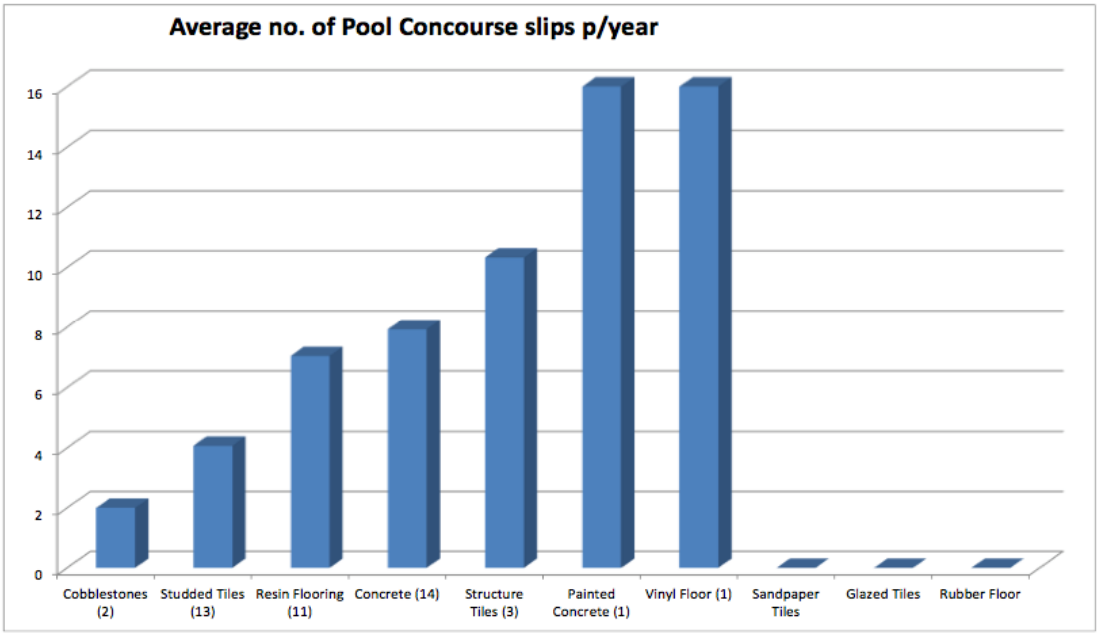
Question 5. How many slips/falls, requiring first aid, have you had in the previous year? (Occurring on the pool concourse)		
Answer Options	**Response Percent**	**Response Count**
A.0-4	53.3%	24
B. 5-10	15.6%	7
C. 11-15	13.3%	6
D. 16+	17.8%	8
	answered question	**45**
	skipped question	**5**



Comment

The table below cross matches data from surface type (question 1) with that of question 5, and considers the average number of slips per year for each surface type.

It is expected that facilities recorded the use of cobblestones are outdoor facilities. Facilities using studded tiles and resin flooring report lower numbers of slips, with painted concrete and vinyl flooring performing worst. As with other survey results, it is difficult to draw concrete conclusions form such a small sample size.



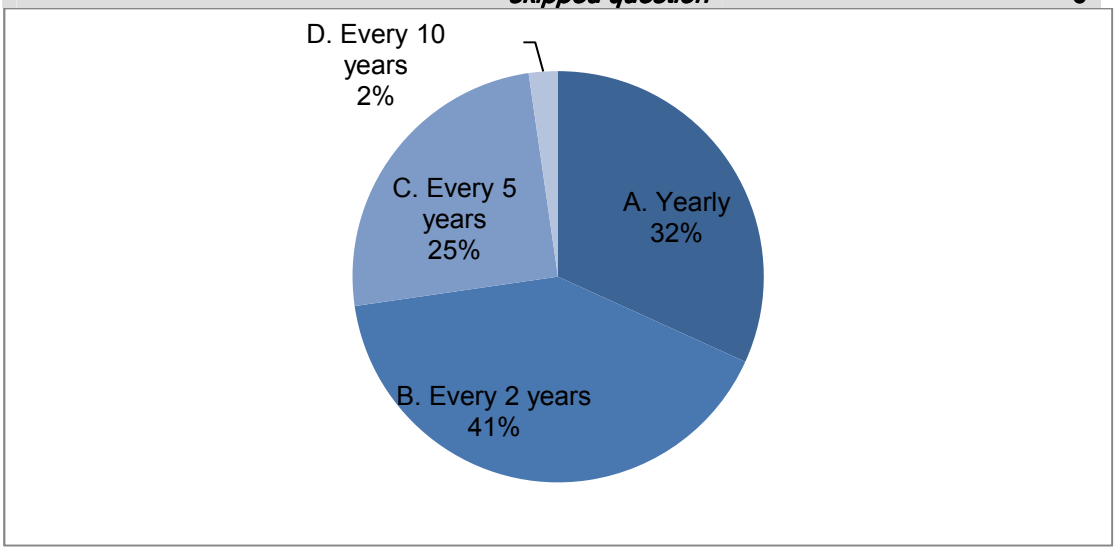
B. Pool Surface Material

Question 1. What is the material of the pool floor?			
Answer Options	**<1200 Pool Depth**	**>1200 Deep Depth**	**Response Count**
A. Studded Tiles	0	0	0
B. Structured Tiles	2	1	3
C. Sandpaper Tiles	8	0	8
D. Glazed Tiles	4	20	24
E. Resin Flooring	0	2	2
F. Painted Concrete-Textured	3	3	6
G. Painted Concrete-Smooth	9	5	14
H. PVC Membrane	2	1	3
Other (please specify)			4
		answered question	**44**
		skipped question	**6**

Comment
Fewer respondants replied to the questions regarding pool surface type, when compred to responses about pool concourse surface. It is not clear why this is the case.

Tiled and painted pool tanks ranked as the most popular.

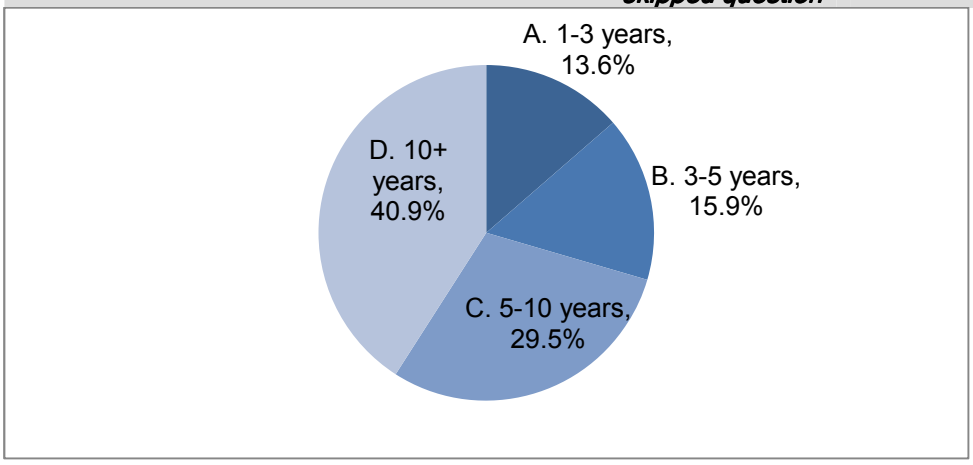
Question 2 How often is regular maintenance undertaken?		
Answer Options	**Response Percent**	**Response Count**
A. Yearly	31.8%	14
B. Every 2 years	40.9%	18
C. Every 5 years	25.0%	11
D. Every 10 years	2.3%	1
answered question		**44**
skipped question		**6**



Comment
The question posed did not accurately define 'regular maintenance'. For example, regular maintenance could involve either isolated surface repair or more

comprehensive replacement with an empty pool tank. As such there could have well have been some confusion on behalf of the respondents, and the only conclusion that can be drawn is that it would appear most facilities have an on-going regular maintenance cycle established.

Question 3 How long has the pool material been in place?		
Answer Options	**Response Percent**	**Response Count**
A. 1-3 years	13.6%	6
B. 3-5 years	15.9%	7
C. 5-10 years	29.5%	13
D. 10+ years	40.9%	18
	answered question	**44**
	skipped question	**6**



Comment

The tables below cross matches pool surface type with longevity for surfaces <1200mm deep and those >1200mm deep. Tiles (of various types) and painted concrete appear to be the both the most popular and longest lasting products used for pool tanks surfaces. The survey did not distinguish between when the surface was first installed and when it was last replaced or had significant maintenance. For example a painted pool tank may have been in place for 10+ years but have been painted 2 or 3 times within this period.

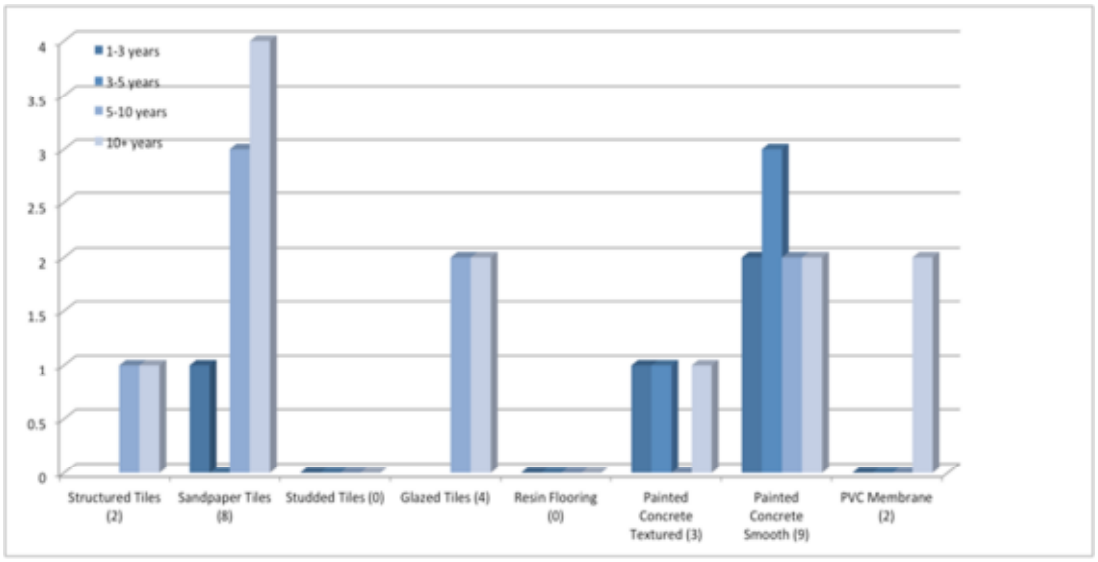


Figure 1 Pool Tank Surface Life-Surfaces<1200 mm deep

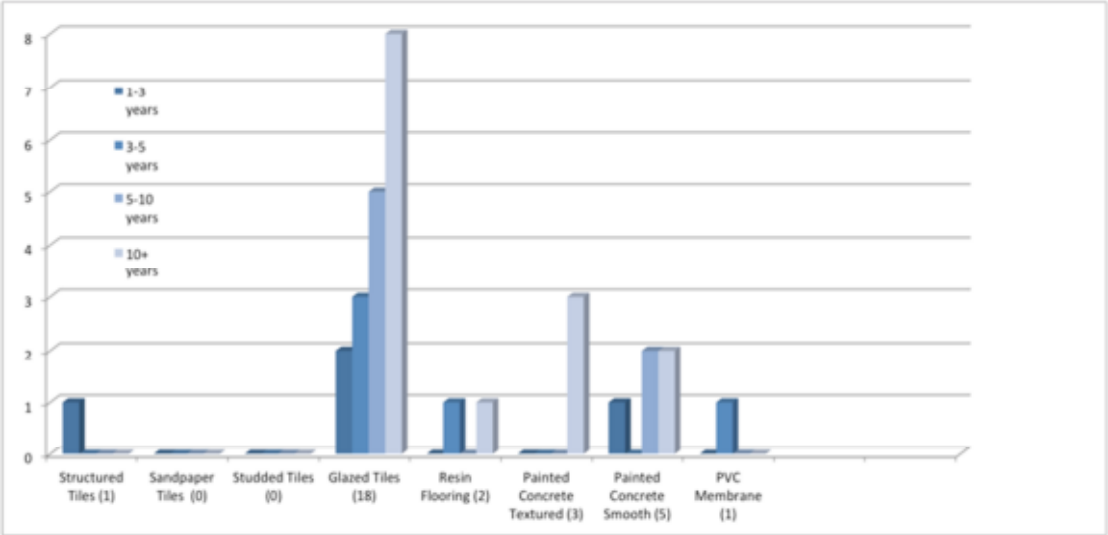


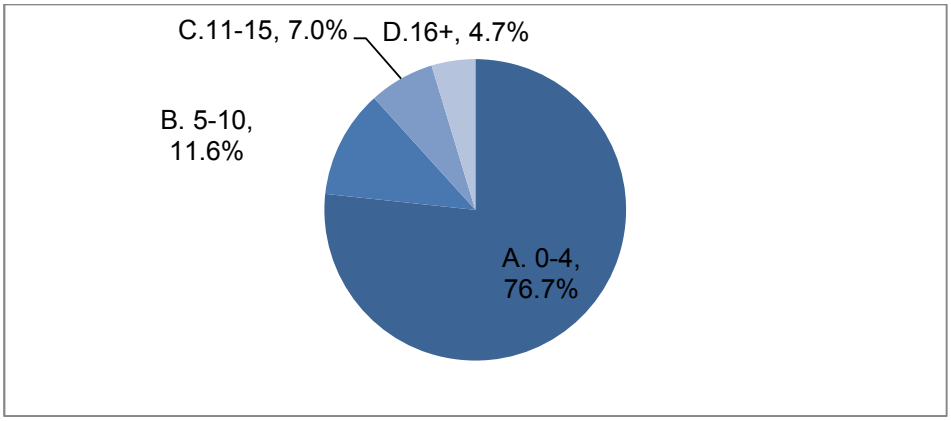
Figure 2 Pool Tank Surface Life-Surfaces>1200 mm deep

Question 4. Issues associated with the pool floor material? (Describe all that apply)		
Answer Options	**Response Percent**	**Response Count**
A. Poor slip resistance	55.8%	24
B. Cleanability	60.5%	26
C. Serviceability / maintenance	60.5%	26
D. Sealant	39.5%	17
E. Others: Please specify	23.3%	10
	answered question	43
	skipped question	7

Comment

Responses to this question were almost identical to the same question asked of pool concourse material, with cleanability, slip resistance and serviceability being the key considerations in roughly equal measure.

Question 5. How many falls/slips, requiring first aid, have you had in the previous year? (Slips within Pool)		
Answer Options	**Response Percent**	**Response Count**
A. 0-4	76.7%	33
B. 5-10	11.6%	5
C.11-15	7.0%	3
D.16+	4.7%	2
	answered question	43
	skipped question	7



Comment
The following chart cross matches pool tank type (<1200mm) with the average number of slips experienced.

Studded tiles and resin flooring can be disregarded as no respondents recorded having used these products in the pool tank.

The question did not allow respondents to distinguish between the trafficable surfaces in the pool tank and those used on walls for example. This appears to have skewed the results. For example, it is unexpected that glazed tiles and smooth painted concrete perform the same or better than surfaces with a non slip texture.