Design and Construction Process for Swimming Pools

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Foreword

The paper “Design and Construction Process for Swimming Pools” has been prepared by the Technical Working Group of The Tile Association.

The Paper has been written with the aim of providing advice for all parties involved in the process of designing, building and maintaining swimming pools, and should be used in conjunction with:-

- Current and forthcoming British, European and International Standards
- Guidelines for Swimming Pools issued by the Amateur Swimming Association (ASA), La Federation Internationale de Natation (FINA), Health and Safety Executive, and Pool Water Treatment Advisory Group (PWTAG).

For many years, the favoured materials for swimming pools have been ceramic tiles and mosaics. For this reason the Paper has concentrated on swimming pools clad with these materials.

The Tile Association acknowledges the support given by tiling contractor and manufacturer members of the Association to the Group, together with invaluable assistance offered by Adshead Ratcliffe Ltd, Biwater International Ltd, Faulkner Brown, Federation of Plastering and Drywall Contractors (FPDC) and Swimming Pool and Allied Trades Association (SPATA).

DESIGN AND CONSTRUCTION PROCESS FOR SWIMMING POOLS

1. Clients' design criteria, e.g. size, construction, features, waterproofing etc.

2. Structural design of various aspects

    a) Pool tank
    b) Surrounds
    c) Ancillary areas

3 Selection of tiles and accessories

4. Selection of adhesives and grouts

5. Beds and backings to receive tiles

6. Fixing of Tiles

7. Movement joints

8. Water Treatment and how it affects tile details.

9. Curing and drying periods

    a) Filling
    b) Heating

10. Cleaning and Maintenance

11. Sources of Reference and Bibliography

1. CONSTRUCTION – (DESIGN CONSIDERATIONS)

The choice of construction methods and the specification of materials associated with the build-up of tiled finishes to swimming pools and ancillary areas is wide and varied. However the goals to be achieved for a successful swimming facility are:

1. Safety in use
2. Long-term performance of finishes
3. Technical performance of a specialist facility
4. Aesthetic performance

A swimming pool complex will generally consist of a combination of different areas each of which, due to their usage, will require the careful consideration of different design and performance criteria if in arriving at the eventual construction specification, the above mentioned goals are to be achieved.

The typical swimming pool complex will be made up of areas/usages utilising tiled surfaces which will fall into the following generic categories:

a Water Retaining Structures/Immersed Surfaces
b Wet Areas
c Dry Areas

The actual combination of area usages and the extent of each will be a direct response to the type of facility to be designed.

Pools can vary from simple water retaining tanks to complex combinations of different water area types and experiences.

Swimming pool operators can vary from local authorities or sporting bodies providing a resource for the general public; to small private facilities; to commercially operated theme parks; to medical and physiotherapy based installations.

To try and categorise such a variety of types and uses is difficult and any such list would prove not to be comprehensive.

For the purposes of providing guidance as to matters for consideration during the design and specification of tiled finishes to swimming pool complexes the following categories of facility have to be considered under types a – water retaining, b - wet and c - dry, the three generic categories given above.

- Competition Swimming Pools:
  The traditional rectangular swimming pool tank either 25 metres or 50 metres long.

- Leisure Swimming Pools:
  A relatively recent development in swimming pools (first introduced into the UK in 1971), often with a freeform shape to the pool.

- Hydrotherapy Pools:
  Used to provide orthopaedic exercise and physiotherapy as part of hospital or sports clinic treatment to both physically impaired and able-bodied users.
- Health Club, Hotel and Private Facilities:
  Facilities, with specific categories of user. Generally all of the design considerations that apply to the building types described above will apply here.

However this category of pool can offer design opportunities/considerations which may not be available on larger schemes.

The design criteria guidance notes which follow under the headings noted above are by way of ‘bullet – points’ to be considered, each of which will require the reader to consult the following sections of this paper for the detailed advice being sought.

The method of procurement which is utilised for tiled finishes and associated elements of the construction, can be a major influence on the success of the finished installation.

For further information please refer to Section 11 Bibliography, at the end of this paper.

2 STRUCTURAL DESIGN OF POOL TANKS, SURROUNDS AND ANCILLARY AREAS

POOL TANKS

Swimming pools are water retaining structures whichever method of construction is utilised and shall be designed and installed to be capable of meeting the watertightness criteria in accordance with British Standard 8007:1987 which states 'that during the 7 day test period the total permissible drop in water level after allowing for evaporation should not exceed 1/500th of the average water depth of the full tank, 10mm or another specified amount such as the SPATA Standard of 12mm'.

The following are methods of construction in general use:-

- Reinforced concrete blocks or reinforced patent blockwork.
- Cavity wall construction containing reinforced concrete.
- Site cast reinforced concrete using formwork or blockwork as the shuttering.
- Pneumatically placed concrete, e.g. Shotcrete and Gunite etc

Please note that when using reinforced concrete blocks and/or patented blockwork, the rendering becomes part of the watertight construction. With regards to Shotcrete or Gunite, this needs a full discussion with the company carrying out the work.

Swimming pool tanks that are out of the ground need particular attention in the design stages particularly if they are constructed/installed on upper floor levels.

Whichever method is used it is essential that the type of pool and the finish is known at the design stage, e.g.

- Competition pool
- Activity pool
- Of freeboard or deck level design
- Tiled finish – type, size and thickness
- Mosaic finish – type, size and thickness
- Direct or indirect fixing
- Suspended pool tanks
- any other relevant consideration

Special consideration must be given for deck level types of pools and particular attention must be given to:

- size of overflow channel[1] and the finish
- width of beach area
- type of beach area
- the avoidance of cut tiles

N.B. Structural movement joints within the pool shell should be avoided if possible unless there are over-riding reasons.

It is also important to know at the outset if timing pads will be used as this needs to be taken into account in order to establish the actual size of the pool tank to be constructed.

[1] full beach in leisure pools and over pool edge to overflow channels in others

Any feature or equipment that is to be incorporated into the pool should be considered at this stage, such as:

- moveable floors
- booms
- starter blocks
- water features
- heated benches
- bubble seats and communal seats
- aqua sports, gymnasium and sports equipment, e.g. polo, canoeing, aqua and sub aqua equipment
- ground supported or suspended shell.

and use to which the pool is being put.

Other items that need to be taken into account are:-

- Recessed rest ledges
- Overflow channels
- Types of pool ladders
    - Recessed into pool tank
    - Built-in and tiled
    - face fixed stainless steel ladders
- Starting platform upstands

Tolerances

The minimum tolerances allowed should be in accordance with British Standard BS5385 Part 4 and the various Codes of Practice, many of which are referenced in this paper.

Direct/Indirect Fixing

It is possible to construct concrete swimming pools to a high degree of dimensional accuracy so that the tiles or mosaics can be thin solid bed fixed directly to the concrete surfaces without the need to apply a render and a screed to the concrete shell. There are advantages in fixing tiles directly onto accurately constructed concrete pool shells. With pools designed with moveable floors this accuracy of concrete pool shell construction will be a requirement.

Where a concrete swimming pool shell is accurately constructed and sufficient time is allowed for the drying/shrinkage of the concrete to occur, a strong and stable background will be provided for the tiling. With this type of construction the only surface preparation is to ensure that formwork release agents, lime bloom and other surface residues are removed. Where freeform pools are constructed with pneumatically placed concrete and accurately finished, direct fixing of tiles and mosaics may not be suitable.

The construction of an in-situ concrete swimming pool shell to the required degree of accuracy needs well designed, good quality formwork. This extra cost has to be weighed against the cost of the mechanical preparation of the concrete surfaces and the application of renders and screeds to ensure true and even surfaces, plus the additional drying times necessary. Where an in-situ concrete swimming pool shell is constructed it should be allowed to dry, under good drying conditions, for at least 6 weeks before either direct fixing of the tiling, or the application of renders and screeds.

Where tiles are installed in swimming pools onto renders and screeds these levelling mortars should be cured and then allowed to air dry as recommended in section 5 (Beds and Backings)

POOL SURROUND STRUCTURES

The surround structure around swimming pools needs careful consideration and basically falls into two categories:

- Solid construction
- Suspended construction

Whichever method is used, the surround slab should be laid to falls; in the case of deck level pool towards the deck level channel and freeboard pools away from the pool into drainage channels around the perimeter of the pool surround. These falls should be between 1:35 and 1:60 dependent on the width of the surround and the type of tiles to be used. The structural concrete should be set to falls and **not** the screed. This is to make sure that the thickness of screed is uniform. The purpose of the pool surround falls is to disperse any water as soon as is practically possible from the surface of the finished work.

Special consideration must be given whenever there are rooms adjacent to the pool surround which are located below the pool surround level as there is a likelihood that water can migrate into these lower areas. In these cases special treatment is needed between the pool surround slab, the tiling, and any perimeter walls in order to avoid this occurring.

If underfloor heating is to be used particular attention is needed and full consultation needs to take place with the manufacturer and installer at the design stage.

POOL UNDERCROFTS

Whenever there is a pool undercroft around the perimeter of the pool the undercroft floor should be laid to falls and a drain installed or a sump and sump pump provided.

PLANT ROOM FLOORS AND STORAGE AREAS

A drain should always be provided in plant rooms and the floors laid to falls to the drain in case of accidental spillage, although in many cases the drain provided for the backwashing of filters is all that is required. Storage areas require a drain to be provided and provision may be necessary for chemical resistant areas (i.e. chemicals store).

ANCILLARY AREAS

- Changing rooms
- Shower areas
- Steam rooms

In these areas there is as much water deposited on the floors as there is on the pool surrounds, if not more, and it is imperative that these areas are treated with the same attention to detail as the pool surround itself. A good drainage system should be provided in order to disperse the water as quickly as possible from these areas. Particular attention

should be paid to the junction of the structural floor with the walls and the wall construction. Tanking membranes may be necessary in these areas which extend up the walls[2].

Adequate ventilation should be provided in areas of high humidity.

[2] Refer to BS5385 Part 4 paragraph 6.4

3. TILES

SELECTION OF TILES AND MOSAICS FOR SWIMMING POOL LININGS

The choice of tiles or mosaics for utilisation in **Swimming Pool Linings** is an area which demands careful consideration prior to specification.

The surface finish to a Swimming Pool has to serve several functions:-

Technical Requirements

Ceramics as with other materials for use within Swimming Pools need to be technically fit for purpose. They should have a low water absorption of 3% or preferably less. Tiles should be selected from either type AI - BS6431:Part 2, EN121(extruded products) or type BI - BS6431:Part 6, EN176(dust pressed products). Product suitability should be sought from the manufacturer/supplier.

CHART 1
Minimum Requirements for product to conform to AI - BS6431:Part2, EN121 (Extruded Products)

Length/Width	-	EN98	+/- 1.25%
Thickness	-	EN98	+/- 10%
Straightness of Side	-	EN98	+/- 0.5%
Curvature	-	EN98	+/- 0.5%
Warpage	-	EN98	+/- 0.5%
Rectangularity	-	EN98	+/- 1.5%
Water Absorption	-	EN99	max 3%
Modulus of Rupture	-	EN100	min 18N/mm²
Chemical Resistance	-	EN122	no visible effect
Frost Resistance	-	EN202	no visible effect

CHART 2
Minimum Requirements for product to conform to BI - BS6431:Part 6, EN176 (Dust Pressed Products)

Length/Width	-	EN98	+/- 0.5%
Thickness	-	EN98	+/- 5%
Straightness of Side	-	EN98	+/- 0.5%
Curvature	-	EN98	+/- 0.5%
Warpage	-	EN98	+/- 0.5%
Rectangularity	-	EN98	+/- 0.6%
Water Absorption	-	EN99	max 3%
Modulus of Rupture	-	EN100	min 27N/mm²
Chemical Resistance	-	EN122	no visible effect
Frost Resistance	-	EN202	no visible effect

Special care must be taken when specifying ceramics or other surface finishes for use in shallow beach areas, steps (inside and outside pool) and ramps (inside and outside pool) Tiles for these applications must meet Construction Product Directive requirements for safety and therefore have adequate slip resistance for the location of use. The tile supplier/manufacturer must confirm fitness for purpose. Slip resistance relates to the Coefficient of Friction and this can rely on the profiled or textured surface of the ceramic floor tile. **This coefficient of friction value is only maintained with the use of a suitable cleaning regime**. Advice should be obtained from the appropriate tile manufacturer on cleaning and maintenance guidance or from “The Cleaning of Ceramic Tiles” issued by The Tile Association.

Pools used for canoeing or scuba diving should utilise products with higher modulus of rupture values due to the increased risk of pool wall tile and floor tile damage.

Aesthetic Requirements

The colour of pool linings is of personal choice but it is common practice to utilise white, black, turquoises or blues. Demarcation lines/pool guidelines/targets and warning lines can be incorporated in the tile layout design with the use of contrasting colours. Commonly black or dark blue are used with white or lighter blue field tiles. For safety reasons dark tiles should never be used for the base of the pool.

For ASA or FINA accreditation guidelines, targets, turning pads and internal dimensions must be laid out to specific requirements.

Coloured glazed tiles can also be used for polo markers. Special screen printed tiles can be used for lane or depth markers.

It must be appreciated that due to refraction of the water colours will appear distorted when the pool is filled. Deeper water distorts colours greater than shallower water. It is quite common for a white tile to be mistaken for a pale blue once the pool is filled. Due to this refraction careful consideration should be exercised when using reds and yellows in pools.

Maintenance

The initial cleaning and regular cleaning and maintenance of products are all essential to ensure that the technical characteristics for which the ceramic tiles were originally chosen are maintained. Guidance from the tile manufacturer or supplier should be sought guidance or from “The Cleaning of Ceramic Tiles” issued by The Tile Association.

Tile Sizes & Fittings

The most popular sized modules for swimming pool lining products are either mosaic or 250mm x 125mm tile modules which allow for 4 x 8 in 1m². Other size formats are also available and are equally suitable. ASA and FINA regulations have a requirement for racing lines, targets and other markers to be at set dimensions. These regulations should be observed for competition class pools whichever size module is chosen.

Associated pool fittings for finger grip pool edgings, ribbed and profiled step edgings, internal and external angles, overflow channels and turning pad tiles are also available in this and other size modules.

SELECTION OF TILES FOR SWIMMING POOL SURROUNDS AND SHOWER/WET CHANGING AREA FLOORS

The choice of floor ceramics for utilisation on **Swimming Pool Surrounds** and on **Shower/Wet Changing Room Floors** is an area which requires detailed consideration prior to specification.

The most important technical consideration in these areas apart from general cleanability and moisture resistance is the slip resistance.

Technical Requirements

Ceramic floor tiles for use on Pool Surrounds or in Shower/Wet Changing areas need to be technically fit for purpose. They should have water absorption values of 3% or preferably less to resist staining and have high coefficient of friction values gained from either a profiled or textured surface. Products should be classified as AI - BS6431:Part 2, EN121 (extruded products) - see chart 1 or type BI - BS6431:Part 6, EN176 (dust pressed products) - see chart 2. Product suitability and fitness for purpose should be sought from the manufacturer/supplier.

Aesthetic Requirements

Colours of ceramics for pool surrounds and wet changing/shower floor areas are to designer's specification. Naturally coloured quarry hues have been used for many years. The current trend is to utilise white or off whites, greys, turquoises, blues or other aqua colours. **Technical suitability must not be sacrificed for the selection of a specific or particular colour.**

Maintenance

In a slip resistant floor tiling installation it is absolutely imperative that the initial clean and regular cleaning and maintenance regime are carried out as per the manufacturers recommendations so as to ensure the technical (especially coefficient of friction values) characteristics for which the tile was specified are maintained during service of the installation.

Tile Sizes & Fittings

Ceramic tiles for use on pool surrounds and in shower/wet changing areas are available in a range of sizes ranging from small mosaics through 100 x 100mm, 150 x 150mm, 152 x 152mm, 200 x 100mm, 250 x 125mm, 200 x 200mm to 300 x 300mm and larger. Technical suitability must be sought from manufacturer/supplier.

Products can be supplied with associated secondary drainage channels, coving systems and step edgings (preferably in demarcation colours).

Mosaics

Reference should be made to BS5385:Part 2:1991 Clause 6.

SELECTION OF TILES FOR POOL HALL WALLS AND SHOWER/CHANGING AREAS

Pool Hall Walls and **Shower/Changing Walls** are the areas where ceramic product selection can be more varied.

Wall tiling to these areas serves many functions including aesthetics, moisture resistance and ease of cleaning.

Technical Requirements

Ceramics for use in wall tiling to pool halls and changing/shower areas should be selected from the following categories AI - BS6431: Part 2, EN121 (extruded products), type AIIa -

BS6431: Part 3, EN186 (extruded products), type BI - BS6431: Part 6, EN176 (dust pressed products), type BIIa - BS6431:Part 7, EN177 (dust pressed products) or type BIII - BS6431:Part 9, EN 159 (dust pressed products). Product suitability and fitness for purpose should be sought from the manufacturer/supplier.

Aesthetic Requirements

Colours and design options for use on pool hall walls and shower/changing walls are almost limitless. Colour coding of changing areas is commonplace as is the use of design/colour and size mixing.

Maintenance

One of the main reasons for utilising ceramic tiles on pool hall walls and shower/changing room walls is their ease of cleaning and maintenance. Glazed wall tiles correctly installed, maintained and regularly cleaned provide a long lasting trouble free, wall finish. Initial clean and maintenance regimes should be sought from the manufacturer/supplier.

Tile Sizes and Fittings

Sizes of suitable products range from small mosaics through 100 x 100mm, 150 x 150mm 152 x 152mm, 200 x 50mm, 200 x 100mm, 200 x 200mm, 250 x 200mm, 300 x 200mm, 330 x 250mm, to 400 x 300mm. This is by no means a definitive list of tile sizes available.

External corners of tiles can be finished with integral glazed edges, rounded (bullnose) edges, special corner fittings or proprietary edging trims.

Additional fittings can be used i.e. coves, angle beads (internal and external), profile feature borders, profiled tiles, rounded edged tiles and cut tile/hand painted murals.

WATCHPOINTS

GENERAL

- Check tiles delivered against specification.
- Ensure all products are of the same (or similar) worksize and shade, particularly pool linings and floors, and that consistent spacing can be achieved.
- Any visually defective tiles should not be fixed. Where unacceptable levels are discovered, this matter should be brought to the attention of the relevant tile manufacturer/supplier.
- When setting out observe the specified joint width and allow for any manufacturing tolerances. This is particularly relevant when fixing to exact metric modular designs (pool racing lines).

SWIMMING POOL LININGS

- Ensure ceramic products are fit for purpose.
- For water depths of less than 800mm (shallow areas) and 450mm (beach areas) slip resistant tiles should be used on the pool tank base.
- Ensure relevant colours and fittings are available.
- For pools used for scuba-diving or canoeing activities utilise products with higher modulus of rupture values due to increased risk of pool wall tile and floor tile damage.
- Ensure FINA and ASA regulations for pool markings can be achieved with the tile module without cutting.

SWIMMING POOL SURROUNDS/SHOWER AREAS/WET CHANGING AREAS FLOORS

- For health and safety reasons ensure products conform to the appropriate class of slip resistance.
- Slip resistance should not be sacrificed for colour choice.
- Ensure ceramic products are technically fit for purpose.
- Check cleaning suitability with manufacturer/supplier.
- Ensure all relevant fittings are available.

POOL HALL WALLS/CHANGING ROOM WALLS

- Ensure products are technically fit for purpose
- Check colour availability.
- Check size compatibility across colours.

4. ADHESIVES AND GROUTS

Factors Affecting the Selection of Adhesives and Grouts in Swimming Pools

Where tiles are installed in swimming pools it is important that the adhesive and grout selected for the bedding and grouting of the tiles will resist the effects of the pool water and other chemicals that come into contact with the tiling. If consideration is not given to this requirement the long-term durability of the installation will be compromised. Even if the selected adhesive and grout meet these criteria, it is still necessary for the pool water to be maintained in a non-aggressive condition.

The tile bed is not designed to protect the structure beneath, e.g. renders, screeds and concrete pool shell, from the effects of aggressive pool water. It is the tiling and grouting which provides protection against the effects of aggressive pool water.

The main factors that influence the selection of adhesives and grouts used in swimming pools are listed below.

- The type of tiling being installed.
- The quality of the mains water supply.
- Chemicals used for the pool water treatment
- The balance index of the pool water.
- The chemicals used for cleaning and maintenance.
- The design of the pool and the location of the tiling

The Type of Tiling Being Installed

If any particular criteria apply to the selection of the grout, in relation to the other factors listed above, it will be necessary to apply the same criteria to the selection of the adhesive when the depth of the grout will not provide adequate protection for the adhesive. This situation usually exists where thin tiles such as mosaics are used and the adhesive will be more vulnerable to aggressive water conditions.

Quality of Mains Water Supply

This is a major factor in the selection of the adhesive and grout as the quality of the mains water is dependent on the source of supply and another source of water is not normally available. The factors that will influence the selection of the grout and possibly the adhesive in relation to the mains water supply are detailed in section 8.

Chemicals used for Pool Water Treatment

The selection of the pool water treatment system may influence the selection of the tile adhesive and grout if either the chemicals used are aggressive to cement-based mortars, or the system cannot provide the required levels of calcium hardness and bicarbonate alkalinity to achieve an acceptable balance index. See section 8 for more details on this subject.

The Balance Index of the Pool Water

The balance of the pool water is an important factor in the selection of a suitable adhesive and grout. If it is evident that the pool water will be consistently aggressive to cement-based mortars then the only solution is to use a chemically resistant mortar, e.g. an epoxide resin mortar, to either grout, or bed and grout the pool tiling. Even if such a precaution is taken it is still important, as far as is practicable, to maintain the pool water in a balanced condition

that will not be aggressive to cement-based mortars. This will be necessary for the long-term protection of the concrete, renders and screeds that come into indirect contact with the pool water. It is usually necessary to bed and grout mosaic tiling in an epoxide resin mortar in pools where the water cannot be maintained in a non-aggressive condition. See section 8 for more details on this subject.

The Chemicals used for Cleaning and Maintenance

The cleaning and maintenance of the tiling in the pool should follow the recommendations given in Parts 1, 2, 3 and 5 of BS 5385. With glazed tiles the use of neutral sulphate-free detergents is recommended and the use of abrasive cleaners that may scratch the tiles are to be avoided. Any acid-based cleaners used to remove lime scale from the tile surface should be applied with care and strictly in accordance with the manufacturer's instructions. The manufacturer's advice on the correct dilution of the cleaner should be followed as the tile grout will be damaged if the cleaner is used in a less dilute form than recommended. It is always advisable to wet the cement-based grout before applying an acidic cleaner and to wash down thoroughly after use, using clean water. If frequent use of acidic cleaners is likely to be necessary then the use of a chemically resistant grout, e.g. an epoxide mortar, to ensure long term durability, should be considered. Note that the use of an epoxide resin based grout will entail a higher initial capital cost but provide better durability under adverse conditions. See section 10 for guidance on cleaning and maintenance of the pool tiling.

The Design of the Pool and the Location of the Tiling

Pools with water features, such as wave making equipment, rapid water rides, beaches, etc., may expose the tiling to more intensive wear and involve extra cleaning requirements. In these circumstances a cement-based grout will be more vulnerable to slightly aggressive water conditions and cleaners. In some locations it may be best to use an epoxide resin based grout in the more vulnerable areas.

The above information gives a brief outline of the factors affecting the selection of adhesives and grouts in swimming pools. If a new pool is being planned it is worthwhile visiting local pools on the same water supply to see what type of grout had been installed and how it is performing. If a cement-based grout is performing well this indicates that, by following the same treatment, the water in the new pool should be able to provide good durability under the same conditions.

Adhesive Specification

For most areas of wall and floor tiling throughout a swimming pool installation, polymer modified cementitious adhesives are recommended. Where it is known that aggressive water conditions are present, especially where mosaics are used, fixing and grouting with a reaction resin product is advised.

Reference should be made to the classification system set out in prEN 12004 "Adhesives for tiles. Definitions and Specifications". (see Appendix 1). The classification system is based on the minimum performance requirements laid down for the relevant test described in the European Norms for the testing of ceramic tile adhesives.

Table 1 below offers guidance on the preferred adhesive types according to the EN Classification System for the different areas of tiling in a swimming pool complex.

Table 1

Location	Cementitious (include modified)	Reaction Resin

Pool Shell – Base	C2, C2E, C2F, C2T	R2, R2T
Pool Shell – Walls	C2T, C2TE, C2FT	R2, R2T
Promenade Deck	C2T, C2E, C2F	R1, R2
Pool Hall Walls	C1T, C1FT, C2T, C2TE, C2FT	R1T, R2T
Changing Room Walls	C1T, C1FT	R1T, R2T
Changing Room Floors	C2, C2E, C2F	R1, R2
Shower Walls	C1T, C1FT, C2T, C2TE, C2FT	R1T, R2T
Shower Floors	C2, C2E, C2F, C2T	R1, R2

Note: the EN classification system for cementitious adhesives encompasses Types 1 and 3, Class AA adhesives in BS5980. Reaction resin adhesives are Type 5 products in BS 5980.

Grout Specifications

Two types of grout are suitable for use in a swimming pool environment, cementitious and reaction resin (usually epoxide based). Where the pool water is hard or can be maintained at a calcium level over 200mg/lit. expressed as calcium carbonate, cementitious grouts, modified with polymers (1 or 2 part) are suitable. The European Norm classification is CG2 – improved cementitious grout with additional characteristics (high abrasion resistance and reduced water absorption).

Where the pool water is soft (low calcium level) and classed as aggressive or where intensive cleaning and high levels of abrasion take place reaction resin grouts should be used (RG1 EN classification).

The use of white cementitious grouts is not recommended for pool surrounds or changing area floor tiling.

Grouting with epoxide resin is increasingly under consideration. The process has the following advantages:-

- Acid resistance – resistance to organic acids (e.g. lactic acid) and inorganic acids (e.g. hydrochloric acid)
- resistance to aggressive pool water
- imperviousness – ease of cleaning
- Better protection of the subsurface when high pressure cleaning systems are used

Table 2 – Classification and Designation

SYMBOL		**DESCRIPTION**
TYPE	CLASS	
C	1	Normal cementitious adhesive
C	1F	Fast setting cementitious adhesive
C	1T	Normal cementitious adhesive with reduced slip
C	1FT	Fast setting cementitious adhesive with reduced slip
C	2	Improved cementitious adhesive with additional characteristics
C	2E	Cementitious adhesive with extended open time
C	2F	Improved fast setting cementitious adhesive with additional characteristics
C	2T	Improved cementitious adhesive with additional characteristics and

		reduced slip
C	2TE	Improved cementitious adhesive with additional characteristics, reduced slip and extended open time
C	2FT	Improved fast setting cementitious adhesive with additional characteristics and reduced slip
D	1	Normal dispersion adhesive
D	1T	Normal dispersion adhesive with reduced slip
D	2	Improved dispersion adhesive with additional characteristics
D	2T	Improved dispersion adhesive with additional characteristics and reduced slip
D	2TE	Improved dispersion adhesive with additional characteristics, reduced slip and extended open time
R	1	Normal reaction resin adhesive
R	1T	Normal reaction resin adhesive with reduced slip
R	2	Normal reaction resin adhesive with additional characteristics
R	2T	Normal reaction resin adhesive with additional characteristics and reduced slip

Note: Additional designations can be inserted according to the combination of the different characteristics

C	Cementitious adhesive
R	Reaction resin adhesive
1	Fundamental characteristics (basic requirements)
2	Improved performance over 1
F	Fast setting classification
T	Reduced slip
E	Extended open time
D	Dispersion

5. BEDS AND BACKINGS

Tiles can be fixed either directly onto a concrete shell or onto screeds or renders which have been applied directly to the concrete shell or other backing.

DIRECT FIXING

When tiling is to be fixed directly onto the concrete shell it is imperative that the shell is constructed to the required tolerances. These are generally tighter when using the direct tiling method than those required for concrete shells that are to be screeded or rendered.

Direct fixing reduces the number of layers and interfaces involved and hence reduces the risk of problems so that it is the preferred construction technique.

Contamination

Preparation of the concrete shell to receive tiling is critical. All contaminants such as shutter release oils, curing agents etc. and any laitance on the surface should be removed to allow a good mechanical key to be formed. The use of a high powered water jet or sand blasting (health and safety precautions necessary) is often sufficient to remove surface contaminants from concrete. The use of coloured shutter release oils and curing agents could be considered to give an indication of their satisfactory removal.

BS5606:1990 'Guide to Accuracy in Building', Table 1 gives "ranges of deviations normally achievable in construction" and for in-situ concrete, brickwork and blockwork walls deviations to straightness over 5m are up to ± 9mm and in verticality up to 2m in height about ±10mm.

For in-situ concrete floors the flatness normally achievable is up to 5mm under a 3m straight edge and deviations from target within ±25mm.

Though the construction of a shell to be screeded and /or rendered requires good working practices, the tighter tolerances required for a shell designed to be directly tiled (maximum gap permitted under a 2m straightedge is 3mm [BS5385:Part 1:1995, clause 3.2.4.1]) mean greater care and attention to detail is needed. Mistakes made at an early stage can often not be rectified later without the use of an additional layer of screed or render and hence time and money spent at this stage is always well spent.

Where the required tolerances for direct tile fixing cannot be attained through the forming of the concrete shell, screeds and renders are traditionally used to provide a finish onto which the tiling can be applied.

INDIRECT FIXING

Screed

General

The constituent materials for the cement/sand screed, the preparation, application and testing should comply with the recommendations given in BS8204-1:1999 and BS5385 Part 3:1989 and Part 4:1992.

Preparation

Only bonded screeds should be used.

Prior to applying the screed the concrete shell should have been allowed to cure and dry sufficiently.

For bonded screeds the concrete base should be treated so as to remove any contaminants such as oils, shutter release agents and curing agents. Any laitance arising through the application of the concrete should be removed mechanically. The surface should be wetted for several hours (preferably overnight), any excess water removed by brushing off. Within a period of 30 minutes (less in hot weather) before the screed is laid, a thin layer of neat cement slurry of creamy consistency should be brushed into the surface of the concrete base and the screed placed and compacted whilst the slurry is still wet. A proprietary bonding agent may be used instead of the slurry or a proprietary bonding admixture may be used in the slurry. In either case the manufacturers' recommendations should be followed.

Materials, Mix Proportions and Protection

The screed mix proportions by volume based on the use of dry sand should be between 1:3 to 1:4.5 ordinary Portland cement. Sharp sand to grading limits C or M of table 1 of BS8204-1:1999. The water content should be the minimum necessary to give adequate workability for laying and full compaction.

It should be remembered that screeds are used to give flat surfaces to receive coverings that are not readily fixed to a base. They are not in general designed as structural components, nor in this application to be wearing surfaces. Hence such screeds should be protected from wear and damage between finishing and tile laying.

Wherever possible the screed should not be in direct contact with pool water, but where this cannot be avoided consideration may be given to the use of polymer modified screeds.

Screed type, thickness and jointing

Screeds for tiling should be laid as bonded screeds with a minimum thickness of 25 mm at any point necessitating a design thickness of 40mm. However it is recommended that bonded screeds are not laid at thicknesses much in excess of 40mm as thicknesses in excess of 40 mm tend to show an increasing risk of loss of adhesion with the base.

Consideration should be given at design stage to bay sizes and construction joints. Screeds should be laid in as large areas as possible in one operation consistent with achieving the appropriate surface regularity and levels required so as to minimise the number of joints. Construction joints should, where possible, coincide with expansion joints or other features. If construction joints are formed, bedded screed beneath levelling battens should be cut away to form a vertical joint. It is recommended that the finish of the surface should be specified to be wood float finish.

Tolerances

It should be noted that the tolerance limit for tiling is 3mm under 2m straightedge, whereas that for screeds (BS8204-1:1999) specified to be laid to a Class SR1 surface regularity is 3mm under 3m straightedge. So provided the architect originally specified the screed to be laid to have a Class SR1 surface regularity, then the achieved surface regularity of the final screed surface should meet the tolerance requirements for a substrate for tiling.

If the Architect specifies another class or fails to specify any class, then the surface regularity produced is unlikely to meet the tolerance requirements for a substrate suitable for tiling.

Curing /Drying

Once laid, all screeds should be correctly cured e.g. by covering with an impermeable membrane for a minimum of 7 days before being allowed to dry out. This curing period is essential as it permits strength to develop within the screed to better withstand the drying shrinkage forces, and reduce the risk of cracking and debonding from the concrete base. The screed should be allowed to air dry for at least a further two weeks, allowing a considerably longer drying time in cold and damp site conditions, before tiling commences.

Movement Joints

Any movement joints within the concrete base should be continued through the screed and into the tiling.

Pool surround

Underfloor Heating

The system manufacturers' recommendations should be followed for all design and application details.

Where underfloor heating is to be used in the pool surround, the type and form of the system should be agreed at the design stage in order that sufficient depth be allowed for the system, the screed and the tiling. Ensure system manufacturer's recommendations for minimum thickness over pipework are followed.

Correct curing of the screed is critical, as described above.

Once cured, the screed should be left to dry for a further 3 weeks before the heating is turned on. It should be heated very slowly (maximum rate of 5°C per 24 hour period) to the operating temperature and maintained at the operating temperature for at least three days before cooling down to room temperature, but not below 15°C, before installing the tiling. The usual operating surface temperature of a heated levelling screed is about 27°C; however, some locations may operate at higher temperatures, e.g. 35°C. As this conditioning is undertaken prior to tiling, it will assist in achieving a more dimensionally stable screed as a base for the tiling.

Waterproof Membrane

If a waterproof membrane is to be included in the construction of the pool surround, the positioning of the membrane should be decided at design stage including and possibly 600mm up the wall. If the membrane is to be sited between the concrete base and the

screed, the screed will be of unbonded construction. An unbonded screed should have a minimum thickness at any point of 50mm (design thickness 70mm plus).

The detailing should be designed to permit permeating water to be removed, either towards and / or away from the pool channels.

Rendering

General

The constituent materials for the cement based internal plaster (called "rendering" in this publication), the preparation and its application should comply with the recommendations given in BS5492:1990, BS5262:1991 and BS5385:Part 2:1991 and Part 4:1992 where appropriate.

Rendering is used to align and smooth walls prior to the application of a tiled surface and, like screeds, is used to provide a suitable surface on to which the tiles can be applied. They are not typically designed to be structural or waterproof elements, though some proprietary renderings and additives are available to provide a watertight installation.

Preparation

All backgrounds should be free from contaminants such as release oil, curing agents etc. The backgrounds should be sound. A pre-treatment should be specified to assist the bond between the background and the first rendering coat. Proprietary bonding agents are available, but it is necessary to ensure that the material will be suitable for use in saturated conditions. Many traditional rendering bonding agents will be unsuitable for use in such conditions.

Tolerance

The accuracy of line to which the background is constructed is of vital importance when a rendering is to be tiled. The rendering being a levelling medium between the background and the tiling, the truer the background, the greater the trueness it is possible to achieve with the tiling. The tolerance required for fixing tiles by the adhesive bed method is 3 mm under a 2m straight edge. That for the rendering is dependent upon the accuracy of the background, the thickness of rendering to be applied and whether grounds are supplied and fixed to a true line. For rendering applied at a thickness of 13mm or more, to a background constructed to within the tolerance required in the rendering surface and with grounds fixed to a true line, then the final surface should not deviate by more than 3mm under a 1.8m straight edge.

For concrete walls accurate alignment of formwork is therefore necessary to produce a suitable background. If the rendering is to be applied over blockwork, greater accuracy may be required than is often specified or achieved in traditional construction. See See "Trueness" earlier under section 5.

High levels of accuracy are especially necessary where pools are designed for competition because of the critical tolerances required on its dimensional accuracy. In order to achieve the overall dimensional accuracy for the pool, it is necessary for the designer to specify the accuracy of the line required of the finished rendering surface. Similarly in order for this latter requirement to be achieved, the structural wall should be specified to be built to an accuracy of line of 3mm under a 1.8m straight edge.

Mix Proportions

The first coat of rendering should have a weaker strength than the background to which it is to be applied.

For most strong backgrounds likely to be used for pools, the first rendering undercoat should consist of one part of cement to between 3 and 4 parts of dry sand by volume. Subsequent coats should be weaker than the previous coat.

Coat Thicknesses

The rendering should not have a total thickness in excess of 20mm. Each coat should be between 8mm and 16mm thick with each subsequent coat being thinner (not thicker) than the previous coat.

Time Delay between Coats

Clause 19.4 BS5385: Part 2 recommends that first coats should be allowed to harden and dry out to permit shrinkage to take place before a second coat is applied. It is recommended that the finish of the final coat should be specified to be wood float finish.

Movement Joints

Any movement joints within the background should be continued through the rendering and tiling.

6 FIXING OF TILES

Factors affecting fixing have already occurred earlier in the whole construction process with decisions taken on tile type, backings, fixing medium, grouting etc.

It is necessary to check decisions, and work in accordance with BS8000: Part 11.1:1989. Before the arrival of tile fixers on site, it is necessary to double check the effect of those earlier decisions and at the same time provide pointers to a successful installation. These are set out below using the same division of areas as in section 2.

Pool Tank

a) Direct fixing to concrete

- Check that substrates are free from contamination and loose material
- Check all critical dimensions for alignment of design requirements
- Check that the concrete surface is true enough to achieve required tolerances for tiling
- With adhesive fixing surface regularity should be such that no gap under a 2m straightedge exceeds 3 mm.
- Establish that tests for water tightness have been carried out successfully.

b) Screeded/rendered surfaces

- Check presented surface for compliance with allowed tolerances and type of surface finish.
- With adhesive fixing surface regularity should be such that no gap under a 2m straightedge exceeds 3 mm.
- Check substrates are dry, sound and free from areas that sound hollow when tapped.
- Establish that sufficient curing period and drying times have been allowed for.
- On competition pools check ability to achieve ASA compliance with the addition of tiling and bedding layer and any timing pad mechanisms.
- Ensure that the pool shell meets the water retaining requirements of BS8007:1987

The tiling contractor should satisfy himself that the above requirements have been met before proceeding.

c) Setting Out/Key points for consideration

Tiling to tank of pools with facilities for competition swimming and water games etc, will usually be set out by the specifier or pool specialist to a predetermined tile module and layout in order to achieve, whenever practicable, full tiles rather than cut tile pieces, whilst also meeting critical dimension requirements for pool racing lane markers and game markers etc.

Setting out points will typically be:-

- the bottom edge of in-pool overflow/scum channels
- the pool edge nosing tile (deck level pools or pools with conventional skimmer units) in deck level pools the nosing tile becomes the key setting out point – dictating both line and level of the pool edge and the line/parallelity of the overflow drainage channel
- points of change in slope of pool base
- step on ladder recesses
- resting ledges

Also, for competition pools required to meet A.S.A. or Olympic standards:-

- Pool tank length and width critical dimensions
- layout of racing lane and turning pad markers
- insitue concrete blocks

d) Tile Fixing

- Check architect's tile setting out drawing against site dimensions.
- Check delivered tiles and adhesives against specification.
- Ensure surfaces to be tiled are correctly prepared
- Where semi-dry bed is used, ensure polymeric additive is incorporated into tile-bedding slurry.
- Set out for whole tile module wherever possible.
- Ensure trowels are of the correct type and that the correct technique is used pressing tiles firmly into the bed to give a solid adhesive bed and to avoid voids. Ensure tiles/mosaics are well beaten into bed.
- Ensure semi-dry bed is thoroughly compacted.
- Remove occasional tile as work proceeds to ensure no voids behind fixed tiles
- Where thick bed semi-dry sand and cement screed is used, ensure it is bonded to pool base.
- Leave agreed movement joints clear of adhesive/fixing mortar.
- Ensure tile joints are sufficiently deep to take grout mortar
- Ensure any fireclay scum channels are bedded
- Ensure 3:1 sand cement mortar (by volume) is used for bedding to prevent leaching.
- Ensure 8:1 sand cement weak mortar (by volume) is used for back filling to prevent fracturing of glazed units.
- Minimum 6 mm joint on fire clay scum channels to take up twists/winds in the material.
- Ensure any nosing tiles are bedded in 3:1 solid sand and cement. Volume proportions based on the use of damp sand.
- Consider use of SBR additives if not already decided upon.
- Ensure concrete is adequately keyed.
- Establish there is adequate depth for bedding pool surround tiles.

e) Grouting

- Ensure grouts used are as specified.
- For consistency of shade and accuracy of cement based grouts, proprietary products are recommended.
- Ensure no voids are left in joints.
- Ensure all traces of grout are removed from the tile surface before it sets.
- Ensure movement control joints are left completely free of any grouting material.

f) Movement joints

- Ensure movement joints are positioned to specification
- Ensure perimeter back up materials are of correct specification and have been installed correctly.
- Check joint dimensions are in accordance with specification
- Ensure that grouting has been completed at least three days prior to the treatment of movement joints.

Pool Surround

a) Floors

- Incorporate polymeric additive into any necessary thick bed/screed including bonding to base under those tile courses between pool edge and channel on deck level pools to avoid leaching of this bed.
- Ensure there is adequate depth for tile bed or bedding system.
- Ensure falls are correct.
- Ensure thick beds are well compacted to minimise leaching.
- Ensure at least 3mm joint width between tiles to allow correct application of grout.

b) Pool Hall Walls

- Ensure backing/rendering is satisfactory for cement based adhesives. With adhesive fixing surface regularity should be such that no gap under a 2m straightedge exceeds 3 mm. Gypsum plaster and timber based materials and boards are not suitable, Inert tile backer boards are now available if lightweight construction is required. In-situ backgrounds and boards should be dimensionally stable and water resistant.
- Ensure solid bed fixing is achieved.
- Ensure movement joints are incorporated at recommended centres as in BS5385, both horizontally and vertically.
- Grouting to be water resistant.
- Ensure correct grout width of at least 1-2mm between tiles as per BS585:Part 1:1995

c) Ancillary Areas

Walls in Wet Locations

- All as for pool hall walls
- Epoxide grouts may be considered in shower areas

Walls in Dry Areas

- Check compatibility of adhesive with prepared backing.
- Ensure movement joints are left at BS5385 recommended centres.
- Ensure correct grout width of at least 1-2mm between tiles as per BS5385:Part 1:1995

Floors in Wet Areas

- Ensure falls in wet areas have a gradient, no steeper than 1 in 35 and no less than 1 in 60 when combined with a slip resistant finish.
- Ensure solid bed fixing is achieved whether bedding in sand and cement or adhesive.
- Ensure 3 mm minimum joints for effective grouting.
- Ensure perimeter movement joints and any intermediate joints are left clean.
- Epoxide grouts may be considered in shower areas.

Floors in Dry Areas

- Check finished levels to be achieved.
- Check screed or base for surface regularity and in-situ crushing resistance.

- Ensure solid bed fixing is achieved whether bedding in sand and cement or adhesive.
- Ensure 3 mm minimum joints for effective grouting.
- Ensure perimeter movement joints and any intermediate joints are left clean.

7. MOVEMENT JOINTS

Sealant Joints in Swimming Pools

In general there are two sealant types used in swimming pool tanks and surround. Epoxy based sealants and unplasticised polysulphide sealants. These types of sealant offer resistance to the effects of treatment used in swimming pools and resistance to vandalism, both of which need to be considered particularly in public swimming pools.

There are two main types of joint – stress relief joints which extend through the tiles and screed and/or render only, and structural joints which should be placed in line with any structural joints in the main structure of the pool or surround and should continue through the screed and/or render and tileing.

Joint location can be crucial, particularly where there is a high risk of erosion of the sealant, for example, where there is severe turbulence created by wave action for instance, and this may influence the particular type of sealant to be used.

Joint formation

Structural joints in the tiling should be located directly in line with structural joints in the concrete below. They should normally be the same width or a width to provide an equivalent sealant performance to that of the joint in the concrete. Stress relieving joints in tiling should be parallel sided and should pass through the tiles and the bedding screed and/or render.

The depth of the joint should be controlled by the use of a compressible joint filler. This is normally a closed cell foam polyethylene backing. Where there is only limited depths of joint, a polythene bond breaker tape may be required. In cases where the hydrostatic pressure is an issue i.e. deep diving pools, a more dense backing may be required to support the load.

Stress relieving joints should normally be a minimum of 6mm wide x 6mm deep. Structural joints should have a depth of sealant at least equal to the width, but not less than 12mm and should be supported by the joint backing material.

When forming a joint by casting concrete or screed against a polyethylene former it is probably that the former will become contaminated.

Before applying sealant into the joint, it is important to ensure that there is sufficient depth above the former and that a suitably uncontaminated surface is achieved beneath the sealant.

To achieve a clean uncontaminated surface, either the foam polyethylene former can be cut back sufficiently to allow for the introduction of a new foam polyethylene joint backer or a self-adhesive polyethylene bond breaker tape be applied to the upper surface of the polyethylene former.

Chemical and Water effects

Whenever joints are sealed in and around swimming pools the sealants used are substantially immersed most of the time in service. The water in which they are immersed contains additives, which may cause chemical attack. Generally joints in the pool shell behind the tiling are less susceptible to chemical attack as they tend to be protected by the bedding or screed and/or render.

Sealants can also be attacked by water movement or by a combination of chemical attack and water movement causing erosion of the sealant. In addition strong cleaning materials can also attack the sealants.

Premature contact with the water or cleaning fluids before the sealants are properly cured can seriously damage the sealant.

Sealants

Two-part modified epoxy resin based types which cure to a hard compressible sealant are used in stress relieving joints. Application is generally by gun and they are generally quick curing. Sometimes they are capable of being applied to wet surfaces or even under water, but water turbulence must be kept to a minimum during their cure period.

They are substantially quicker curing than the polysulphide types and because of these properties are generally more suitable for temporary or permanent repairs to the pool. It should however, be recognised that these types of sealant should only be used in appropriate joint types.

Two part polysulphide sealants need to be of a type that offers resistance to the chemicals within the pool. They also need to be able to accommodate movement in both tensile and compression and need to be of a modulus that will resist foot traffic loads and some hydrostatic pressures. They will differ considerably from polysulphide sealants used to seal movement joints in buildings as these types of sealants would generally be too low in modulus to resist the pressures and would be extremely vulnerable to chemical attack.

The polysulphide sealants are normally used for the sealing of the construction joints in the shell of the pool or structural joints both in the shell and in the tiling, they are also used to seal peripheral joints in walkways etc, particularly where the tiles abut structural walls. In order to achieve the maximum bond to the tile edges or bedding or screed and/or render or the edge of the joint in the concrete shell primer systems are normally required, and these can be more complex than those used when sealing movement joints in other constructions.

Joint preparation

The tiles must be fixed and the adhesive or bedding allowed to cure thoroughly before joints are sealed. Joints must be cut or formed with parallel edged, free from contamination with grout bedding or other materials. Any loose grout adjacent to the joint should be removed and made good with the sealant in the course of sealing the joint.

Back-up Materials

In pools up to 4 metres deep, dense, close cell polyethylene foam sections should be used as a joint back-up material. In pools greater than 4 metres deep expanded neoprene or expanded butyl rubber should be used as back-up material inserted to give the correct joint dimensions.

Priming

It is advisable to carry out adhesion tests to the tiles before sealing the joints; this will identify the most appropriate priming systems should it be required.

Mixing

Both the epoxy type and the polysulphide types are two-part materials and therefore require very careful mixing. This is particularly important, as any unmixed or partially mixed material will be extremely vulnerable to attack from chemicals within the pool water. Care must be taken in mixing to ensure that the curing agent is evenly dispersed throughout the base compound; also care must be taken to minimise the amount of air inclusion during mixing. This is best achieved by using slow running mixers and using special spiral stirrer blades.

Application

It is important to ensure that when applying the sealant that the joints are solidly filled, avoiding any air entrapment, this is best achieved by using a nozzle that fits the joint, and then ensuring it is well compacted by tooling the sealant.

Joint Protection

Joints sealed with two-part polysulphide sealants require protection until they are fully cured and should not be exposed to contact with water or cleaning chemicals for a period of 14-21 days, depending on the temperatures during the cure cycle. Epoxy based sealants can often be exposed immediately to water provided there is little or no turbulence and can be exposed to cleaners or turbulent water approximately after 48 hours.

8 WATER TREATMENT

The water in swimming pools has to be maintained in a safe, hygienic condition and comfortable condition for the bathers. There are no mandatory requirements however any pool operator must provide safe water in a swimming pool under health and safety regulations. Guidance on the generally accepted requirements is contained in "Swimming Pool Water Treatment and Quality Standards".

The water in a swimming pool will gradually become polluted whilst in use and the addition of pool water treatment chemicals will gradually increase the amount of dissolved solids in the pool water. The water has to be treated to remove the pollutants and keep the dissolved solids to an acceptable level to maintain the water in a quality suitable for bathing. Disinfection and filtration will remove most pollutants and dilution of the pool water is achieved by additions of fresh water after the filters have been backwashed. The pollutants can be divided up into surface pollution (hair, dust, body fats and other floating debris), dissolved pollution (urine, perspiration, cosmetics, etc.), suspended pollution (fine insoluble solids) and insoluble materials (sand, precipitated chemicals, etc.).

The water treatment system should effectively circulate the pool water through the pool water treatment equipment and also ensure that the circulation of the water in the pool is effective so that treated water reaches all areas of the pool. Surface pollution should be removed by scum channels, surface skimmers, or deck level overflow, whilst insoluble pollution deposited on the base of the pool should be removed by daily sweeping or vacuuming.

Where chemicals are added to the pool the total dissolved solids (salinity) of the pool water will increase. This has to be kept in check by draining off a sufficient amount of the pool water and adding (topping up with) fresh water to reduce the total dissolved solids level of the water in the pool. This is usually achieved by backwashing the filters so that the collected pollutants are lifted off the filter bed and wash down the drain. If the total dissolved solids are allowed to rise too high the pool water will taste salty and other problems are more likely to occur. The total dissolved solids should not exceed 1000 mg/l above source water with a maximum of 3000 mg/l

To ensure good quality water in the pool the treatment of the pool water should ensure that:

- an adequate disinfect level is maintained at all times
- surface water is continuously and efficiently drawn off
- the filtration equipment is operating effectively
- flocculants and algaecides are used as necessary
- the pH of the pool water is maintained in the optimum operating range
- the pool water is maintained at the appropriate temperature
- the pool water is correctly balanced
- the total dissolved solids are kept sufficiently low by adequate topping up water

Where chemicals are added to the pool water they should first be dissolved to make up a solution and, where proprietary materials are used, the manufacturer's instructions should be carefully followed. The pool water should be regularly checked every four hours using the appropriate testing equipment particularly where automatic dosing monitoring equipment is employed. This monitor equipment should be regularly independently calibrated.

Pool water quality

The pool water should be treated to ensure that it not only provides hygienic and comfortable conditions for the bathers but also provides water that will not degrade or erode the materials and equipment that it will come into contact with. The standard method of ascertaining that the pool water will not degrade or erode materials in the pool is to test the saturation index (balanced water index) of the pool water regularly to maintain balanced water conditions.

The balanced water index of the pool water is calculated from the calcium hardness, bicarbonate alkalinity and pH of the pool water, taking into account the temperature and salinity (total dissolved solids) of the pool water. The original work on a balanced water index was intended to determine if water in heating systems would either be aggressive and corrode the pipes, or deposit lime scale that would gradually block the pipes. This work produced a method of indicating if the water was within a range where either any scale forming, or corrosive tendencies to iron pipe work were negligible. The use of the balanced water index was useful in heated swimming pools as, when cast iron pipes were used, pool water with aggressive or corrosive tendencies would form 'rust' stains on the tiling where it entered the pool, as well as eroding the cement and sand grout. It is important to bear in mind that water with low calcium content may be aggressive to cement-based mortars but not to cast iron pipe work.

With low levels of calcium hardness and bicarbonate alkalinity the pool water has little buffering capacity against changes in pH caused by the addition of acidic or alkaline chemicals. In these circumstances the water can easily switch from a balanced condition to either an aggressive or scale forming condition with small additions of either acidic, or alkaline chemicals making it difficult to consistently maintain balanced water conditions. For this reason it is best to maintain sufficiently adequate levels of bicarbonate alkalinity and calcium hardness with the balanced water index just slightly on the negligible scale forming side of an ideal balance, e.g. 0.0 to +0.5 using the Langelier index.

Calcium hardness and bicarbonate alkalinity levels

Where the water supply is soft the calcium hardness and bicarbonate alkalinity levels will be low but the pH value may be high. If such water is used in the pool without treatment the pool water could still have the tendency to dissolve lime out of cement-based mortars, even though the water gives an apparently suitable balance index with respect to metal components. This situation can be corrected by increasing the calcium hardness and bicarbonate alkalinity levels either by selecting a pool water treatment system that adds calcium salts to the pool water, or by artificially hardening the pool water. As a general guide a calcium hardness of at least 200 mg/litre expressed as $CaCO_3$ and a bicarbonate alkalinity of at least 80 mg/litre expressed as $CaCO_3$ should be considered where the pool water comes into contact with cement-based mortars within a pH range of 7.4 to 7.6. The optimum values will depend on the disinfectant used and other factors e.g. if the main water supply is soft then a higher calcium hardness value can be helpful.

Sulphate levels

The maximum permitted concentration of soluble sulphates in swimming pool water is given in BS 5385: Part 4: 1992 and is 300mg/litre (expressed as SO_3 equivalent to 360mg/litre SO_4) for swimming pools where cement-based mortars are used. This is a maximum level and the level in the pool water should be kept as low as possible since the effects of sulphate attack is dependent on the concentration.

9 CURING and DRYING PERIODS

The need for adequate curing and drying periods at all stages of the construction process before tiling is even commenced cannot be underestimated, as drying shrinkage is the most often encountered cause of any subsequent tiling failure.

British Standard BS5385: Part 4 : 1992 sets out minimum curing periods which are referred to below.

a) Concrete shells constructed to BS8007

The primary objective in the construction of concrete shells is that the basic structure should be watertight and containing no structural movement joints. There is a direct correlation between drying periods for concrete and its mass to such an extent that large mass concrete constructions may take longer than six months effectively to dry.

Pool shells of minimum thickness construction and/or small size will take an absolute minimum of six weeks between casting and commencement of rendering/screeding or direct tiling.

Atmospheric conditions and period of the year when cast both have a bearing on curing times and a prolonged period of wet weather will increase the six weeks minimum.

Other forms of construction may require different drying periods and specialist installer's advice should be sought.

Although it is possible to reduce the period for pneumatically sprayed swimming pool tanks owing to the reduced water content, specialist advice must be taken in these circumstances.

b) Screeds/renders

Where screeds/renders are included or form part of the pre-tiling process of establishing flat and level surfaces a further curing and drying time of at least three weeks will be required.

Screeds and renders should be kept covered with water proof sheeting for at least seven days after laying or applying to allow them to cure effectively. They should then undergo a further fourteen days air drying before tiling commences. The purpose of the waterproof covering is to enable the applied layers to gain strength whilst delaying drying shrinkage. When drying shrinkage subsequently takes place the applied layers are better able to resist stresses caused by shrinkage. Again, longer periods may be necessary dependent on atmospheric conditions.

Again the time period relates to minimum applied thicknesses. For greater thicknesses one needs to be aware of the rule of thumb for drying of cement based layers of 1 mm per day for thicknesses up to 50 mm in ideal atmospheric conditions.

c) Tiling and grouting

Minimum period between completion of tile fixing and commencement of grouting is three days, assuming cementitious adhesives are being employed. As it is not good practice to grout finished work in small patches, the bulk of the installation is likely to have had a far longer drying time.

Use of epoxide or rapid setting cementitious adhesives may allow a reduction of this period.

d) Sealant application

The minimum period between grouting and sealant application is three days.

Curing time after sealant application is dependent on materials employed. Polysulphides will require at least 21 days whereas epoxides will be fully cured within forty eight hours. Choice of sealant will also dictate the length of time between tiling/grouting and mastic application as polysulphides require dry cavities whereas some epoxides can be applied to damp joints.

e) Pool Filling

The completed installation should stand for a minimum period of three weeks before pool filling commences providing that all the criteria for curing sealants have been met.

Pool filling should be undertaken slowly in order to minimise stresses arising from loading and thermal changes arising from the impact of mains water.

Rate of filling should be carefully controlled to ensure water level rises at no more than 750 mm every 24 hours.

Similarly stresses arising from initial heating will be minimised by restricting the rise in temperature to 0.25 °C per hour.

10. CLEANING AND MAINTENANCE

Initial Cleaning Instructions

a) **Cementitious Grout**

The grouting process leaves behind the residue of jointing mortar, known as “cement film”. Proprietary cleaners should be used for the cleaning process.

When using chemicals, attention must always be paid to the fact that the joints should be saturated with water otherwise the chemicals in the cement film remover can degrade the surface of the joint and thus lead to new films of cement being formed. Following the cleaning process it is thus advisable to thoroughly wet the floor several times and then to take up the water completely each time – this applies in particular when ‘powdering off’ was carried out after the jointing. The adding of a little detergent to the water improves the wetting and helps to neutralise the chemicals in proprietary cleaners.

In no case should puddles or a grey film be allowed to remain behind. Good quality sponges and strippers work well.

In the case where the cement film cannot be removed until after several days have passed, and where the floor may have been walked on before this, it is recommended that cleaning is carried out with grease-loosening agents before the cement film remover is used to eliminate the possibility of the cement film being protected by a layer of grease which prevents the chemical from acting.

b) **Reaction Resin Grout**

It is essential that any residues of grouting are removed before the grout mortar sets. If this is not done the favourable product properties of ceramic tiles e.g. slip-resistance, can be altered. Any set and hardened epoxy grout residues that are not removed immediately after the grouting process, will be extremely difficult to remove later.

It is essential with epoxy resin grout that the residual film is wiped off with a moist sponge as work proceeds before the resin sets, using a water-based solvent cleaner. Any residue remaining will be very difficult to remove.

Cleaning specification for the removal of Excess Grout Residues from Ceramic, Profile and Corundum Tiles

Cementitious Grout

1. A safe descaling acid that will not harm the surface of the tiles is required.

Such a product would be ideally based on Sulphamic acid with other detergent ingredients. The product should be diluted at one part to three parts of water, applied to the surface to be cleaned, agitated with an appropriate hard bristle brush, allowed to stand for 5 minutes, agitated once more and then rinsed away using clean water.

Try a test area initially and ensure that floor surface is wetted before application.

2. **Epoxy Grout**

- Thin films of set epoxy grout can be removed by the careful application of a water-diluted paint stripper containing dichloromethane (methylene chloride). The manufacturer’s

instructions must be carefully followed. Cleaners should not be left in long term contact with surfaces.

- Thicker localised deposits may also be removed by the careful application of the same paint stripper undiluted. Extreme care should be taken to avoid the undiluted paint stripper coming into contact with stainless steel, other metals, sealants and plastic fittings etc. Cleaners should not be left in long term contact with surfaces.
- Thick layers may need more than one application
- Thorough washing off with clean water (not pool water) is required
- All safety legislation must be complied with

It is therefore essential that a very strict cleaning regime is employed and close inspection follows the cleaning operation to ensure no deposits are left on the face of the tile, in particular carborundum faced anti-slip tiles. This immediate cleaning process will be successful using detergent based products which again will not damage the surface of the tile. If by any chance the cleaning regime fails and residues of epoxy grout are allowed to set across the surface of the tile, removal becomes extremely difficult. In this case a highly concentrated solvent product should be used.

This product should be applied by brush to the surface as a thick coating, allow several minutes for the product to work and remove with a scraper or Wet Vac Machine.

In situations where deposits are particularly thick, more than one application may be necessary.

General Routine maintenance of ceramic profile and corundum tiles

In order to maintain the surface quality of these tiles, it is important that a strict cleaning regime is implemented, the soiling that collects on these tiles is a mixture of body fats, skin, scale and other deposits which require regular treatment using appropriate products specifically designed for cleaning tiles in swimming pool areas and equipment.

Daily Maintenance

At a suitable appropriate time, a daily cleaning cycle should be adhered to, using a suitable hard surface cleaner to remove the daily soiling caused by the above mentioned mixture. Again, the use of a deck or rotary scrubber would be an advantage.

Weekly Maintenance

To ensure that the tiles are completely free of soiling, a weekly deep clean using an effective but safe descaling liquid should be used along with a rotary or deck scrubber to remove stubborn soiling in accordance with the manufacturers instructions.

Cleaning Recommendations

- Swimming pool surrounds, beach areas and changing room floors

Cleaning unglazed floor tiles and terracotta tiles should be performed with cleaning solutions similar to those described in the glazed tile section above. Powdered cleaners should not be used on unglazed tile floors on an occasional basis to remove localised surface staining.

- Pool Hall and Changing room walls

Wiping glazed tiles with a damp sponge, a sponge mop or cloth is all that is usually necessary to maintain their lustre. Where moderate staining occurs, routine cleaning may be performed with appropriate non-abrasive proprietary cleaners For heavily soiled surfaces, a stronger solution may be used.

Soap should not be used to clean ceramic tiles as it forms a film which dulls the lustre and promotes the growth of mildew and bacteria in damp areas such as showers.

The cleaning solution used should always be thoroughly removed from the surface by rinsing with clean water.

If the grout is dirty, scrubbing with a plastic bristle brush may be required. Steel wool type scouring should never be used to clean tiles as pads leave small particles on the surface of the tile and in the grout. These may then rust producing unsightly brown stains.

- Shower Area Wall and Floor Tiles

Hard water deposits, soap, scum and body oils build up, therefore thorough and frequent cleaning is essential.

The best way to prevent build up of soap, scum and body oil deposits is to use a plastic scouring pad with the appropriate cleaner when cleaning.

Showers with inadequate ventilation to remove excess moisture usually have continual fungal growth on the tiles. This can be controlled by wiping with a dilute solution of bleach and leaving it for five minutes before cleaning off. If the fungal growth is not completely removed the bleach may be re-applied and scrubbed with a brush to loosen. The surface should always be rinsed thoroughly with clean water. Bleach should always be used with caution and never mixed with other chemicals. Adequate ventilation should be provided when using these materials.

Reference can also be made to the “The Cleaning of Ceramic Tiles” published by The Tile Association.

11. BIBLIOGRAPHY

BS882:1992
Specification for aggregates from natural sources for concrete

BS5262:1991
Code of practice for external renderings

BS5385 Wall and Floor Tiling:
BS5385:Part 1:1995
Code of practice for the design and installation of internal ceramic and natural stone wall tiling and mosaics in normal conditions.
BS5385:Part 2:1991
Code of practice for the design and installation of external ceramic wall tiling and mosaics (including terra cotta and faience tiles)
BS5385:Part 3:1989
Code of practice for the design and installation of ceramic floor tiles and mosaics
BS5385:Part 4: 1992
Code of practice for tiling and mosaics in specific conditions
BS5385:Part 5:1994
Code of practice for the design and installation of terrazzo tile and slab, natural stone and composition block floorings.

BS5492:1990
Code of practice for internal plastering

BS5606:1990
Guide to accuracy in Building

BS5980:1980 (1997)
Specification for adhesives for use with ceramic tiles and mosaics

BS6431:- Ceramic floor and wall tiles

BS8000
Workmanship on building sites
BS8000:Part 8:1994
Code of practice for plasterboard partitions and dry linings
BS8000:Part 9:1989
Code of practice for cement/sand floor screeds and concrete floor toppings
BS8000:Part 10:1995 Code of Practice for plastering and rendering
BS8000:Part 11:Section 11.1:1989(1995)
Ceramic tiles, terrazzo tiles and mosaics
BS8000:Part 11:Section 11.2:1990
Natural stone tiles
Bs8000:Part 16:1997
Code of practice for sealing joints in buildings using sealants

BS8007:1987
Code of practice for design of concrete structures for retaining aqueous liquids

BS8204:Screeds, bases and in-situ floorings
BS8204-1:1999
Concrete bases and cement sand levelling screeds to receive floorings – Code of practice.
BS8204:Part 2:1987

Code of practice for concrete wearing surfaces
BS8204:Part 3:1993
Code of practice for polymer modified cementitious wearing surfaces
BS8204:Part 4:1993
Code of practice for terrazzo wearing surfaces
BS8204:Part 5:1994
Code of practice for mastic asphalt underlays and wearing surfaces

BS EN ISO 10545:Ceramic Tiles (Test Methods)

ISO/FDIS 13006 – Provisional international standard on ceramic tiles – Definitions, classification, characteristics and marking.

prEN 12004 – Provisional European Standard on Adhesives and Grouts

British, European and International Standards are available for purchase from the British Standards Institution, 389 Chiswick High Road, London W4 4AL Tel 020 8996 9000 Fax 020 8996 7400

Section 3 “Tiles” makes reference to Amateur Swimming Association and FINA regulations, which are available in the following publication: “The ASA Information Binder 1996. ASA telephone number 0800 220292

Swimming Pools by Philip Perkins, published by E & FN Spon, 11 New Fetter Lane, London WC4P 4EE Tel 020 7583 9855

“Swimming Pool Water Treatment and Quality Standards” published by Pool Water Treatment Advisory Group, Melton Mowbray, Leicestershire

“The Cleaning of Ceramic Tiles” published by The Tile Association Tel 020 8663 0946