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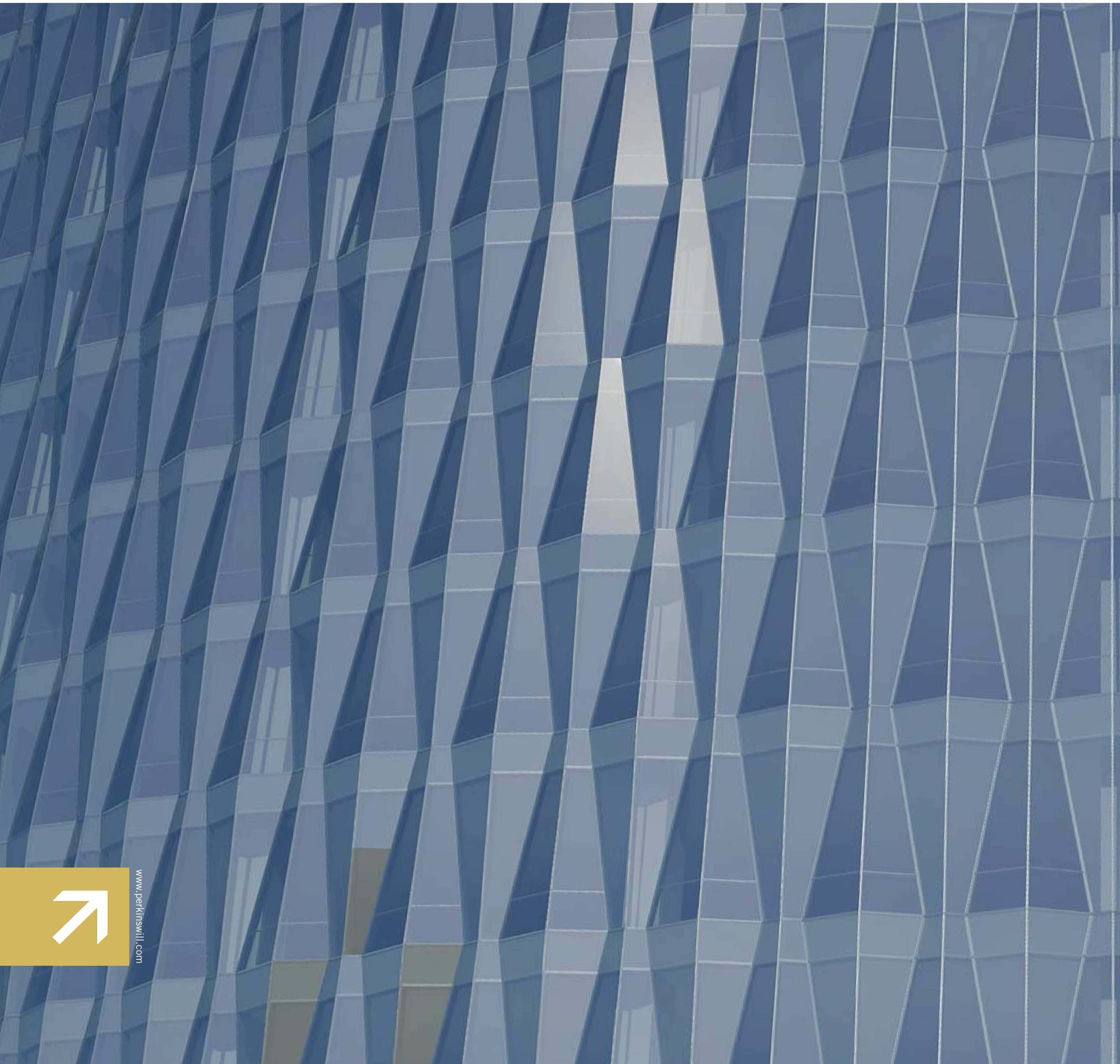

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DESIGN CONSIDERATIONS FOR POOL ENVIRONMENTS:
Cold Climates

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ABSTRACT
The natatorium environment is one of the most challenging environments to design and build in northern climates. This is due to the large swings in levels of humidity and temperature between interior and exterior conditions. The challenge remains how to balance the interior pool environment, requiring a consistent temperature and humidity level with the exterior; while taking into account the atmospheric by-products of chlorination.

This article reviews the predominant elements present within the pool environment. It discusses elements that cover a broad range of pool related design issues and explores considerations to be aware of when designing a natatorium and its interfaces. The discussion will first define the basic elements within the pool environment that must be understood, air temperature and humidity, air quality and movement and air pressure. The remainder of the article will cover a broad range of pool-related design issues and explore considerations to be aware of when designing a natatorium and its interfaces. Some of the factors that should be considered during the design phase of a project include the functionality of the mechanical system, the ratio of solid to void in the exterior skin, massing of the pool volume, curtain wall and glazing, finishing materials (interior and exterior) and their durability and control of the vapour migration and roof and ceiling finishes. All will have an impact on decision making. The intention of all decisions is to create an enduring enclosure that provides comfort and recreation to its patrons.

KEYWORDS: air vapour barrier, air handling systems, chloramines, envelope design

1.0 INTRODUCTION
One of the most important elements that we first look at when we begin a project is the environment. We examine the context, site, the weather patterns, views and vista, circulation and a localized characteristics. All together this information provides us with the knowledge that will inform the design process.

When developing a natatorium the approach is similar. By examining the composition of the pool environment, air temperature and humidity, air quality and movement and air pressure, we can establish the type of environment within which we are working.

When the environment is known, we begin to design the necessary elements that will physically generate the pool environment. Any decisions regarding the exterior envelope, interior materials, glazing, roofs and ceilings, volume orientation and structural materials must be considered in relation to the overall pool environment for compatibility. When these items have been thoughtfully considered, we have a better understanding of the functioning of the pool and its limitation and the possibilities of the natatorium typology.

2.0 RESEARCH CONTEXT AND PAST STUDIES
The basic elements contained within a natatorium are: pool(s), deck, slides, change rooms, monitoring, patron viewing, saunas, whirlpools and spray features. All of these items contribute to the functionality and patron experience within a pool. The factors that affect conditions include air temperature and relative humidity, air

movement and air pressure. These elements are impacted by the large swings in external temperatures to which the pool environment must adjust to maintain its operation balance. The following sections review considerations for interior natatorium environments.

2.1 Air Temperature and Humidity

The air temperature of the pool environment needs to be set higher than the temperature of the pool water to prevent condensation occurring on interior surfaces. Typically, it is set to be two-three degrees warmer than the water temperature and is typically designed to be 77 degrees F for competitive pools to a warmer 94 degrees F for therapy pools. The humidity level will be approximately 60-65 percent. These conditions influence design considerations such as choice of materials within the pool area, air handling and condensation issues[1].

Materials within a pool should always be impervious to moisture penetration. By preventing the use of carpet, untreated gypsum board, wood laminates as well as untreated metals premature deterioration can be avoided. Elements like door and window frames should always be constructed of aluminum due to their inherent resistance to constant moisture (the composition of the wall assemblies will be discussed later). Permanent elements within the pool area such as spray features, hand rails, hanging acoustic panels, lighting and signage should all be considered for materiality.

2.2 Air Quality and Air Movement

Perhaps the largest misconception is that the quintessential 'smell' of a pool is attributed to the use of chlorine. In fact this odour is created by chloramines. Chloramines are a by-product of the interaction of bather's sweat, body oils and other ammonia-nitrogen compounds with lower than required levels of chlorine, creating chloramine compounds. Airborne chloramines in large quantities will begin to irritate bathers and can begin to infiltrate spaces creating on overpowering smell that can affect patrons not involved in the pool function[2].

This is one compelling reason why the decision regarding air movement within the pool environment is pivotal. Another is that chloramines are corrosive and will hasten the deterioration of unprotected metal surfaces. Even stainless steel is not fully resistant to the actions of chloramines. There are various mechanical air and water treatments that can be used to lessen the quantity of chloramines in the pool environment, but these will not negate the need to separate the pool environment or choose resistive materials and finishes.

Several methods can be used to deliver air to a pool volume, but the most effective is the method that will provide the best air movement within the volume. While low-level supply air will provide maximum comfort for bathers, it also creates the condition for condensation at the ceiling level. The amount of air flow created with perimeter supply at the exterior walls will prevent condensation at the exterior glazing, but will do very little to address the temperature needs of the bathers. Higher level return with low level supply creates a convective current of air that maximizes air circulation through the pool volume. Separate perimeter supply at glazing will address the issue of sweating glass during the seasonal shifts in temperature. The components of the supply and return of air will be discussed in more detail.

2.3 Air Pressure

The air pressure that builds up in the humid pool environment will inevitably seek to escape through the easiest path to the location of lesser pressure. In a pool environment, controlling and mitigating this pressure is necessary to maintain the necessary relative humidity and temperature, but also to protect the HVAC system, the exterior shell and the surrounding interior spaces. Serious air leakage due to pressure against poorly installed, poorly detailed or incompatible materials will force the HVAC system to continually condition air, thus reducing its efficiency and its life span. To guard against this scenario, the pool volume should remain in constant negative pressure. By doing so, chloramines and moisture will not be permitted to escape into the remainder of the facility and at the same time the pool will be replenished with dryer air than what is present within the pool. This is especially advantageous in the summer months when the exterior air can be warmer and more humid than the pool environment. Drawing the already conditioned interior air, albeit a small amount, will allow the HVAC to run more smoothly, negating the need for make-up air from the exterior.

The environmental considerations discussed in this section will have a significant effect on the design decisionmaking process. Detailing to avoid air leakage, maintaining negative air pressure and protection against material adjacencies for prolonged durability of the facility, program, circulation, enclosure, cost and construction all play a role. To determine the course of action, a series of basic design decisions become necessary without which these elements can cause problems within a pool environment, leading to prolonged shut-down and costly repairs. The following section dis-

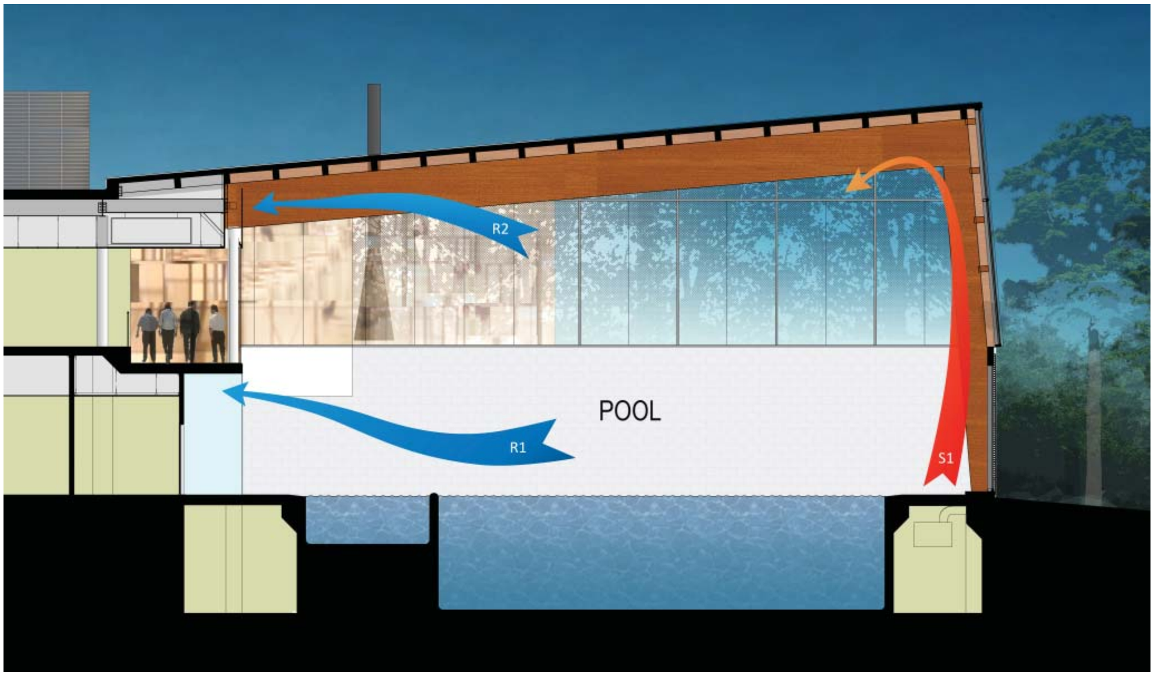
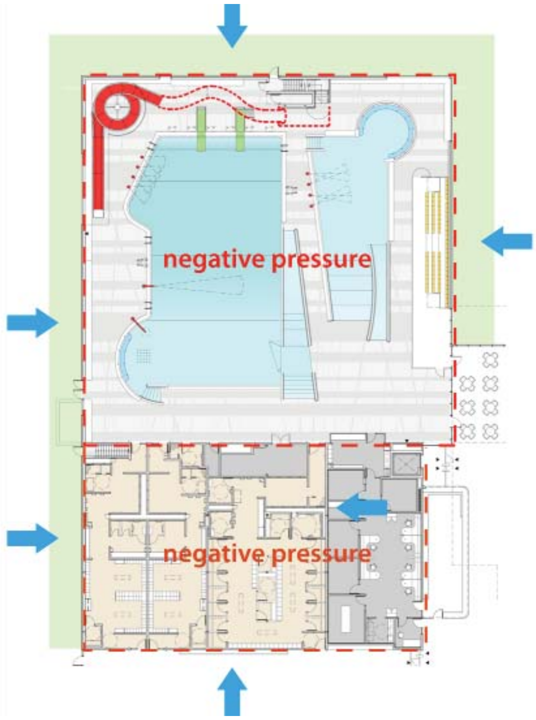


Figure 1: Air movement; S1- provides perimeter low level air supply, moderates temperature at glazing; – R1 - return air draws air from above the pool tank; R2 - return air draws air from high level.



Figures 2: Illustrates the pressure required in a pool environment and the adjacent spaces.

cusses design considerations and guidelines that can be followed.

3.0 DESIGNING FOR QUALITY 'DECISION POINTS'

3.1 Air Handling Systems

Two points of view exist when considering options for HVAC systems to be used in a pool environment:

1. The 'push-pull' system consists of a make-up air handling unit sized for six air changes/hour. The unit is capable if exhausting 100 percent of the supply air during a period when the exterior air conditions permit free cooling. The unit will typically run with minimal outdoor air to control the humidity. The air handler is complete with filtration and heating coil, but no cooling coil, which can cause problems in northern climates. The problem is that the unit is much less effective in the warmer summer months where the exterior air can be equally, if not more, humid than the air within the natatorium. No cooling coil means that the increase in temperature and humidity within the pool cannot be controlled. This condition would occur approximately 15 percent of the time depending on the geographic location.

2. Pool Area Dehumidification Systems (PADS) are sized for approximately four air changes/hour. The compartmentalized unit contains a supply fan, heating coil, refrigerant cooling coil and has the ability to transfer recovered heat into the supply air stream or into pre-heating of the pool water creating energy savings and reducing the operational cost of the overall pool system.

Both systems are suitable for use in northern climates, but as the demand continues to grow for more energy efficient buildings, so will the demand for the systems that are required to handle a greater range of conditions.

Evaluating the two systems will bring three considerations to light. The PADS system will provide continuous control of the environment during all seasons while the 'push-pull' will be forced to mimic the summer temperatures in temperature and humidity. A higher capital cost of the PADS will be offset by a four-six year payback through the heat recovery used for the pool water and the outdoor air. The final, perhaps the most important and least tangible, is the effect that a consistent humidity level has on the structural elements within the pool and its adjacent spaces. Pool environments that are susceptible to swings in relative humidity will allow conduits of corrosion to develop and will pre-maturely deteriorate the facility over time. Due diligence suggests that a PADS type system is perhaps the best solution given its potential for energy savings and ability to maintain a constant negative pressure while providing a relatively short payback.

3.2 Envelope Design

There are two envelope considerations: the internal and external. The design of exterior walls requires a balance of achieving design intent to attract visitors while maintaining a comfortable interior environment. In this case, careful decisions will ensure that the building is suitable aesthetically, but also tectonically. For both the internal and external envelope, the designer must bear in mind that the goal is to ensure the aquatic space remains in negative pressure. Proper material selection and detailing is required to ensure the wall system withstands the pressure differential from interior to the exterior.

3.2.1 Air Vapour Barrier

A continuous vapour barrier is critical to maintaining air pressure differential and separation of environments. All exterior solid walls will be required to have a vapour barrier that ties into the curtain wall/screen system to ensure continuity. Care should be taken to ensure that the impermeable vapour barrier is installed on a flat surface and should be overlapped by 12 inches and tapped at all joints on the warm side/pool side of the insulation. This will ensure that the pressure being exerted on the exterior envelope, from keeping the pool volume in negative pressure, is not escaping into the wall and condensing. To further protect the wall system, using spray-applied urethane foam is ideal for use in a pool environment. It is forgiving in terms of its application over less than perfect wall constructions and it will also expand to fill all voids leaving less chance that small capillaries will remain through which moisture can migrate. It should be noted that spray-applied urethane foam is not a vapour barrier. Spray foam insulation should be used in conjunction with a compatible adhered membrane to ensure maximum moisture protection[3].

3.2.2 Structure and Exterior Wall Materials

Masonry is a logical choice for the interior wythe of an exterior pool wall. It will provide a durable base on its own or can act as a substrate for an impervious finishing material. It also has spanning capabilities. Typically, a block wall can span vertically a sufficient distance to interface with a horizontal steel girt that will be performing two functions (supporting the curtain wall system and providing lateral support at the top of the masonry wall). Depending on the volume and the configuration of the curtain wall system, the introduction of several levels of girts supporting block is an acceptable way to create the overall wall system.

The supporting steel structure must be thoughtfully detailed and the layer of finishing should be clearly specified. Columns, girts, roof decking, supports and bracing should be factory cleaned and primed with final painting taking place on site. Site welding should also take place at steel connections in lieu of bolted connections. This will reduce areas where condensation can occur creating staining on the surrounding steel and the pool deck. The use of other metals in the pool should be approached with care. Door frames, grilles, escutcheon plates and handrails should be constructed out of stainless steel or aluminum, depending on what is appropriate. Both provide good moisture resistance[3].

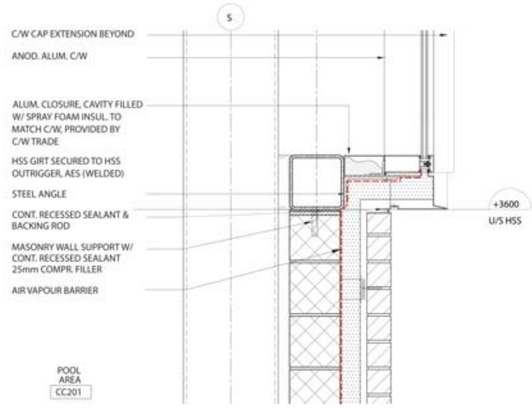
Another structural option is treated engineered wood. Due to the capacity of the treated wood to resist moisture and absorb thermal changes, wood has a significant advantage in the longevity of the wood surface that will not require maintenance in a continuously humid environment.

Curtain wall glazing is the recommended system for a pool environment due to its specified thermal performance. Whether annodized or pre-finished, the curtain wall should be aluminum with specified warm edge spacers, argon filled cavities within the glazed units and fiberglass pressure plates. These provide further protection against thermal bridging. Care should be taken to detail the tops of the curtain wall verticals and fill them with spray insulation. Premature failure of the curtain wall can occur through convective current within the curtain wall frames themselves. Air, heated from contact from the sun, will rise through the vertical mullions and, if not properly sealed, can exhaust warm air on colder steel either at parapet details or at intermediate supports and cause premature corrosion. The curtain wall should also be detailed to separate the horizontal mullion at the bottom from the ground condition. Freeze-thaw action underneath the caps of the curtain wall can rupture the sealed units and, within a pressurized pool environment, water vapour will quickly move into these locations and condense leaving the window units permanently foggy until they are replaced.

Wood is generally not acceptable in large quantities as an exterior wall construction material. Structural wood decking, however, is ideal as a roof plane. Depending on the species specified for the loading conditions, various treatments are available to prevent the typical degradation of material one would expect. The density, thickness and self-sealing ability of wood allow any anchored elements to the underside of the deck to be corrosion free, unlike a metal deck. The use of exposed unpainted wood warms the space giving a more tactile feeling to the facility and eliminates any future maintenance. For a lasting appearance, wood deck should be treated and sealed.

Exterior cladding will be in contact with the climatic elements on a continual basis. To perform as a cladding material, the pre-requisites are simple: have a very low water absorption, allow for and maintain the ability to construct a pressure equalized rain screen and be durable in all weather conditions. Standardized unit masonry will facilitate this with ease as will any number of pre-manufactured panel systems. Almost any combination of materials can be implemented as long as bulk water is not trapped against the insulation (to limit the possibility of water to move into the building through wind pressure and the cavity) and has the ability to dry out.

3.2.3 Interior Wall Materials
The use of masonry as an interior demising wall is ac-



Figures 3: Section detail locating the vapour barrier on the warm side of the insulation. *Note:* The detail shows interface and transition from the vertical wall into the anodized curtain wall system.

ceptable as long as the following considerations are adhered to. The pool environment must be under negative pressure. This will allow a painted block wall, through its inherent properties, to act as an air barrier and retain the air within the pool enclosure. The demising wall of masonry should also separate the pool from the locker rooms and associated spaces. Adjacent spaces such as locker rooms do not require insulation or continuous vapour barriers, as the environments are complimentary and the condensation of moisture within the cavities of standard masonry block is not likely. Since the moist air is constantly being evacuated around the block and not through them.

Separation of programs dissimilar from the pool environment can be achieved through the use of aluminum framed glazed screens. Hollow metal, stainless steel or galvanized metal frames, over time and without a diligent maintenance routine, will succumb to corrosion.

3.2.4 Roof and Ceiling Finishes
Material selection for the ceiling of a natatorium is connected to a multitude of elements: acoustics, ceiling fixtures, roofing materials selection, HVAC ducting and structural elements. There are three options for the finish of a ceiling in a pool: wood, concrete or steel. In all cases the structure should remain exposed, as suspension systems within aquatic centres can be problematic due to the possible erosion of suspension framing. For wood decking, the cross nailed tongue and groove profile of the decking provides a uniform continuous level surface. It is possible to specify the use of sleepers above the deck to create an interstitial space that sup-

ports the routing of conduit and plate bracing. Aesthetically the pool volume will be unencumbered with the visually distracting conduit and wiring that supports the lighting, alarms, controls and A/V equipment. If this is not possible or affordable, the depth of the wood decking will allow anchoring of the system elements with the advantage that wood will self-seal around the anchors and not deteriorate or rust. The same is not true for steel deck. Penetrations through steel deck may corrode, therefore, the specification for the decking must be upgraded from a typical assembly.

Any steel deck within the pool environment must have a prefinished synthetic non-corrosive coating finish on the top and bottom with a dry film thickness of 8mil to resist corrosion. The deck must be fastened to the structure and not welded to avoid damaging the surface. Any deck penetrations are to be corrosion resistant and painted to match the deck. To maintain the environment under negative pressure, it is necessary to fill the deck flutes top and bottom along the perimeter of the pool. This also supports the intent of preventing the mixing of colder air above the deck with the warm moist air of the pool creating condensation in an area that is impossible to drain. Maintaining the non-permeable enclosure is not possible with an acoustic deck and should be avoided in the pool area. The acoustic properties in this type of steel deck are achieved with the use of perforations in the deck, which will trap moisture and corrode the deck from above in a pool environment. Instead, the use of acoustic panels is one alternative that provides an opportunity to accentuate the environment.

Lastly, concrete can be used within a pool environment without issues. The robust nature of concrete gives it the longevity to continually perform. It will, however, require acoustic treatment more so than wood or steel decking systems.

Acoustic panels play an important role in the life safety of a pool. Pool environments tend to be large open volumes this creating the ability for sound to travel in many directions, continuously reverberating and creating an echo. This poses a problem for the life guards. With a long reverberation time, it becomes difficult to distinguish between sounds. The life guard's whistle, a call for help or just joyful shrieking can be confused. Acoustic panels in the pool can be mounted to the walls or ceiling. In either case the panels are made up of two inches of semi-rigid insulation within an aluminum frame that is fully wrapped in a perforated, moisture resistant material covering. The acoustic panels can be suspended with stainless steel fittings and cables. The quantity for acoustic covering required mainly depends on the volume of the environment and the desired reverberation time. Typically, a reverberation time of three to five seconds is common.

Perhaps the most common element that is overlooked in the pool environment is the roof membrane and the roof vapour barrier. The shift towards sustainable building practices has more buildings moving away from modified bitumen roofing, Ethylene Propylene Diene Monomer (EPDM) and built-up roofs in favour of Thermoplastic Polyolefin (TPO) or reflective roofing systems. These newer roofing systems can assist in achieving green building rating systems, such as LEED, but must be installed in the correct manner. Any membrane in-

Figure 4: a) Steel roof deck over a steel and concrete structure with perimeter and centralized supply of air; b) Wood deck over a steel structure with perimeter only air supply.

stalled over a natatorium roof must be fully adhered. Typically, they are mechanically fastened, which creates the opportunity for the deck to be penetrated by incompatible fasteners that will only serve to increase the pace of corrosion in a metal roof deck. The roof vapour barrier must be self-sealing and adhered to the substrate. This ensures that the penetrations will be sealed. Lesser quality vapour barriers such as craft paper should not be considered for this application.

3.2.5 Exterior Wall Orientation

When deciding on the ratio of solid versus void the orientation and site conditions become important. With pools, controlling glare and heat penetration should be at the forefront. Changes in latitude affect sun angles, but generally protecting the pool environment from intensely consistent southern sun path is ideal. Northern light is the most advantageous as it is the most constant in rendition. Depending on the programming of the facility, eastern morning light may be favorable due to lower bather count. Reducing the heat gain from exterior light would be more beneficial in the afternoon and evening where the bather count is high in a warmer environment.

3.2.6 Glazing

Using the variables above, the massing of the skin should be designed to have lower bands of transparent glazing that allows light in without glare. While a southern elevation may have double height glazing, there is an advantage to splitting the glazing to reflect/block the intense sun above, but allow segments of light to enter the volume from below. Similarly, the west elevation could take advantage of the vista created by the setting sun by having a translucent screen at high level and a more transparent screen at low level. Ceramic fritting can also be used within the curtain wall system to control and block glare and heat gain. The decision to frit glass is necessary early in the process and should be designed to provide the maximum glare control.

All together heat gain and glare can be controlled by glazing and by the installation of motorized blinds. Motorized blind installation may create other problems from long runs of exposed conduit to cutting and drilling into materials that may have only been face-treated, therefore, negating the resistance to corrosion. It is advisable to plan and implement motorized blinds against heat gain and glare within the design stages. If done correctly, the units can be incorporated into the horizontal girt system used to support the walls themselves.

Figures 5: Shading devices within a pool environment.

4.0 CONCLUSION

The intent of this article is to illustrate the varied and often interconnected levels of decision-making that are involved in designing a pool environment. From the outset, many decisions must be made that will affect not only the pool environment, but the cost of the project. It then becomes important to ensure that when the decisions are being made that a comprehensive pros and cons mode of evaluation be employed to give the designers and the clients the necessary information to make informed design decisions.

In the early phases of the design, decisions relating to the air temperature and humidity will be determined by the type of pool that is being designed and the types of services the client will be able to offer their end-users (leisure pools versus therapy pools). Deciding on how the environmental balance is to be maintained is perhaps one of the most important factors to be considered. The larger pool environments will require larger conditioning system. This affects everything from the assembly of the exterior walls to the orientation of the pool volume and the interior finishes. Assemblies have to be incorporated that are both robust and capable of withstanding air pressure and protect against moisture migration through the system from high to low pressure.

By understanding and addressing the issues of materiality, air temperature, humidity, placement and types of vapour barrier, glazing, ceiling materials, volume, wall assemblies and HVAC systems, we can begin to re-examine the use and functionality of these items and continue to innovate in the development of the pool typologies.

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