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Swimming Pool with Composite Wall

Abstract

A swimming pool wall, and method for forming same, including a plurality of layers of reinforced composite material. Each layer includes a thermoplastic resin and a plurality of elongate glass strands of reinforcing material. A first set of the plurality of layers has the strands running in a first direction, and a second set of the plurality of layers has the strands running in a second direction. The first direction is offset in angle from the second direction, and the first and second set of layers are fused together to form a unitary composite wall. The pool wall permits the use of a composite material which provides sufficient strength and resists degradation. The wall structure may be a plurality of interconnected panels both arcuate and arcuate and planar in shape to determine the overall shape of the composite wall enclosing an area where water or ice is retained.

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Background/Summary

[0001] This application is a Continuation of U.S. patent application Ser. No. 18/123,800 filed on Mar. 20, 2023, which is a Continuation of U.S. patent application Ser. No. 16/645,264, filed March 6, 2020, which is the U.S. National Stage filing under 35 U.S.C. § 371 of International Application No. PCT/US2018/049697, filed Sep. 6, 2018, which in turn claims priority to U.S. Provisional Patent Application Ser. No. 62/556,055 filed on Sep. 8, 2017 and U.S. Provisional Patent Application Ser. No. 62/666,457 filed on May 3, 2018, the entire contents of each application being incorporated by reference herein for all purposes.

TECHNOLOGICAL FIELD

[0002] The present disclosure relates to a swimming pool having a composite wall, and more particularly, a swimming pool having a thermoplastic wall with reinforcing elements.

BACKGROUND

[0003] Swimming pool walls, and in particular above ground swimming pools, are typically constructed of a perimeter wall made from rolled steel material that is supported by frame elements. The perimeter wall forms an interior in which a flexible liner is placed to retain the water. This construction is beneficial in that it allows for above ground and semi-above ground pools of various sizes and shapes to be cost effectively manufactured and installed.

[0004] Some swimming pools are formed with a non-metallic sidewall such as flexible polymers. These pools include small children's pools which are filled with water of only a few inches deep and typically emptied after each use. Other non-metallic wall pools include an external frame. A pliable waterproof fabric is attached to the frame and forms a flexible basin. The weight of the water expands the basin walls to keep them apart. An upper edge may include an inflatable portion which floats and also helps the pool retain its structure. However, these types of pools are limited in the size and shape in which they can be formed. They lack the durability of steel wall pools.

[0005] Fiberglass reinforced polymer composite has also been used to formed pools. These pools are preformed offsite as a large rigid basin of thermoset polymers and then transported to the installation site. Due to the nature of the construction, transportation, and installation associated with such pools, the size and shape of the pool is limited.

[0006] While steel allows for above ground swimming pools to be formed in different shapes and sizes, the material can degrade, most often by corrosion, over time thereby limiting the useful life of the swimming pool. This is especially the case for pools using saltwater systems, which are becoming more popular. The salt can quickly degrade the properties of the steel pool wall and shorten its useful lifespan to retain thousands of gallons of water in a confined space against the perimeter strength of the structure. Moreover, regardless of use of fresh or salt water, any metallic structure could be adversely affected by the chemicals typically used to sanitize and otherwise maintain the water in the swimming pool. Even structures of aluminum can be affected.

[0007] Accordingly, it would be desirable to provide a swimming pool having a wall which can withstand the forces of a full size pool and still retain its shape and resist corrosive degradation.

SUMMARY

[0008] The present disclosure provides a swimming pool including a base rail, a top rail, and a plurality of supports extending between the top rail and the base rail spaced along a circumference of the base rail. A pool wall extends between the bottom rail and top rail and forming an enclosed perimeter of the swimming pool. The pool wall includes a plurality of layers of reinforced composite material fused together to form a unitary composite wall. Each layer includes elongate glass fiber strands of reinforcing material. One of the plurality of layers has the strands running in a first direction, and a second of the plurality of layers has strands running in a second direction, wherein the first direction is offset in angle from the second direction.

[0009] The present disclosure further provides a swimming pool wall including a plurality of layers of reinforced composite material. Each layer includes a thermoplastic resin and a plurality of elongate glass strands of reinforcing material. A first set of the plurality of layers has the strands running in a first direction, and a second set of the plurality of layers has the strands running in a second direction. The first direction is offset in angle from the second direction, and the first and second set of layers are fused together to form a unitary composite wall.

[0010] The present disclosure still further provides a method of forming a swimming pool wall comprising joining, to form a cylindrical structure, opposing ends of a laminate comprising a plurality of layers of reinforced composite material, each layer including thermoplastic resin and a plurality of elongate glass strands of reinforcing material, a first set of the plurality of layers having the strands running in a first direction, and a second set of the plurality of layers having strands running in a second direction, wherein the first direction is offset in angle from the second direction, and the first and second set of layers are fused together to form a unitary composite wall; and inserting a pool liner in the interior of the cylindrical structure.

[0011] The present disclosure still further provides a swimming pool including a base rail and a top rail. A plurality of supports extend between the top rail and the base rail spaced along a circumference of the base rail. A pool wall extends between the bottom rail and top rail and forming an enclosed perimeter of the swimming pool. The pool wall includes a reinforced polymer composite formed of a thermoplastic resin and e-glass fiber strands encapsulated therein.

[0012] The present disclosure still further provides a cylindrical structure requiring hoop strength to resist pressure from inside or outside the cylinder, including a sheet of reinforced fiber composite having opposing lengthwise ends. The sheet comprises a plurality of layers of glass fibers embedded in a thermoplastic matrix. The plurality of layers has multiple relative orientations among the layers. The structure includes a means for joining the opposing lengthwise ends.

[0013] The present disclosure further provides a swimming pool including a base rail, a top rail, and plurality of supports extending between the top rail and the base rail spaced along a circumference of the base rail; and a pool wall extending between the bottom rail and top rail and forming an enclosed perimeter of the swimming pool, the pool wall including an inner wall surface and outer wall surface and a core disposed there between, at least one of the inner wall surface and the outer wall surface including a plurality of layers of reinforced composite material fused together to form a unitary composite wall, each layer including elongate glass fiber strands of reinforcing material, one of the plurality of layers having the strands running in a first direction, and a second of the plurality of layers having strands running in a second direction, wherein the first direction is offset in angle from the second direction, the inner and outer wall surfaces being secured to opposed sides of the core.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] FIG. 1 is a top perspective view of a swimming pool incorporating the features of the present disclosure.

[0015] FIG. **2** is a top perspective view of a bottom rail for supporting a pool perimeter wall.
[0016] FIG. **3** is a cross-sectional view of the pool wall.
[0017] FIG. **4** is a partial perspective view of coping secured to the top of the pool wall.
[0018] FIG. **5** is a partial perspective view of the bottom of the pool wall.
[0019] FIG. **6** is a top view of the pool wall.
[0020] FIGS. **7A** to **7D** are side elevational views of various layers which form the pool wall.
[0021] FIG. **8** is an exploded view of the ends of the pool wall.
[0022] FIG. **9** is a top plan view of the pool wall ends joined together.
[0023] FIG. **10** is a top perspective view of an alternative embodiment of a swimming pool wall.
[0024] FIG. **11** is a perspective view of a wall panel of FIG. **10**
[0025] FIG. **12** is an exploded view of the wall of FIG. **10**.
[0026] FIG. **13**. is a partial end view of the wall of FIG. **10**.
[0027] FIG. **14** is a partial plan view of the wall of FIG. **10**.
[0028] FIG. **15A** is a top perspective detail view of two joined wall panels.
[0029] FIG. **15B** is a top perspective detail view of two joined wall panels showing a spline partially inserted.
[0030] FIG. **16** is a perspective end view of a wall panel with coping.

DETAILED DESCRIPTION

[0031] With reference to FIGS. **1-5**, a swimming pool **10**, includes a frame **12** and a perimeter pool wall **14** which is adapted to be secured to the pool frame **12**. The pool wall **14** forms and surrounds a pool interior **15**. A flexible pool liner **16** is disposed in the pool interior **15** and is generally attached to the top of the pool wall **14**. The liner **16** is formed of a waterproof material such as flexible polyvinyl chloride ("PVC") and forms a basin that holds the water.

[0032] The pool wall is made from at least thermoplastic resin and glass fiber. Non-limiting examples of the thermoplastic resin are polyolefins such as polyethylene (PE) in its various density grades and polypropylene (PP), polyesters such as polyethylene terephthalate (PET) and glycol modified polyethylene terephthalate (PETG), thermoplastic olefins (TPO), and combinations thereof. Of these polypropylene is present preferred.

[0033] Non-limiting examples of the glass fiber are e-glass and s-glass. Individual glass fiber diameters can range from about 10 μm (also called microns) to about 25 μm and preferably from about 14 μm to about 18 μm . The glass fibers can be introduced into the thermoplastic in the form of rovings. The glass fiber reinforcement can comprise continuous fibers or discontinuous fibers or both, depending the hoop strength of pool wall **14** needed. The diameters of glass fiber and continuity in the various layers of pool wall **14** can be the same or different depending on choice of the polymer engineer.

[0034] The glass fibers can comprise from about 50 weight percent to about 75 weight percent and preferably from about 60 weight percent to about 70 weight percent of the pool wall **14**, with the remaining weight percentage being the thermoplastic resin and also minor amounts, if any, of optional functional additives. The weight percent content of glass fiber in the various layers of pool wall **14** can be the same or different depending on choice of the polymer engineer.

[0035] The frame **12** includes various interconnected rigid elements including a bottom rail **18**, a top rail **20**, and a plurality of vertically aligned upright supports **22** spaced around the perimeter of the pool. The bottom rail **18** includes a plurality of members **19** joined together and laid upon a support surface **21**, such as level ground. The bottom rail **18** is laid in a configuration corresponding to the desired perimeter shape of the pool. The bottom rail **18** includes a groove **24** that receives and retains the bottom of the pool wall. The vertical supports **22** are secured to the bottom rail **18** and extend upwardly engaging the top rail **20** which forms an upper portion of the wall. Coping **26** may be used to secure the liner to the top rail **20** in a manner known in the art.

[0036] With reference to FIGS. **6** to **7D**, the pool perimeter wall **14** may be formed of a rolled sheet of a composite of material formed from thermoplastic material with reinforcing strands. This

material may be a single continuous sheet which is cut to length to form the perimeter pool wall **14**. Alternatively, a plurality of separate wall sections can be joined together to form the pool wall. [0037] In a preferred embodiment, the pool wall **14** may be formed of a reinforced polymer composite formed of a thermoplastic resin **30** and e-glass fiber strands **32** encapsulated therein. The glass fibers are preferably continuous strands of non-woven material extending unidirectionally, usually made by a pultrusion process in which the continuous pulling of strands through a polymeric bath permits formation of sheets, tapes, or other extruded shapes of strands reinforcing the polymer which has fused around such strands in such extruded shape. A number of companies make pultruded reinforced polymer composites, including PolyOne Corporation via its Advanced Composites Group, particularly its Polystrand business selling thermoplastic fiber reinforced composites.

[0038] In a preferred embodiment, multiple wall layers **14a-d** of reinforced material are joined together in a variety of relative orientations of fiber reinforcement to form a single wall structure **14**.

[0039] The reinforced material is laminate of a plurality of composite layers including at least a first composite layer and a second composite layer, each comprising a plurality of longitudinally and unidirectionally oriented fibers in a thermoplastic matrix. The plurality of composite layers are bonded together to form the laminate.

[0040] The various layers can have a unidirectional orientation or alignment of fibers **32** in the thermoplastic matrix relative to the direction of the pultrusion process. Zero degrees (0°) means that the orientation of the fibers **32** is the same as the pultrusion direction as shown in FIGS. 7B and 7C. Ninety degrees (90°) means that the orientation of the fibers **32** is orthogonal or transverse to the pultrusion direction as shown in FIGS. 7A and 7D.

[0041] The lamination of multiple layers relative to their respective orientations is a significant determining factor to the strength, flexibility, and other physical properties of the reinforced thermoplastic composite laminate as it is used in particular architectural or construction assemblies.

[0042] Non-limiting examples of the number of layers can range from 2 to 6 layers with orientations of any combination of 0° and 90° and any angles between them. Thus, this invention is not limited to any particular number of layers in the composite nor any particular combination of orientations of layers in the composite. However, it has been found to be desired that a four-layer reinforced composite laminate provides satisfactory strength to serve as the pool wall **14**, and it is preferred when those four layers are oriented in a $90^\circ/0^\circ/0^\circ/90^\circ$ combination.

[0043] Without being limited to a particular theory, the $90^\circ/0^\circ/0^\circ/90^\circ$ four-layer reinforced composite for a pool wall the 0° designation in this case means parallel to the diametral plane P-P of the cylindrical pool structure, while the 90° designation is defined as parallel to the axial direction Y-Y of the cylindrical pool structure. With reference to FIGS. 7A-D, the 90° layers, **14a** and **14b**, form the outermost circumferential layer and innermost circumferential layer of the structure. A pool wall formed in this manner provides the strength required around the circumference to resist the pressure produced by the water inside the structure, as well as the required stiffness in the vertical (axial) direction to resist the buckling loads induced on the top edge of the structure by the attached flexible pool liner when filled with water. This orientation of layers also increases the flexibility of the pool wall parallel to the diametral plane P-P, which allows the wall material to be more easily rolled into a smaller diameter cylinder for storage and shipping.

[0044] Additionally, this construction of the individual wall layers, and other structures contemplated herein, benefit from the reinforcement which renders the structure more impact resistant and more "buckling" resistant than would exist in either a thin gauge steel or aluminum sheet construction typically used in an above ground swimming pool construction.

[0045] With reference to FIGS. 7A-D, the individual wall layers **14a-d** may include a plurality of continuous glass fiber strands each extending in a predetermined uniform direction. The strands are

preferably continuous in that they extend along the wall uninterrupted. The wall may be formed of four layers **14a**, **14b**, **14c** and **14d**. Two of the layers **14b** and **14c** may include the continuous glass fiber strands **32** each extending longitudinally along the length, L, of the wall material, i.e., extending about the circumference of the swimming pool. Two of the other layers **14a** and **14d** may include continuous glass fiber strands **32** each extending along the height, H, of the wall, i.e., vertically from the top to the bottom of the wall. This non-limiting embodiment utilizes the 90°/0°/0°/90° orientation of the four layers. Another embodiment could be utilizing a 90°/0°/90° orientation of the three layers with the sole inside layer being of a different thickness than the two inside layers of the 90°/0°/0°/90° orientation of the four layers.

[0046] Accordingly, the two types of layers have strands running 90 degrees offset from each other. But in the preferred combination, the two outside layers have unidirectional fiber reinforcement transverse to the two inside layers.

[0047] To obtain each of the layers, pultrusion is preferably used when the reinforcing fibers are continuous. Each layer may be formed separately by covering and encapsulating the glass strands within thermoplastic resin, such that when the resin cures the glass strands are embedded therein. To obtain the 90°/0°/0°/90° orientation, the wall layers **14a** and **14d** are cut from sheets and oriented transversely to the direction of wall layers **14b** and **14c**. The four-layer composite is then produced to the length, L, of pool wall **14**.

[0048] The wall layers **14a** to **d** may be assembled together such that the layers having latitudinally oriented strands and layers having longitudinally oriented strands are joined together, preferably in that 90°/0°/0°/90° combination to the length, L, of pool wall **14**. The orientation of the strands and the positioning of the various layers have a significant influence on the physical characteristics of the wall. A swimming pool wall is subjected to long term hoop stress caused by the water and requires a continuing hoop strength to counter the force of water against the pool interior **15**.

Plastic materials tend to undergo creep deformation when subjected to continuous force. Creep results in dimensional changes and weakening of the structure, which the hoop strength of the pool wall **14** must resist. Pool walls are also subject to mechanical stresses caused by users both in and out of the pool impacting the wall. The wall is also subjected to the extremes of temperature and other exposure to the elements. The composite pool wall **14** is constructed to address such factors.

[0049] This 90°/0°/0°/90° orientation combination of the four layers **14a-14d** has been found to provide the satisfactory results for resisting the high hoop stresses created when water is added to the pool. The pool wall **14** is able to maintain its shape and prevents bulging.

[0050] With reference to FIG. **6**, once the layers are aligned over one another, the four layers **14a**, **14b**, **14c** and **14d** may be bonded together using heat and pressure. The surfaces of the adjacent layers fuse together such that the wall becomes a single unitary sheet of material for forming the pool wall **14**.

[0051] While the pool wall is described herein as being formed of 4 layers of reinforced thermoplastic, it is within the contemplation of the present invention that the number of layers could be varied from at least two to as many as six or eight or ten in order to create the desired wall strength and flexibility. The orientations of each layer, expressed in angular degrees from the direction of pultrusion, can vary as determined without undue experimentation by a person having ordinary skill in the art after understanding this disclosure. The desired hoop strength for the pool wall benefits from orthogonal orientations among the four layers but not in an alternating manner. Yet, other orientations could introduce biased angles such as 30°, 45°, or 60° for layers between the 0° layers and the 90° layers, if “layup” of the layers is possible during formation of the composite. Stated generically with respect to the four layers, but applicable to any laminate of two layers or more, the orientation can be Not 0°/0°/0°/Not 0°. Stated more generically with respect to three layers or more, the orientation can be Not 0°/0°.sub.n/Not 0°, where n is between 1 and 8. Stated even more generically with respect to three layers or more, the orientation can be Not 0°/(Not 0°.sub.m) (0°.sub.n)/Not 0°, where n is between 1 and 8 and m is between 0 and 7.

[0052] In addition, in forming the wall **14**, sheets of the wall material may be placed side edge to side edge and joined together in order to increase the width of the sheet and in turn the height H of the pool wall. Therefore, the vertical height of the pool wall can be formed to a desired value. For example, two sheets having a width of 5 feet can be joined together side to side to form a sheet 10 feet wide for use as a pool wall **14** or other object requiring such height, if hoop strength can be achieved via the combinations of orientations of layers and numbers of layers sufficient to assure internal integrity with and without contents pressing on the pool interior **15**.

[0053] UV light from the sun tends to degrade plastics such as thermoplastic. In order to further increase the durability of the pool wall **14**, the outer surface of the wall may be covered with a UV protectant film **31** containing polypropylene and ultra-violet light inhibitors or absorbers or stabilizers, such as conventional or custom-made film from DuPont Teijin, Optimum Plastics or Wiman Corporation. This film blocks or attenuates the transmission of UV light which tends to degrade the thermoplastic.

[0054] This film blocks or attenuates the transmission of UV light which tends to degrade the thermoplastic. In addition, this covering may include a UV protectant film layer having graphics formed thereon and may be attached to the outer surface of the wall in order to provide an aesthetic appearance. Alternatively, the materials used to construct the pool wall **14** especially the exposed layers of the pool wall **14**.

[0055] The inner surface of the wall although covered by the pool liner **16**, is also susceptible to UV light passing through the liner. Therefore, it is within the contemplation of the present invention that carbon black or any conventional UV absorber may be added to the resin to help reduce the negative effects of UV light on the wall material.

[0056] After the sheet wall material is formed, the material is cut to a predetermined length consistent with the circumference of the pool, e.g., pools of greater circumference will have longer wall lengths. The wall material can be cut to different length in order to accommodate swimming pools of different configurations and sizes. It is also within the contemplation of the present invention that when forming the pool wall **14**, various cutouts or openings may be formed in the material in order to allow for skimmers, plumbing and electrical or other service hardware to extend through the pool wall.

[0057] With reference to FIGS. **8** and **9**, upon installing the swimming pool, in order to form the perimeter of the pool, pool wall ends **34** and **36** are secured together at a joint **37**. The joint **37** resists the significant hoop stress generated by the water pushing out in all directions. In order to form the joint, the pool wall ends **34** and **36** are overlapped and a plurality of fasteners **42** is placed through holes **40** formed in the wall ends. A plurality of through holes **40** is formed along the height of the reinforced ends to receive the fasteners **42**. In order to securely join the wall ends **34** and **36** together the wall ends are reinforced with reinforcement strips **38**. The reinforcement strips may be a strip of reinforced thermoplastic resin bonded to the wall ends **34** and **36** such that they become an integral part thereof. This increases the thickness of the wall ends at the location where the holes **40** are formed, thereby adding increased strength and preventing the wall material from tearing.

[0058] In addition, in order to reinforce the joint between the ends of the walls, a pair of metallic elongate bars **48** may be used. One bar **48** may be placed on the inside wall surface and the other on the outside wall surface, sandwiched there between the wall ends **34** and **36**. The bars **48** may include through holes **50** therein which align with through holes **40** in the wall ends in order to allow fasteners **42** to extend there through. The bars **48** provide extra reinforcement to the wall ends. This reinforcement is desirable since when the pool is filled with water, there is a considerable hoop stress which acts to pull the wall ends apart. The reinforced ends of the walls along with the metallic members **48** ensure that the ends remain secured together.

[0059] In order to assemble the pool, the pool wall **14** may be inserted into the upper and bottom rails and attached to vertical supports in a manner similar to that used for steel wall construction. In

addition, with reference to FIGS. 3 and 5, cove material **54** may be formed along the bottom of the wall **14** in order to support the liner **16**. The cove material **54** may be sand, earth, rigid foam or other material known in the art. When water is added to the pool interior the weight stretches and smoothens out the liner **16**. The force of the water acts on the liner which is pushed up against the pool wall **14**. The water pushes outwardly and creates a force resisted by the pool wall **14**.

[0060] With reference to FIGS. **10-16**, an alternative embodiment of a swimming pool wall is shown. The pool wall **100** may be formed with a core of insulating material **102** sandwiched between two wall surfaces, an inner wall surface **104**, and an outer wall surface **106**. The inner wall surface **104** forms the inside of the swimming pool and is typically covered with a liner in a manner known in the art. The outer wall surface **106** forms the pool's exterior surface.

[0061] Both of the inner and outer wall surfaces, **104** and **106**, may be formed of layers of reinforced thermoplastic including a plurality of continuous glass fiber strands each extending in a predetermined uniform direction in a similar manner as the wall **14** described above. As with wall **14**, each of the wall layers **104** and **106** be formed of four layers. Two of the layers may include the continuous glass fiber strands each extending longitudinally along the length, L, of the wall material, i.e., extending about the circumference of the swimming pool. Two of the other layers may include continuous glass fiber strands each extending along the height, H, of the wall, i.e., vertically from the top to the bottom of the wall.

[0062] Alternatively, it is contemplated that only one of the inner and outer wall surfaces be formed as wall **14**. For example, the inner wall surface **104** may be formed of the formed of layers of reinforced thermoplastic including a plurality of continuous glass fiber strands as wall **14**. In this embodiment, the outer wall surface **106** may be formed of a single layer of unreinforced polymer or of metal.

[0063] The inner and outer wall surfaces **104** and **106** may be secured to core **102** of heat insulating material. The insulating material may be formed of foam or other material which acts to retard the transfer of heat. The thickness of the insulating core material **102** made of foam may be approximately one to four inches. However, it is contemplated that the thickness of the insulating core material may be varied depending upon the thermal resistance or insulation value (measured as an "R-factor") desired. In one embodiment, the core **102** of the pool wall **100** may be comprised of rigid closed-cell expanded polystyrene EPS foam with a R10 insulation value. This foam material resists water absorption making it suitable for inground swimming pool installations. The foam material may also be treated with an insecticide and/or pesticide in order to help it sustain a below grade insulation.

[0064] Adhesive **109** may be applied to both sides of the core insulating material **102**, and/or on the mating surfaces of the inner and outer wall layers, and the inner and outer wall surfaces may be layered onto opposed sides of the core material. Alternatively or additionally, heat and/or pressure may be applied in order to allow for a firm connection between the inner and outer wall surfaces **104** and **106** and the core **102**.

[0065] With reference to FIGS. **11-15A** and **B**, the pool wall **100** may be formed by a series of discrete panels **110** which are joined together side edge to side edge in order to form an enclosed pool wall having requisite hoop strength for containment of water or other liquid within an enclosed perimeter and/or circular area **105**.

[0066] Each wall panel **110** has similarly formed opposed side edges **112** having connecting ends **114**. Connecting ends **114** permit adjacently positioned panels to be secured together. The connecting ends **114** may be secured to the panel side edges **112** by mechanical fasteners and/or adhesive. A void **115** may be formed between the connecting end **114** and the foam core **102** as shown in FIG. **13**. The void **115** may be filled with expanding polyurethane foam **117** to provide insulation and support. The connecting ends **114** include a channel **116** having inwardly turned lips **118**. In one embodiment, the connecting ends may be formed of extruded aluminum. As shown in FIGS. **15A** and **B**, two panels **110** may be joined end to end by elongate splines **120** which interact

with the connecting ends **114**. Splines **120** may have an E-shaped cross-section with a main wall **122** as well as two end projections **124** and a central projection **126** extending outwardly from the main wall **128**. The central projection **126** may be longer than the end projections **124**. When two panel ends **114** are placed together, a pair of splines **120** may be inserted into the adjacent channels in order to secure the panels together. One spline **120** may be inserted adjacent the inside wall surface and another spline **120** inserted adjacent the outside wall surface to firmly secure the wall panels **110** together. The end projections **124** engage the connecting end lips **118**, thereby preventing the wall panels **110** from separating.

[0067] While one embodiment of the interconnectivity of adjoining panels **110** has been described, it is to be understood that a person having ordinary skill in the art without undue experimentation could arrange for other geometries of linkage of adjoining panels **110**, particularly in a convenient assembly/disassembly fashion, and especially with structure to assure containment of water or other liquid within the wall **100**.

[0068] With reference to FIG. **16**, the top of the pool wall **100** may be covered by coping material **130** which protects the upper edges of the thermoplastic wall surfaces and the core.

[0069] Having understood the patentably inventive value of pool walls made of fiber reinforced composite of multiple layers having multiple relative orientations among the layers, it is contemplated that any cylindrical structure requiring hoop strength can benefit from the disclosure herein. Non-limiting examples of the types of structures include storage bins for any type of solid or liquid material ranging from cattle feeders to cisterns, temporary shelters, shipping containers, etc. where hoop strength resisting pressure from inside the cylinder is important to the use of the structure. Likewise, hoop strength can be needed for structures where the hoop strength resists pressures from outside the cylinder such as submariner structures of many types. The use of floors and roofs with the cylindrical structure is dependent on the use of the cylindrical structure.

[0070] Referring again to FIG. **10**, each wall panel **110** may be straight or curved for placement as desired to form a wall **100** of circular “race track” configuration, or “hockey rink” configuration. A “race track” configuration has the shape of a rectangle with semicircles attached at the ends, whereas a “hockey rink” configuration has a rectangular shape with arcuate panels in place of orthogonal corners. The difference between those two wall geometries depends on the number of straight or planar panels **132** interposed between curved or arcuate panels **134** at 180° opposite locations or the number of curved or arcuate panels **132** interposed between straight or planar panels **132** at 90° locations, in order to convert the enclosed circular area into either an area resembling a skating rink or an area resembling a regulation shaped and/or sized hockey rink. Alternatively, complex pool wall configurations can be formed using a combination of curved and straight panels.

[0071] Departure from a circular wall to a “race track” skating rink wall or “hockey rink” wall will require adjustment of strength of the panels because of the loss of circular hoop strength, such that the enclosure strength of a “race track” or “hockey rink” geometry is sufficient to restrain water within the wall **100** as much at the interconnections of the planar panels **132** as at the interconnections of the arcuate panels **134**. Optionally, the wall **100** may also be supported along its perimeter by supports **136** in a manner known in the art, especially at planar panels **132**. Use of planar panels **132** in the wall **100** expands useful embodiments from a circular structure as a swimming pool (or circular skating rink) to a “race track” structure or “hockey rink” structure, both suitable for use as a skating rink, especially an ice skating rink in which water is first added before being frozen by weather conditions. A sheet of ice within a structure as seen in FIG. **10** also benefits from the height of the wall **100** if the game of ice hockey is being played within the enclosed skating rink area. One or more of the planar panels **132** can be configured to have panel interconnections to form a door for entry onto the sheet of ice.

[0072] It will be appreciated that variants of the above-disclosed and other features and functions, or alternatives thereof, may be desirably combined into many other different systems or

applications. Various presently unforeseen or unanticipated alternatives, modifications, variations, or improvements therein may be subsequently made by those skilled in the art which are also intended to be encompassed by the following claims.

Claims

1. A swimming pool comprising: a base rail; a top rail; a plurality of supports extending between the top rail and the base rail spaced along a circumference of the base rail; and a pool wall extending between the bottom rail and top rail and forming an enclosed perimeter of the swimming pool, the pool wall including a plurality of layers of reinforced composite material fused together to form a unitary composite wall, each layer including elongate glass fiber strands of reinforcing material, one of the plurality of layers having the strands running in a first direction, and a second of the plurality of layers having strands running in a second direction, wherein the first direction is offset in angle from the second direction.
2. The swimming pool as defined in claim 1, wherein two of the plurality of layers are adjacent to each other forming inner layers and the strands of the inner layers being oriented in the same direction.
3. The swimming pool as defined in claim 2, wherein two of the plurality of layers form outer layers and the two inner layers are disposed between the outer layers, the strands of the outer layers being oriented in a direction offset in angle from the strands of the inner layers, expressed in orientation as a Not 0°/0°/0°/Not 0° combination.
4. The swimming pool as defined in claim 2, wherein the strands of the inner layers run in a direction along the circumference of the pool wall in a 0° orientation.
5. The swimming pool as defined in claim 4, wherein the strands of the outer layers run in a direction generally 90 degrees offset from the strands of the inner layers, expressed in orientation as a 90°/0°/0°/90° combination.
6. The swimming pool as defined in claim 1, wherein the wall has an inner surface and an outer surface, the outer surface being covered with a UV attenuating film.
7. The swimming pool as defined in claim 1, wherein the wall is formed of thermoplastic resin and glass strands.
8. A swimming pool wall comprising: a plurality of layers of reinforced composite material, each layer including thermoplastic resin and a plurality of elongate glass strands of reinforcing material, a first set of the plurality of layers having the strands running in a first direction, and a second set of the plurality of layers having strands running in a second direction, wherein the first direction is offset from the second direction, and the first and second set of layers are fused together to form a unitary composite wall.
9. The swimming pool wall as defined in claim 8, wherein the layers of the first set of layers are disposed adjacent to each other forming inner layers and the strands of the inner layers are oriented in the same direction, and wherein the layers of the second set of layers form outer layers and the two inner layers are disposed between the outer layers, the strands of the outer layers being oriented in a direction offset in angle from the orientation of the strands of the inner layers, expressed in orientation as a Not 0°/0°/0°/Not 0° combination.
10. The swimming pool wall as defined in claim 8, wherein the strands of the inner layers run in a direction along the circumference of the pool wall in a 0° orientation and wherein the strands of the outer layers run in a direction generally 90 degrees offset from the strands of the inner layers expressed in orientation as a 90°/0°/0°/90° combination.
11. A method of forming a swimming pool wall comprising: joining, to form a cylindrical structure, opposing ends of a laminate comprising a plurality of layers of reinforced composite material, each layer including thermoplastic resin and a plurality of elongate glass strands of reinforcing material, a first set of the plurality of layers having the strands running in a first direction, and a second set

of the plurality of layers having strands running in a second direction, wherein the first direction is offset in angle from the second direction, and the first and second set of layers are fused together to form a unitary composite wall; inserting a pool liner in the interior of the cylindrical structure; and wherein the first set of wall layers is disposed between layers from the second set of wall layers and the strands of the first set of layers extend along a longitudinal extent of the first layers, and the strands of the second set of layers include strands running transverse to a longitudinal extent of the second layers, and wherein the first set of layers are disposed between a pair of second set of layers.

12. A swimming pool comprising: a base rail; a top rail; a plurality of supports extending between the top rail and the base rail spaced along a circumference of the base rail; and a pool wall extending between the bottom rail and top rail and forming an enclosed perimeter of the swimming pool, the pool wall including a reinforced polymer composite formed of a thermoplastic resin and e-glass fiber strands encapsulated therein.

13. A cylindrical structure requiring hoop strength to resist pressure from inside or outside the cylinder, comprising: (a) a sheet of reinforced fiber composite having opposing lengthwise ends, wherein the sheet comprises a plurality of layers of glass fibers embedded in a thermoplastic matrix, wherein the plurality of layers have multiple relative orientations among the layers, and (b) a means for joining the opposing lengthwise ends.

14. The structure of claim 13, wherein the structure is selected from the group consisting of storage bins for solid or liquid material, temporary shelters, shipping containers, cisterns, and submariner structures.

15. The structure of claim 13, wherein the multiple relative orientations comprise 0° , 30° , 45° , 60° , or 90° relative to the lengthwise ends.

16. The structure of claim 13, wherein the sheet comprises a fiber reinforced composite laminate of between three and ten layers having an orientation $\text{Not } 0^\circ/(\text{Not } 0^\circ.\text{sub.m}) (0^\circ.\text{sub.n})/\text{Not } 0^\circ$, where n is between 1 and 8 and m is between 0 and 7.

17. The structure of claim 13, wherein the sheet comprises a four-layer $90^\circ/0^\circ/0^\circ/90^\circ$ oriented fiber reinforced composite laminate.

18. A swimming pool comprising: a plurality of interconnected panels forming an enclosed perimeter of a swimming pool, each panel including an inner wall surface and outer wall surface and a core disposed there between, at least one of the inner wall surface and the outer wall surface including a plurality of layers of reinforced composite material fused together to form a unitary composite wall, each layer including elongate glass fiber strands of reinforcing material, one of the plurality of layers having the strands running in a first direction, and a second of the plurality of layers having strands running in a second direction, wherein the first direction is offset in angle from the second direction, the inner and outer wall surfaces being secured to opposed sides of the core.

19. The swimming pool as defined in claim 18, wherein both the inner and outer wall surfaces include a plurality of layers of reinforced composite material fused together to form a unitary composite wall, each layer including elongate glass fiber strands of reinforcing material, one of the plurality of layers having the strands running in a first direction, and a second of the plurality of layers having strands running in a second direction, wherein the first direction is offset in angle from the second direction.

20. The swimming pool as defined in claim 18, wherein the core is formed of temperature insulating material.

21. The swimming pool as defined in claim 18, wherein the plurality of interconnected panels each include connecting ends wherein adjacent panels are secured together by a plurality of elongate splines joining together connecting ends of adjacent panels.

22. The swimming pool as defined in claim 21, wherein the connecting ends include a channel having inwardly turned lips, at least one spline extending along the length of the channel and

engaging the inturred lips to secure together adjacent panels.

23. A swimming pool wall comprising: an inner wall surface and outer wall surface and a core disposed there between, at least one of the inner wall surface and the outer wall surface including a plurality of layers of reinforced composite material, each layer including thermoplastic resin and a plurality of elongate glass strands of reinforcing material, a first set of the plurality of layers having the strands running in a first direction, and a second set of the plurality of layers having strands running in a second direction, wherein the first direction is offset from the second direction, and the first and second set of layers are fused together to form a unitary composite wall surface, the inner and outer wall surfaces being secured to opposed sides of the core.

24. The swimming pool wall as defined in claim 23, wherein both the inner and outer wall surfaces include a plurality of layers of reinforced composite material fused together to form a unitary composite wall, each layer including elongate glass fiber strands of reinforcing material, one of the plurality of layers having the strands running in a first direction, and a second of the plurality of layers having strands running in a second direction, wherein the first direction is offset in angle from the second direction.

25. The swimming pool wall as defined in claim 23, wherein the core is formed of temperature insulating material.

26. A structure requiring enclosure strength to resist pressure from inside or outside the enclosure comprising: an inner wall surface and outer wall surface and a core disposed there between, at least one of the inner wall surface and the outer wall surface including a plurality of layers of reinforced composite material, each layer including thermoplastic resin and a plurality of elongate glass strands of reinforcing material, a first set of the plurality of layers having the strands running in a first direction, and a second set of the plurality of layers having strands running in a second direction, wherein the first direction is offset from the second direction, and the first and second set of layers are fused together to form a unitary composite wall surface, the inner and outer wall surfaces being secured to opposed sides of the core.

27. The structure as defined in claim 26, wherein both the inner and outer wall surfaces include a plurality of layers of reinforced composite material fused together to form a unitary composite wall, each layer including elongate glass fiber strands of reinforcing material, one of the plurality of layers having the strands running in a first direction, and a second of the plurality of layers having strands running in a second direction, wherein the first direction is offset in angle from the second direction.

28. The structure as defined in claim 26, wherein the core is formed of temperature insulating material.

29. The structure as defined in claim 26, wherein the structure is a wall comprising a plurality of interconnected panels.

30. The structure as defined in claim 29, wherein each panel includes opposed side edges having a connecting ends for securing together adjacent panels.

31. The structure as defined in claim 30, wherein the connecting ends include a channel having inwardly turned lips, at least one spline extending along the length of the channel and engaging the in-turned lips to secure together adjacent panels.

32. The structure as defined in claim 30, wherein the wall is circular constructed of interconnected arcuate panels.

33. The structure as defined in claim 29, wherein the wall is of "racetrack" or "hockey rink" configuration constructed of interconnected arcuate panels and interconnected planar panels.

34. The structure as defined in claim 33, wherein the configuration is a skating rink.
