MARN 011

Maintain Seaworthiness of the Ship (Ship Construction)

3.2.2.3 Hull Structure

Structural Components on Ships

- Frames are vertical structural members that run along the length of the ship and give it strength and support.
- Floors are horizontal pieces that connect the frames and help make the hull rigid as a whole.
- Transverse frames are like frames, but they run across the length of the ship instead of parallel to it.
- They add extra support to the structure.
- Deck beams are flat pieces that hold up the ship's decks.
- Knees and brackets are reinforcements that connect different structural members and make the hull stronger and more stable.

Structural Components on Ships

- The outer skin of a ship's hull is called shell plating.
- It keeps water out and protects the ship from the marine environment.
- Decks are flat surfaces inside the ship's superstructure that are used for living and working.
- Tank top is the top deck inside the hull. It covers the top of the cargo holds or tanks.
- Stringers are long structural members that run along the length of the ship and give the hull extra support and strength.

Structural Components on Ships

- Bulkheads are vertical walls that divide the ship's interior into different rooms.
- They keep the structure strong and separate the hull for safety and functionality.
- Stiffeners are extra pieces of structure that are often attached to bulkheads and decks to make them stronger and more rigid.
- Pillars are vertical structural members that hold up the decks or other parts of the superstructure.

Structural Components on Ships

- Hatch girders and beams are structural members that hold up the hatches, which are openings in the ship's deck that let you get to the cargo holds or compartments.
- Coamings are raised edges or borders that go around hatch openings to keep water out of the deck.
- Bulwarks are vertical extensions of the ship's hull that go above the main deck and protect people from the water.

Structural Components on Ships

- The structural parts at the front and back of the ship are called bow and stern framing, respectively.
- They give these important areas strength and support.
- Cant beams are angled beams that connect the hull to the superstructure.
- They make the structure stronger and more stable.
- Breasthooks are reinforcements that connect the deck to the hull plating at the bow or stern. They give these areas extra strength.

Principal Materials and Construction of a Ship

Materials Selection

- The construction of a ship involves selecting appropriate materials based on factors such as strength, durability, and corrosion resistance.
- Common materials include steel, aluminum, fiberglass, and composite materials, each with specific properties and applications.

Principal Materials and Construction of a Ship

Properties of Materials

- Understanding the properties of materials used in ship construction is essential for ensuring structural integrity and performance.
- Properties such as tensile strength, elasticity, and thermal conductivity influence material selection and design considerations.

Steel

Steel is known for being very strong, which makes it good for building big things like ships and buildings. It is very flexible and tough, which makes it useful for a wide range of designs. It's also easy to get and can be quickly put together and joined.

Corrosion can happen to steel, especially in marine environments where oxygen and seawater speed up the rusting process. Corrosion can be stopped by regular maintenance, such as applying protective coatings and cathodic protection. Steel is also pretty heavy compared to other materials, which affects how much the ship weighs and how well it uses fuel.

Steel Sections used in Ship Construction

- Flat steel plates are rectangular, flat, and uniformly thick. Shipbuilding uses them for decks, bulkheads, and hatch covers. Flat plates provide structural integrity and a smooth surface for attachment.
- Flat offset bulb plates have one or more bulbous protrusions. In load-bearing areas like hull plating, these bulbous sections add strength and stiffness. Shipbuilders use offset bulb plates to reduce weight while maintaining structural integrity.
- Equal angles are L-shaped steel sections with equal sides and thickness. A 90-degree leg angle. Shipbuilding uses equal angles for framing, bracing, and stiffening. They are strong and rigid in compression and tension.
- Unequal angles, or L-sections, have one leg longer than the other, resulting in uneven sides and thickness. In shipbuilding, they provide unequal support due to loading or structural requirements. Unequal angles are used for structural framing, stiffeners, and supports with unequal load distribution.
- U-shaped steel channels have a base and two parallel side flanges. Shipbuilding uses them for structural framing, longitudinal stiffening, and support. Due to their shape, channels resist bending and torsional stresses, making them suitable for various structural configurations.
- Tees are steel sections with a stem and "T" cross-section. Shipbuilding uses them for framing, bracing, and joining. Tees are strong and stable in compression and tension, making them ideal for ship structural components and connections.

Aluminum

Strong points: Aluminum is light and strong for its weight, so it can be used for fast ships and low-speed craft. Due to the formation of a protective oxide layer, it is very resistant to corrosion, especially in saltwater.

Weaknesses: When aluminum comes into contact with metals that are not the same, it can rust. To stop galvanic corrosion, you need to pay close attention to how well the materials work together and make sure there is enough insulation. Aluminum is also not as stiff as steel, so to get the same stiffness, you need to use thicker sections or add more structural support.

Fiberglass (Fiber Reinforced Plastics or FRP)

Strengths: Fiberglass is very strong, especially when stretched, and it's not heavy like metals. It doesn't rust or corrode easily in most chemicals and marine environments. It can also be easily shaped into complicated shapes, which gives designers more options.

Fiberglass can be damaged by impact and wear and tear, which can cause it to delaminate or crack. It may also break down over time if it is exposed to ultraviolet (UV) light for a long time. Fixing fiberglass can also be hard work and may need special tools and methods.

Plywood

Strengths: Plywood is cheap, doesn't weigh much, and is easy to work with. It's strong and stiff, especially when it comes to bending. It can also resist rot and marine pests if you treat it with the right chemicals.

Problems: Plywood can soak up water, which can cause it to swell, separate, and lose strength over time. To keep water out and keep it from breaking down, it needs to be properly sealed and maintained. Additionally, plywood might not last as long or be as durable as materials like steel or aluminum.

Timber

Strengths: Wod, especially hardwoods like oak and teak, is naturally beautiful and aesthetically pleasing. Because it is stiff, it is strong, especially when compressed. It is also pretty light and floats, which means it can be used on some types of boats.

Weaknesses: Wood can rot and be eaten by marine pests like teredo worms and marine borers if it isn't treated with the right chemicals. Regular maintenance, like sealing and varnishing, is needed to keep water out and keep it from breaking down. Also, timber might not be easy to find and might not be as good for building with as other materials.

Cold-Pressed Wood Laminate

Strengths: When compared to solid wood, cold-pressed timber laminate is stronger and more rigid. It is made by pressing layers of wood veneers together with adhesives to give it uniform properties and make it less likely to warp or split.

Weaknesses: Cold-pressed timber laminate can get wet and rot like solid wood if it's not properly protected. It could also delaminate or lose its adhesive if it is exposed to extreme temperatures or moisture for a long time. In addition, it might need special ways to be made and quality control measures.

Ferro Cement

Strengths: Ferro cement is very strong and lasts a long time because it is made of cement mortar that is reinforced with layers of mesh or steel bars. It doesn't cost too much and can be shaped into complicated shapes. Fire and rot can't damage it much.

Weaknesses: Building with ferro cement can take a lot of work and skilled craftsmanship to make sure the structure is properly reinforced and holds together. It is easy for the embedded reinforcement to crack and rust if it is not properly maintained. In addition, it might be heavier than materials like aluminum or fiberglass.

Ship Building Sections.

By far the most common material is steel and this has informed shipbuilding in it’s current form of utilizing welded sections that are prebuild before being attached together.

- Longitudinal framing uses keels, stringers, and longitudinals parallel to the vessel's length.
- Transverse framing uses frames, floors, and bulkheads perpendicular to the ship's length.
- Combined systems optimize vessel strength and stiffness by combining longitudinal and transverse members.

Ship Building Sections.

- Double-bottom configurations have two layers of bottom plating separated by a space, improving buoyancy, stability, and safety by preventing hull damage and flooding.
- Hold drainage systems remove water from cargo holds to protect cargo and vessel stability. Scuppers, drains, and bilge wells are usually built into the ship's framework.
- A duct keel, located longitudinally along the ship's hull bottom at the keel line, reinforces structural integrity and channels piping and cabling.
- Deck edge marks the ship's deck-hull boundary, while sheer strake is the highest continuous plating on the side. Both components are crucial to hull structure.
- Radiused sheer strakes, which curve along the ship's side, add strength and beauty. Bulwarks and railings are essential.
- Deck round hatch openings can cause stress concentrations due to abrupt geometric changes and localized loading, causing structural fatigue and failure if left unchecked.
- Reinforcing surrounding structures, hatch design changes, or specialized materials can reduce stress concentration and strength around hatch openings.

Hatch Coaming and Corners

Ship hatch coamings are vertical walls or structures around the hatch opening. Hatch coamings, usually made of steel or other durable materials, support and contain cargo to prevent shifting or spilling.

The main purpose of hatch coamings is to contain cargo and prevent waves and seawater from washing it overboard. These surfaces secure hatch covers and prevent water ingress.

Hatch corners connect vertical coaming to horizontal deck. They are reinforced with structural members to withstand cargo loading and handling.

Hatch corners provide structural support at hatch coaming-deck intersections. They keep the hatch coaming rigid under heavy loads and bad weather.

Deck-Freeing

Ships have scuppers, freeing ports, and open rails to free the deck. These arrangements help water drain from the deck, preventing accumulation and maintaining stability.

Deck-freeing arrangements drain water from the ship's deck to prevent weight and instability. Water drains overboard through scuppers, freeing ports, and open rails.

Connecting Superstructures to Hull

Construction and Design: Bulkheads, pillars, and supports connect superstructures like cabins, bridges, and accommodations to the ship's hull. These connections are strengthened for seaborne forces.

Connections between superstructures and hulls provide stability, structural integrity, and habitable spaces for crew and passengers. Even in rough seas or bad weather, these connections keep superstructures attached to the ship's hull.

Corrugated Bulkhead

Construction and Design: Corrugated bulkheads are stronger and more rigid than flat bulkheads due to their ridged or grooved surface. The anticipated forces determine the vertical or horizontal orientation of these corrugations.

Corrugated bulkheads strengthen and resist load-induced bending and deformation. Transverse bulkheads use vertical corrugations to resist longitudinal forces, while fore-and-aft bulkheads use horizontal corrugations.

Bilge Keels

Bilge keels are long, narrow plates attached to a ship's bilge. Bilge keels, usually steel or other durable materials, increase hydrodynamic resistance to reduce ship rolling.

Bilge keels dampen rolling motion to stabilize and comfort ships in rough seas. Bilge keels reduce rolling by increasing hydrodynamic drag along the ship's sides.