

Review

# Design Criteria for the Floating Walkways and pontoons considering the Extreme Climatic Conditions

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**Abstract:** Construction of pontoons is based on multiple elements, dimensions and weight. The study has addressed about how the industry of the floating reinforcement concrete precast (pontoons) installs in the factory with the combinations of utility, electricity services, and Internet service. The pontoon bridges are successfully installed in the road for transport or sea for shops. The installation process for pontoons is successfully attempted in a balanced situation above surface of the sea to the resistant of floating precast (pontoons) to any ambient effects such as weather conditions, the movement of the waves or any others effects. The findings elaborate that it is not just a military solution. Pontoon installation can significantly serve for civil purposes.

**Keywords:** Identification; Manufacturing; Transportation; Installation

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## 1. Introduction

The manufacturing of pontoons is based on different materials, dimensions, and weights in marine construction to enable them to lift large weights. It has been broadly accepted that pontoon bridges are only available to the field of military engineering [1]. However, these bridges are also seen for swamps and crossing rivers purpose and; therefore, are considered as obsolete and folkloristic works. pontoons are widely used for different purposes such as timber pontoons, concrete pontoons, and metal pontoons (steel and aluminum). It is a common dilemma that the theory and technique of the pontoon bridges are not taught in the universities [2]. Mostly structural designers do not think that they have any opportunity to tackle such situations. On the contrary, the pontoon bridges are significant to install new structural applications; whereas, it presents a rapid, economic, and simple solution to cross water sheets [3].

An increase in the development and significance of pontoons has been observed with respect to its structural infrastructures. pontoons have been widely used in Canada, china, Norway, United States, and other eastern countries for creating infrastructures of great significance and have brought a massive progression in the industrial sector [4]. The installation of the four longest pontoon bridge in the North America is quite evident of its support in controlling a massive amount of heavy traffic in extreme climatic conditions. The massive installation of the pontoons bridges is illustrated in North American countries considering the extreme climatic conditions. The design and structure of Snøhetta Rovdefjordbrua in Norway are emphasized with a submerged tunnel of a floating bridge [5]. The design consists of a 230-meter-long submerged tunnel that enables passengers to cross the fjord south of Ålesund regardless of any interruption of vessel traffic. An actual floating bridge has been adequately and excellently reconciled the requirement for connection between two islands with environmental and landscape requirements in the Maldives. It has been notified that several big foundations at the sea bed were associated with a conventional design, which are costly designed

and imply negative impacts on any life at the bottom of the ocean [1]. However, the vitality of this type of structure in a rapidly growing country has been proven from the expansion hypothesis of a pontoon bridge in China.

Concrete pontoons are present in different dimensions such as concourse pontoons up to (6m wide, 1m wide central service channel, 20m long, and 1.5m height), super yacht pontoons up to (4m wide, 20m long, 1.5 m height), premier pontoons (3m wide, 15 m long, 1.2 m height), and super yacht fingers pontoons (2m wide, 20 m long, 1.2 m height). The quality assurance system ISO 9001:2000 is used in fabrication of concrete pontoon, which is manufactured through preparing the mold, reinforcing installation, using expanded polystyrene, and casting of concrete [6].

This study has found new inspirations to identify the pontoon bridges of the future although several new ideas are already presented by the most imaginative designers. The idea of self-floating reinforced concrete precast bridge is a novel idea to be installed in shipyard based on tugging and assembling in the selected locations. Another important idea is to support a pontoon bridge by a railway line crossing the Bering Strait. Therefore, this study has presented the steps to manufacture and install the Floating Reinforcement Concrete Precast considering the extreme climatic conditions. The remaining sections explain the procedures of mold preparation, reinforcement, and use of expanded polystyrene, casting, and the pontoon installation.

## 2. Experimental Investigation of Pontoon Bridges

### 2.1 Preparing the mold

Mold plate constructions are made of smooth mold purpose steel as they are installed based on required tolerances to meet all structures measured. The fixing bolts are tightened and all holes are plugged with welding and grounded smooth to clean the mold surfaces and treat them with oil (Figure 1 and 2).



**Figure 1:** Preparation of the mold



**Figure 2:** Phases of Mold Preparation

### 2.2 Reinforcing Installation

Within the reinforced concrete industry, there is an increasing significance to use higher strength reinforcing steel for specific applications. Relief of congestion, is the prime factor toward this interest specifically in constructions assembled in a high seismic design category. Construction efficiencies or high strength concrete enhance the other areas where high strength bar enable reinforced concrete to be utilized in more inspiring applications. Today, Grade 60 steel is used within the concrete design and construction along with the occasional but increasing use of Grade 75. It has been notified that different grades of steel can be used for large projects with higher grades and a minimum grade for ordinary tasks for more inspiring structures. The increase in costs is generally observed for higher grades; therefore, smaller and cheaper quantities are used as compared for larger quantity of a lower grade. In actual scenario, smaller concrete members are usually permitted by higher grades that are associated to the space issues for reinforcement placement. The steel is a major cost factor although the steel usually comprised merely a few percent of the total reinforced concrete volume. The cutting and bending, the cost of the steel, and the forming of the deformed bars are included in the form's installation. The general attempt is represented from the cost-saving factor by using the minimal reinforcement and the concrete, which reflects typical unit costs for the two materials.

All reinforcing mesh and steel bars of stainless steel to resist corrosion (Side mesh, intermediate wall mesh, intermediate wall corner rebar and vertical rebar, side wall upper long rebar, deck mesh) are included in the pontoon installation. The minimum yield stress of steel bars is 500 MPa, which must be cleaned completely of lubricate and any dirt to use plastic spacers and checked all installed reinforcing. It is not allowed to mix stainless and galvanized when attaching seaflex to anchors.

The importance of Grade 500 steel allows to reinforce bar in all international and national building codes and standards. All the current codes restrict the allowable design strength of reinforcement to 80 Ksi (MPa) from a design standpoint. Economy can also be accomplished using Grade 500 steel rather than commonly accessible Grade 415 bars in the market. One of the main advantages of using Grade 500 is to replace the steel congestion in the foundation mat and at the beam column joint. On the contrary, the development length differs for Grade 500 steel as compared to Grade 415 steel. Higher strength concrete and better engineering judgments are required for achieving maximum benefits from Grade 500 steel.

### 2.3 Using expanded polystyrene (EPS)

The manufacturing of buoys, floats, and pontoons is commonly observed through expanded polystyrene (EPS) due to its excellent physical properties. In addition, it possesses better resilience and buoyancy properties and are light in weight. Archimedes principles are used for Buoys, Floats,

and pontoons for displacing its own fluid weight. There is no standard shape, pattern or design for pontoons, floats, and buoys whereas it is simply customized based on the application nature. It is not essential that EPS is used to manufacture buoys, but pontoons are manufactured with high densities either with proof coating or without coating (Figure 3).



**Figure 3:** Use of expanded polystyrene

### **3. Features of EPS pontoons**

#### **3.1 Stable**

High-quality expanded polystyrene materials are used to form these products. The main reason for using these high-quality materials is that it floats on water and will not crumble once an individual board on it.

#### **3.2 Durable**

EPS is lightweight and durable to withstand any amount of weight specifically for pontoons. Due to its stability, individuals in huge numbers can stand on it regardless of any fear of falling off.

#### **3.3 High Compressive Strength**

The manufacturing process of pontoons is meticulously attempted to ensure that it is tough and robust, at certain extent, to withstand extreme climatic conditions. The manufacturing process of Pontoon EPS is of two-fold. Steam are used to expand the raw beads by creating pre-puff beads that are cured in large bags before mold preparation. The pre-puff beads are steamed to form a block that is anywhere from 37-1/2" – 54" x 49" x 121-1/2"-220" once in the mold. Afterwards, the placement of blocks is made on the storage floor based on the adequate time length before being cut into assorted sizes and shapes. To meet specific project needs, blocks are manufactured and produced in several densities.

#### **3.4 EPS Size and Density**

There are different block sizes available for state-of-the-art Hirsch mold anywhere from 37-1/2" – 54" x 49" x 121-1/2" – 220". The most common cut sizes available are 48 inches X 96 inches and 24

inches X 96 inches even though pontoon does not stock any foam. Following specifications are used in the manufacturing process of pontoons.

**Table 1:** EPS Requirements

Items	Dimensions
Thickness	1/4" to 54"
Lengths	Up to 216" (18')
Widths	Up to 48"
Densities	75 lb to 2.85 lbs per cubic foot

During the pontoons manufacturing, all the ducts are needed for the installations of utility, electricity services, and Internet service. The EPS blocks were used as filling and casting molds inside the pontoon and bottom is treated to resist marine borers by using polyurea coating and after reinforcing installation, which allow to lift the readymade EPS into the mold.

### 3.5 Casting

Before start casting, the area of casting is checked because it must be level and flat. Check the height position of deck mesh before casting, the strength of concrete is durable (45 N/mm.s) containing cement, super plasticizer, Micro-Silica and plastic fibers. Color pigment impregnation should be added to concrete whereas water resistant silicone impregnation is used to treat the concrete. Casting must be done very carefully to prevent any risk considering the correct positioning of EPS. Following steps are used when completing the casting procedure:

Pouring pontoon deck till bottom of service duct.

Lifting the service duct and completed the casting of pontoon deck (Figure 4).

Compacted the concrete by using vibrating rods.

Using linear and vibrating beam for deck surface.

Using integrated air operated side mold vibrators to increase the quality of pontoon sides

All side and deck structures of pontoon must be uniform and continuous.

Make the anti-slip graining by using mild brushing.

Protected the poured concrete with water curing and plastic covering.

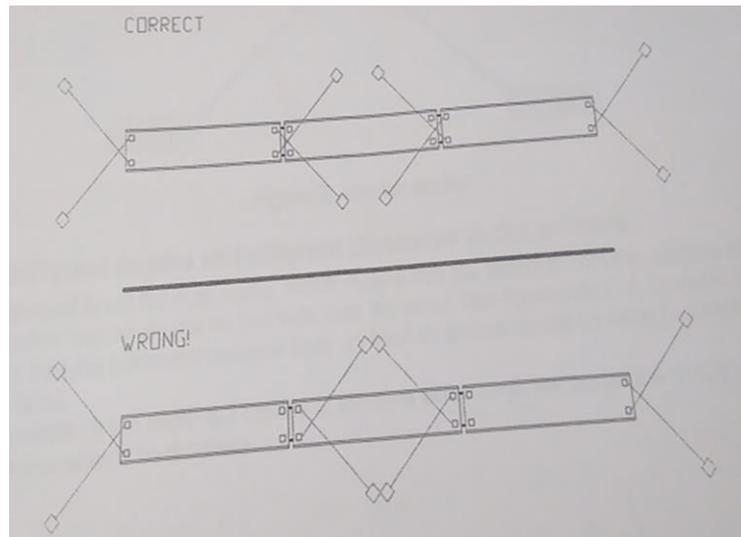
Supplied the pontoons with seaflex mooring tubes.



**Figure 4:** Service Duct Lifting

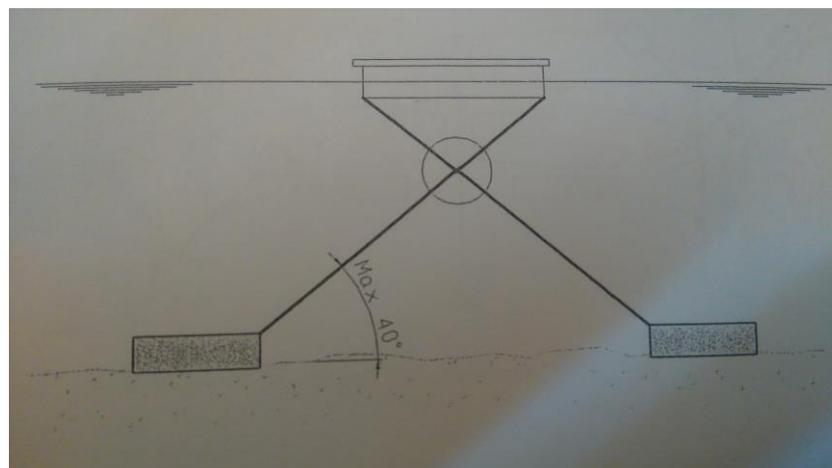
### 3.6 Concrete Sinkers and Seaflex Mooring System

This system solved many problems in pontoons design & installation specifically the efforts made by the experienced divers. It used to moor the pontoons to the seabed to keep the pontoon in its place regardless of the wave's movement or the difference of water level consisting of seaflex and rope. Seaflex is an active part of the mooring, it does not cover all the distance from anchor blocks to pontoon, always pre-tensioned at lowest water level, adjusting for water level changes and taking care of forces. The number of seaflex is calculated by the attachment distance and the length of pontoon (Figure 5).



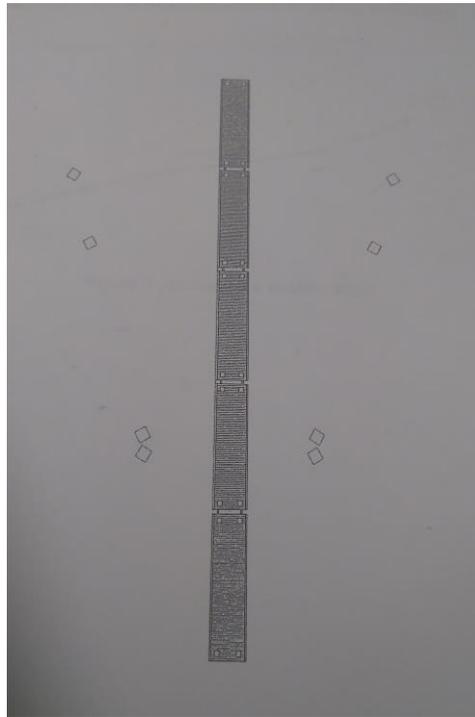
**Figure 5:** Placement of Seaflex

The seaflex mooring is placed at horizontal angle of 45 degrees as this angle depends on the direction of the main force. Vertical angle between the mooring line and the seabed do not exceed  $40^\circ$  at the highest water level because if the angles increases the stability of pontoons, it will decrease (Figure 6).



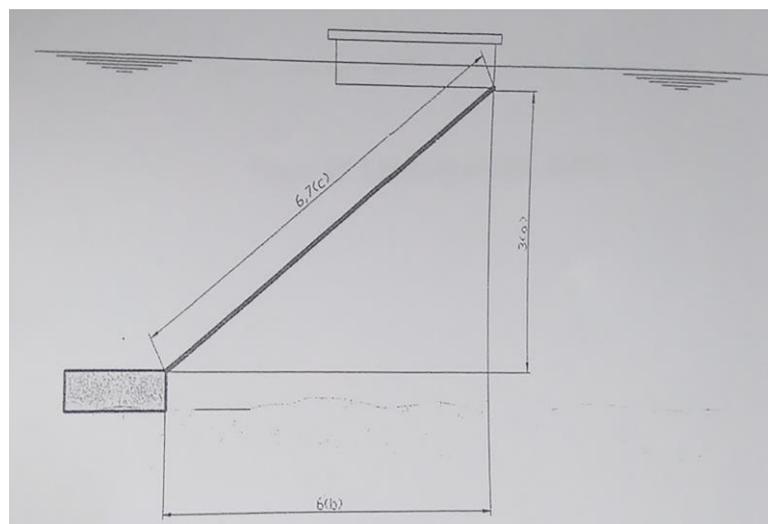
**Figure 6:** Right Vertical Angle between the Mooring Line and the Seabed

When the depth is increasing further out from land, the distance between pontoon and anchors will increase (Figure 7).



**Figure 7:** Deeper Further Out from the Shore

If the seabed is not flat, the horizontal distance between pontoon and the anchor will be twice the medium water level. For instance, when the water depth was 3m, the horizontal distance between pontoon and the anchor was equal to 6m. From Pythagoras theorem, the distance from the anchor is found to the rope, which was the hypotenuse of the depth and the horizontal distance to the anchor equal the root of  $(3^2 + 6^2) = 6.7\text{m}$  (Figure 8).



**Figure 8:** Hypotenuse Calculation

The type of rope used is different according to the breaking load of rope and the number of seaflex rubber hawsers such as square plait polyester rope. Seaflex always pre-tensioned 30% at lowest water level even if the pontoon is moved (re-installed). The seaflex is pre-tensioned according to its length when it left in the factory. This system is safe, strong, no affect for sea beds, easy to handle, low corrosion, simple to install, low maintenance, keeps pontoon in the right place, handles any variation in water level, no bottom erosion, and no damage to the marine ecosystem.

### 3.7 Anchors

Anchors are normal dead weight from reinforced concrete on the land, expressed in ton and it shall be the same number of rubber hawsers in the seaflex. Therefore, if a seaflex is used with 4 rubber hawsers, the weight of anchor will be 4 tons or more. The weight on anchor depends on the type of seabed; if the bottom is soft, it will be easier for anchor to skin down and a lighter anchor can be used. If there are small stones in the seabed and the friction is very low, a heavier anchor will be used. If the anchor is 10 tons, two 5 tons anchors can be connected together instead of 10 tons.

## 4. The Pontoon Installation

All pontoons contain service channels, underwater lighting system, electricity and water outlets, and illuminated stainless steel mooring bollards, led lighting, safety equipment, service buildings, and a sewage sanitation pump out system. The chafing between the ropes is removed because they are crossing each other under the pontoon so that the ropes can be fixed by swapping. This shows that the rope that is under moves and lays over the other rope. Some pontoons such as super yacht fingers are fixed to walkways with flexible joints. When the moorings are moved, the free depth for boats is increased.

Following steps are followed to install the pontoon;

- Each pontoon is lifted after checking the strength.
- The pontoons and anchors (sinkers) are transported by trailers or barges and sometimes by tag boats.
- The inner corners of pontoon are moored to the land.
- The pontoon is moored temporary in its position with lighter anchor.
- The permanent anchors are placed.
- The anchor with a seaflex attached to the rope are loaded on the boat.
- The anchor is lowered slowly down by a winch.
- Diver is checking if the anchor in the correct position.
- The rope is connected to the pontoon.
- The seaflex is pre-tensioned.
- This system is available for all the pontoon units.

## 5. Conclusion

It must be evident that the pontoon bridges are not just a military device or folkloristic curiosity but they also portray an economical and effective solution for crossing large stretches of even deep water. The length of the pontoon bridges is not restricted by technological or structural problems. However, it has been concluded that EPS blocks consist of difference dimensions. Seaflex always pre-tensioned according to its original rubber length. Seaflex system shows better stability for pontoons as it is manufactured faster as compared to any other system, is gentle to the environment, are the most modern method for mooring a pontoon bridge. The weights for pontoons differ up to 75 ton, resulting pontoon as strong and carrying large weights.

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