Modular GRP Intake Towers

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Summary

An efficient operation of intake towers is crucial in the overall performance of a desalination plant or cooling water system for a power plant. Although indispensable for the operation of a plant, its definition and execution frequently neglects the operational and maintenance requirements, structural durability and external environmental factors, such as fish impingement, marine growth, suction of debris, wave action, salinity, accessibility, etc.

As result, there are currently a significant number of plants in operation with reduced capacity and requiring permanent maintenance and refurbishment of equipment. However, through the last years it is being noticeable the increase of consciousness on the importance of these structures, from owners, contractors, designers and operators.

The fast pace of the projects and the high competitiveness of the market stresses the owners and contractors to explore improved designs that can satisfy time and cost constraints, and complying with local and international regulations and standards.

This study focus on the use of GRP intake towers and how a customized design can reduce time of installation, maintenance costs and improved efficiency. This study also presents the most recent experience in the MENA region in which Sogreah – Group Artelia has participated as main designer and Global Composites as manufacturer.

Keywords

Intake Structures, GRP, Marine Lines, Desalination plants

Introduction

Offshore intake tower is a type of intake structure that is commonly used to subtract seawater for desalination plants and/or cooling system for power plants.

This element is located offshore where the water characteristics are within the requirements for the process upstream (desalination or cooling), such as salinity, total suspended solids, temperature, etc.

It can be installed in the seabed or partially buried, depending on seabed characteristics, submergence available or wave action.

Due to the crucial importance of this structure in the operational efficiency of an intake system and considering the deficiency/lack of maintenance sometimes observed, it is essential to ensure a long lasting structure with provisions for easy maintenance operations, and with minimum of maintenance required.

This article focus on the use of intake towers totally made of GRP in two different projects (Egypt and Kingdom of Saudi Arabia), as alternative to the use of other materials generally used such as structural concrete and steel elements.

Why Glass reinforced plastic (GRP)?

Glass Reinforced Plastic (GRP) is an extremely useful material within a number of different and varied industries. Ranging from hotels to construction, marine docks to education, GRP is very versatile and can be easily fitted to any location within any industry and atmospheric conditions. The inherent qualities of GRP make it a highly desired material for its various use and applications.

- Low Maintenance required

GRP has virtually no maintenance cost, involved since It is a hardy material which can withstand outside conditions with very little wear and tear. Colors used for GRP go through a process of pigmentation, which means that there will be no fading / discoloration regardless of where the product is used. Hence there is no spray painting or color topping up required.

- High Strength against Weight Ratio

Since it is light, it is easy to transport and install which requires lesser man power comparing with other materials.

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- Versatile

As a result of the controlled molding process used in the GRP fabrication, it can take any shapes required, ensuring that all GRP products are made to an exact size to guarantee the perfect fit, making it an extremely versatile material to use.

- Resistant to corrosion

The resins used in GRP offer corrosion resistance over a wide pH range and environments, such as salt water

- Durability

They are all able to withstand any wear and tear, pressure or damage. This means that all GRP products are long lasting and remain in good condition.

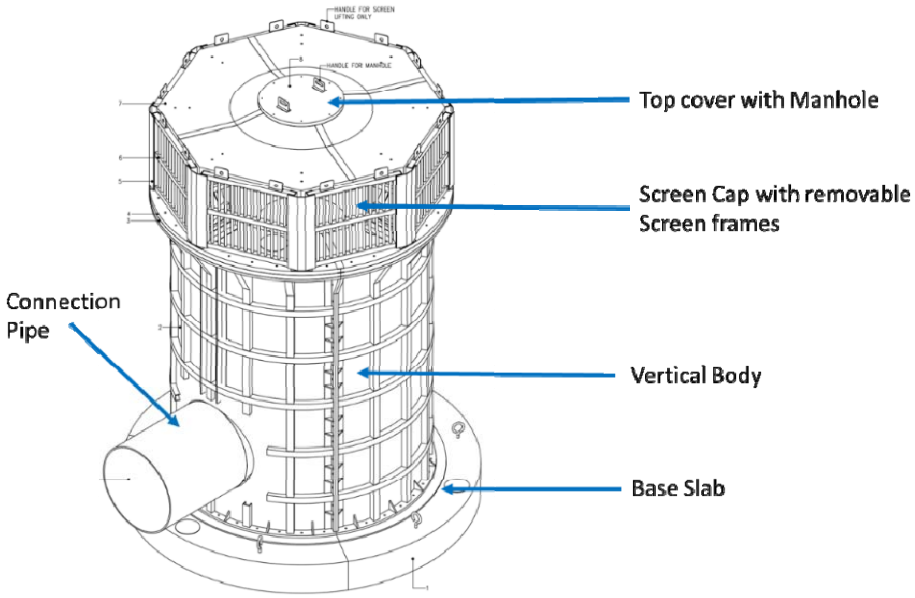
- Affordable / Economy:

While comparing with other corrosion resistant materials such as Stainless Steel, GRP provides more economical solution for construction companies to complete projects within minimum budget. Moreover, GRP lasts for a long time since no money spending is required to replace this product in general.

Design considerations for Modular GRP Intake towers

Open intake structures usually have a singular vertical collection head made of concrete or formed in GRP pipes.
The intake head is located at a pre-determined location and sufficient sea depth, where the water is extracted and piped to land. The structure is generally composed by different elements bonded together, as shown in Figure 1 and as briefly described below.

Figure 1: Different elements of the intake head structure



The submerged intake head will be a capped radial flow structure constructed in GRP and placed on a prepared granular foundation. The design considerations are listed below:

- Design low water level:

The lowest astronomical tide shall be adopted in the design of the intake structure;

- Submergence :

The minimum depth of water above the intake structure is determined to avoid air being drawn into the intake by formation of a surface piercing vortex and to avoid exposure of the intake cap at the trough of a wave:

- Sill Height:

The sill of the intake is required to be high enough above the seabed level to prevent sediment and debris drawn from the seabed into the intake. This also reduces the risk of drawing in benthic dwelling fish. The greater the sill height, the further the inlet needs to be located offshore. The final sill height is dependent on the characteristics of the seabed.

- Screening Panels:

The optimum direction of the entry of flow into the structure is horizontal, as it has been observed that fish can avoid rapid changes in horizontal flow. Therefore, the required screen area is governed by the design flow for the vertical height and the required uniform velocity through the intake screen that will allow fish to escape. To promote

horizontal flow and avoid trapping fish, an approach velocity of around 0.15m/s to a vertical screen in the intake head is proposed(Figure 2). This recommendation is in line with international best practice. The USEPA Clean Water Act requires a maximum intake velocity of 0.15m/s [1]

Figure 2: Fish swimming safely around GRP Intake tower (Kingdom of Saudi Arabia)

Operation and Maintenance

The Intake Head screen is designed to facilitate access by divers for maintenance and cleaning.

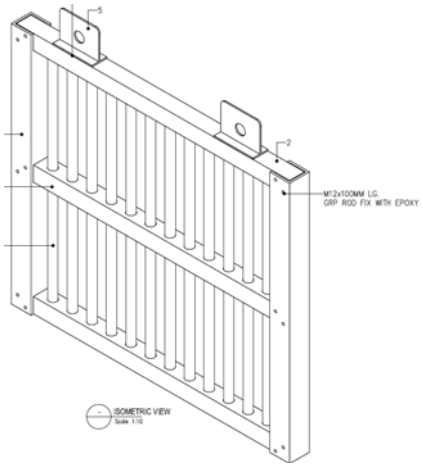
To facilitate the maintenance operations, this structure is equipped with removable prefabricated screens, so they can be removed and/or replaced during maintenance operations, as well as manhole access at the top cover of the structure.

These vertical screens are removable, and composed by an external holding frame or guide that maintains the vertical bars of the screen in position (Figure 3). The width and thickness defined to prevent a bending of each screen unit during handling and cleaning operation. The vertical sides of the frame slide easily with a minimum tolerance in the sliding channels.

Dimensions of the screen mesh shall consider the type of fish or other biota to be excluded.

As shown in Figure 3 , the vertical bars, the screen bars are coated with antifouling paint to prevent bio-fouling. The coating would need to be replaced frequently.

Figure 3: GRP Intake tower with removable screen frame (Egypt); 3D View of screen frame on guide

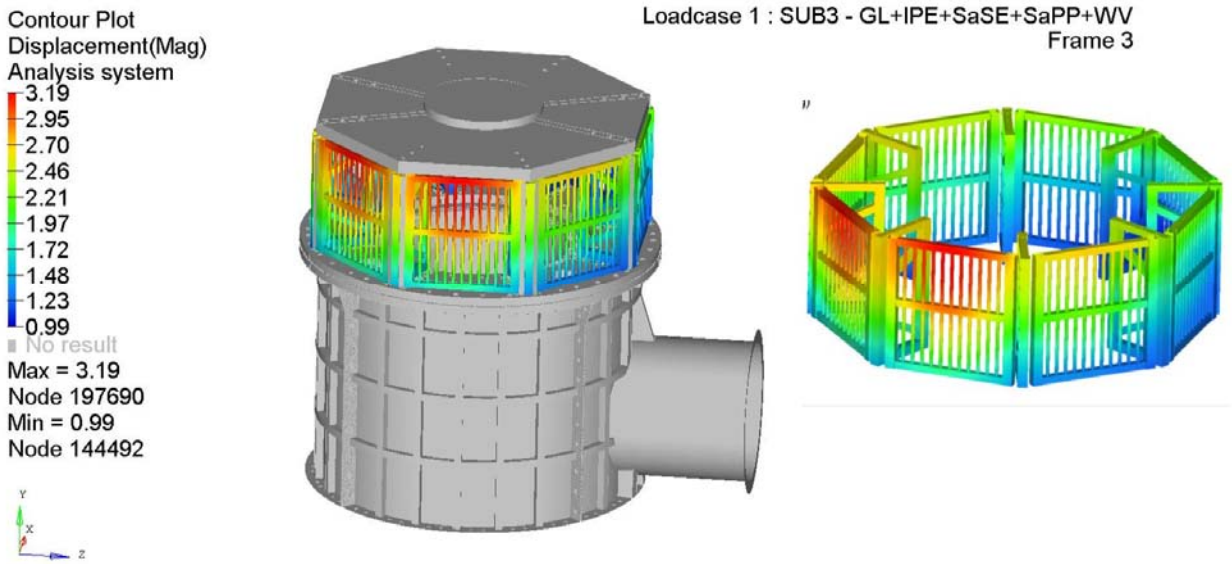


The cap of the intake head shall be flange connected to the main core of the intake head structure. This will allow the installation of the cap in different stages of RO plant capacity and simple replacement in case of damage. During earlier stages of a project, when the pipelines are not required, the cap can be replaced by a blind flange. At all stages of the project, chlorination of the line shall be guaranteed.

Structural Design

The vertical body of the main is the most prominent element of the intake tower. Depending on the project flows and offshore conditions, this element can reach more than 8m height and 4m in diameter.
The vertical body can be built with a cylindrical section of GRP pipe or with a polygonal structure made of GRP/FRP laminated, with provision of an exit bend to connect to the main intake line.
To overcome the challenge of the high diameters, frequently required for this element (more than 4m) a modular polygonal structure of GRP was developed with due consideration of wave action for the structural design (Figure 4) (developed by the fabricator).

Figure 4: Output of the structural design model (Egypt)



The development of a modular solution for the vertical body of the intake structure took in consideration the easy assembly on site (Figure 5) and was found to facilitate the works on site and allowed a simpler transportation.

Figure 5: Vertical body with pipe before and after assembly of modular parts(KSA)

Depending on the soil conditions and project restrictions, such as contractor machinery and capabilities for lifting and sinking, the base slab can be built in GRP or by means of a concrete block.
To ensure a safe lifting and installation of the tower, the base slab is equipped with lifting hooks.

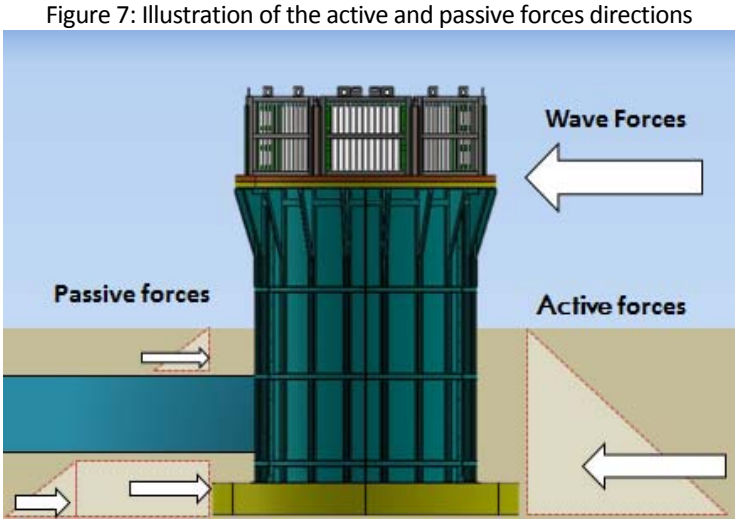
Figure 6: Intake structure with concrete base slab in Egypt (left) and GRP (right) base slab in KSA

Stability Verification

Geotechnical stability of the Intake Head Structure shall be carried out to ensure stability against sliding and overturning, with due consideration of the data obtained from offshore geotechnical campaigns, and also by assuming the wave forces in the direction that provides minimum passive resistance.

In case of a partially buried intake structure, minimum passive resistance is obtained when the passive forces act on the side where the pipe is coming out of the intake head structure, since the lateral pressures will not act in the space occupied by the pipe. The critical directions of the active and passive pressures and forces are illustrated in Figure 7.

Figure 7: Illustration of the active and passive forces directions



Chlorination System

Any surface exposed to sea water provides an opportunity for the settlement and subsequent growth of organisms, as a very great diversity of aquatic species whose adults live attached to solid surfaces employ planktonic larvae for dispersal. The internal surfaces of sea water intake systems can provide an ideal habitat for such species.

As the majority of these species are fixed in place and live by filtering suspended matter out of the overlying water, the internal walls of sea water intake systems are virtually ideal for the following reasons:

- The steady flow conditions guarantee a continuous supply of food and dissolved oxygen; and
- The physical screening means that predators are few.

Given such perfect conditions, settlement occurs readily and growth can be rapid. Without constraints, this growth can begin to interfere with the operational systems and lead to their failure.

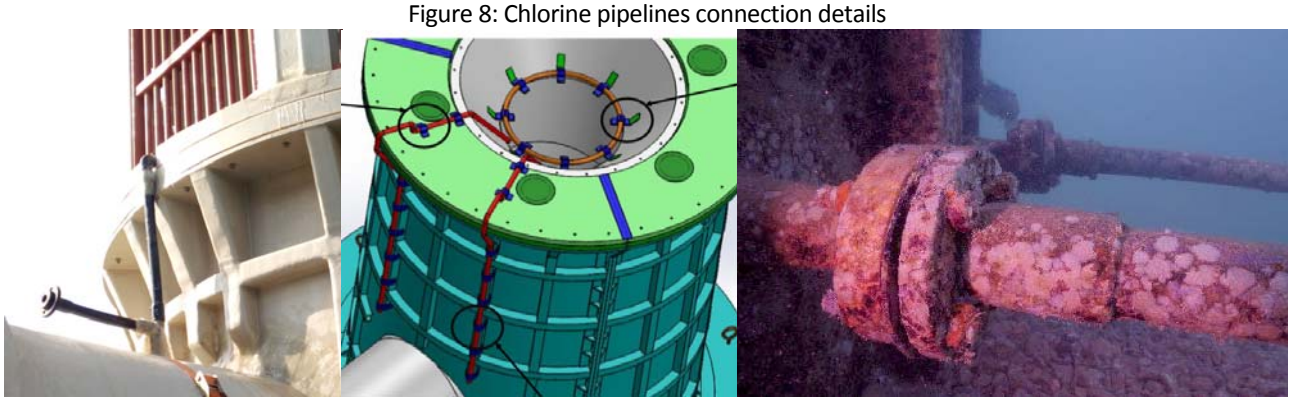
Each macrofouling species has its own characteristics in terms of settlement behaviour, and the effects and the occurrence of each species varies with site, season, and between years.

Therefore, a disinfection system shall be installed in the intake structure to control the marine growth in the marine lines.

Typically in SWRO plants, hypochlorite production occurs at an onshore electro-chlorination plant, where it is pumped to

the intake head structure through twin pipelines fixed on the outer side of the main intake line (Figure 8). This line will be connecting to a sparger ring fixed in the body of the intake head structure.

Figure 8: Chlorine pipelines connection details



Conclusions

GRP is widely used as preferred material for seawater pipelines, mainly due to its resistance to seawater and weight, and it presents a proven record of satisfactory installations worldwide. We have been extending successfully its application to the Seawater Intake Towers during the last years across the Middle East, which is considered one of the most adverse regions in the world for the marine installations.

Our current experience in using modular GRP intake towers for offshore marine applications also revealed that it has a positive impact in the program of works on site, from fabrication and delivery to assembly and installation.
On both cases, after fully assemble of all the modular GRP element, the structure weight was less than 10 tonnes. This is a significant reduction when compared with a reinforced structure of the same dimensions (flow capacity), which are 10times heavier. We are confident that this solution has room to be further developed and applied in different geographies.

References

[1] U.S. Environmental Protection Agency (EPA), "Issuance and Implementation of the Final Regulations Section 316(b) of the Clean Water Act," in Programmatic Biological Opinion on the U.S. Environmental Protection Agency's, 2014.