A NEW GRAVITATIONAL CONCEPT

Natalia Zubenko, GTT, France, presents the case for gravity-based structure technology as an innovative infrastructure concept for the LNG supply chain.

To meet the increasing recent demand for LNG, and to comply with the current environmental regulations for shipping required by the International Maritime Organization (IMO), the maritime fleet requires a dedicated and accessible network of onshore and floating infrastructure. LNG bunker stations integrated into a gravity-based structure (GBS) perfectly meet these requirements because they are incorporated into the LNG supply chain and facilitate access to LNG.

Overview of GBS technology

The GBS concept provides many advantages for this kind of storage. The concept consists of prefabricating reinforced concrete or a steel structure with caissons equipped with

liquefied gas containment tanks in floating or dry docks. The finished facilities are then towed to the installation location, where they are ballasted to rest on the seabed. A GBS can be installed in a harbour or in a remote area, with very limited requirements for any additional infrastructure. The selection of GBS technology for building offshore oil and production facilities in the North Sea led the LNG industry to consider the application of this technology for LNG.

Structural simplicity

The primary components of a GBS include: an integral outer concrete tank; a moisture barrier to prevent water migration from the concrete to the insulation; an insulating structure fastened to the concrete wall, base and tank roof; and a corrugated membrane welded onto the insulating panels of the wall, base and tank roof. The general architecture of the GBS is designed to provide a massive, rigid structure – a fundamental requirement for LNG storage.

Figure 1. Acciona gravity-based structure (GBS) LNG storage concept.

Figure 2. An internal view of a GBS.

Figure 3. An aerial view of a GBS.

A flexible solution

A GBS is suitable for various liquefied gas applications, including LNG, ethane, LPG, etc. It is appropriate for storage capacities from 5000 m^3 to 200 000 m^3 or greater (several caissons can be combined to increase storage capacity). In addition to this, all types of vessels (small LNG tankers, containerships, ferries, etc.) can moor alongside it.

A GBS can contribute to the LNG supply chain in the form of a liquefaction or regasification plant, peak shaving storage, or a satellite station. It can also be utilised in inland distribution systems. In a harbour setting, this type of storage can also be used for bunkering vessels with LNG as fuel. Another option for GBS utilisation is power generation (e.g. captive power, etc.). Indeed, for small and medium-sized power plants, GBS technology can be connected to a regasification module and replace the LNG floating storage and regasification unit (FSRU) with a solution that requires no onshore space, thus providing significant cost savings.

Reliability and safety combined

GBS technology combines the structural resistance of concrete with the insulation performance and tightness of membrane containment. In order to achieve this, the structure incorporates Gaztransport & Technigaz's (GTT) membrane containment system, with the possibility of using various GTT technologies, such as: Mark III, GST® or GTT MARS™ (for LPG applications).

This type of structure is highly durable and built with maintenance-free material. A GBS benefits from high resistance to extreme environmental conditions, making it suitable for both harsh and arctic environments (such as ice and earthquake zones). In addition to this, industrial risk is considerably reduced, since the equipment is located far from populated areas. As the storage is under atmospheric pressure, the explosion risk is limited, which provides a high level of safety.

As far as the protection of the storage tank is concerned, in contrast to onshore storage, a storage tank on a GBS may be exposed to vessel impact. However, even if high-speed collisions cause significant local damage to the caisson base structure, this will not result in loss of containment and the risk of LNG spillage. Again, the separation of the functions guarantees the integrity of the storage tank even in the event of severe impact. Indeed, the tank is located in the middle of the caisson base, several metres inside its outer walls. In the event of collision, it is the caisson base structure that is impacted and structurally affected, not the storage tank structure.

In addition to the fact that the structure is able to withstand significant vessel impacts, a number of preventative measures may be applied in order to mitigate such collisions. In heavy traffic, vessels must proceed at low speed and using extra caution, or an exclusion area may be created around the GBS. As far as the manoeuvrability of the LNG carriers is concerned, the approach and berthing of the vessels are handled by experienced crew in order to guarantee the safety of the operation.

Other advantages

Among the advantages of a GBS, it is notable that this system can be quickly deployed to develop LNG as a fuel source, or switch to green energies. The fact that the design of the station is based on standard components offers schedule flexibility and enables the storage tank to be easily installed. As the construction activities are located in a different place than the operational installation site, the existing terminal or harbour activities are not impacted by its implementation.

A GBS provides some technical advantages. For example, by adding mooring dolphins, loading and unloading of liquefied gas can be carried-out directly from a GBS. The caisson can also be deballasted and relocated if required.

Another significant advantage is that a GBS can provide access to energy for countries and islands which are not connected to the grid and which have limited land availability, while minimising visual impact, particularly in populated areas or areas with high levels of tourism.

Current applications and challenges

Nowadays, only one of this kind of LNG storage has been built in the world and is still in operation. Located in the northern Adriatic, 1700 nautical miles from Italy, operations at the Adriatic LNG terminal began in 2009.

However, this Adriatic GBS project will soon no longer be a standalone example of GBS technology. Indeed, in September 2019, GTT announced the design and construction of three GBS terminals intended for the Arctic LNG 2 project, operated by Russia's NOVATEK. These GBS terminals will consist of concrete caissons with membrane containment tanks using GTT's GST technology. The units will be built in a dry dock at the NOVATEK Murmansk LNG Construction Center, before being towed to their final location in the Gydan Peninsular in the Russian Arctic, where they will be installed.

The number of these structures may increase in the coming years. The potential of GBS technology is great, since this solution is suitable for various liquefied gas applications, for all types of vessels, and can be adapted to different storage capacities. In addition to being a flexible and adaptable solution, this modular concept offers great advantages in terms of simplicity, safety and cost.

For the future, the main challenge is that the GBS solution is quite site-specific. There are also currently no standards available. Geotechnical investigations must be carried out to ensure that the soil bearing capacity is appropriate for the vertical load applied by the GBS structure. LNG