INFLATABLE GATES - CONSTRUCTION, COMMISSIONING AND WARRANTY

by

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1. INTRODUCTION

Since the first installation of a rubber gate in 1957 in the US, more than 5,000 inflatable gates have been installed all around the world. Both, the design of inflatable gates and the construction process have been constantly improved during the decades. However, the basic principles always stayed the same. An inflatable gate consists of a rubber membrane or air bladder that is fixed to a concrete weir sill. By regulating the filling volume of the rubber body, the inflatable gate can be raised or lowered.

Specific requirements concerning construction, commissioning and warranty of inflatable gates typically relate to the properties of this gate type. Inflatable gates are flexible structures that need to be clamped to the civil construction. Additionally, pipes have to be embedded in the weir sill. These parts need to be installed precisely with installation tolerances of several millimeters. The installation of the embedded parts requires a good coordination between the civil and the electro-mechanical contractor. An advantage of the rubber membrane or air bladder is its flexibility and its light-weight structure. The rubber body can be rolled or folded for transportation. Therefore, even big gates can be stowed in a container and transported by lorry. The installation of a rubber membrane or air bladder requires thorough preparation. Special lifting equipment and clamps are needed to handle the rubber body (Fig. 1). Following installation, all functions of the gate need to be evaluated during commissioning.

Figure 1: Installation of a rubber membrane

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2. CONSTRUCTION

2.1 Coordination of works

Success of construction largely depends on the coordination of works between the civil and the electro-mechanical contractors. As the fixing system of the membrane and the piping have to be embedded in the concrete of the weir sill, the interfaces of the contractors need to be defined in the early design phase. Especially for water filled rubber gates with several spans, the number and the diameter of pipes can be considerable. The pipe routing largely influences the reinforcement planning. Other issues that have to be considered concern the geometrical tolerances. These are defined by the supplier of the inflatable gate. Typically, tolerances of several millimeters will be imposed for the civil construction because variations in elevation of the concrete crest will result in even larger variations of the crest of the inflatable gate. Another key point that has to be regarded in an early stage of the project is the water management. Especially on water ways, the upstream water level has to be maintained during the construction phase. This affects the way of construction. Normally, one span of a weir has to be constructed after the other.

2.1 Phasing of works

The construction of each span of an inflatable gate can be divided into two main phases. In the first phase, the embedded parts i.e. the pipes, anchors and embedded plates are installed (Fig. 2; left span). In the second phase, the rubber membrane or air bladder is installed (Fig. 2; right span).

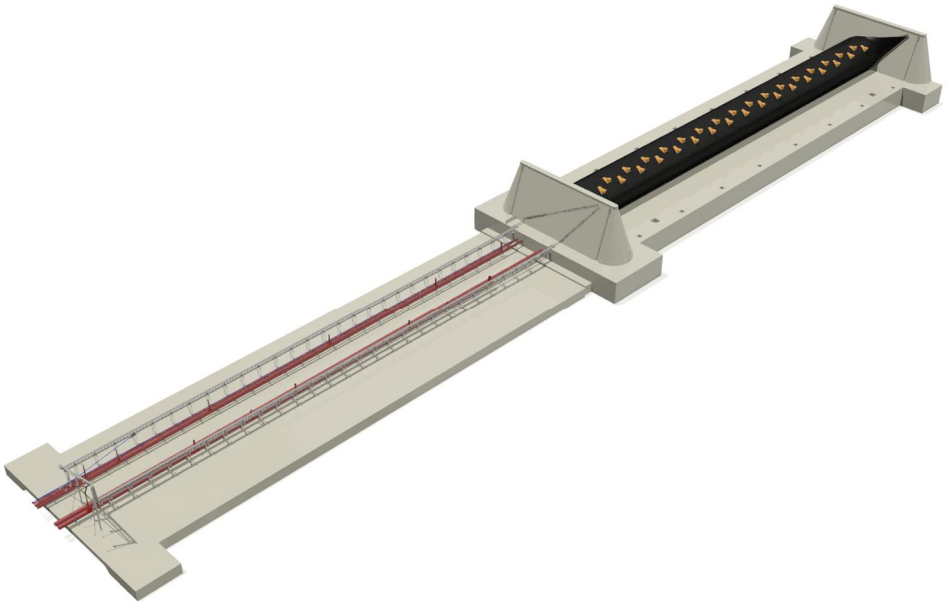

Figure 2: Installation phases for rubber gates

Normally, the embedded parts are installed with adjustable supports on a smooth layer of blinding concrete (Fig. 3). Depending on the reinforcement planning, it may be necessary to install some parts of the reinforcement before. However, the presence of reinforcement can significantly complicate the installation of the embedded parts of the inflatable gate and slow down the installation process. The embedded parts need to be carefully aligned, positioned, leveled and fixed. During further construction steps, especially during concrete pouring, these parts may not move. At the end of the first phase several tests and checks are necessary. These normally include a water- or air-tightness test of the pipe work, checking the position and fixation of pipes, plates and anchors as well as the completeness of assembly.

These tests and checks are of great importance as correction works after concrete pouring are extremely difficult and time consuming. The installation of embedded parts can be accelerated by using preassembled parts.

a)   b)

Figure 3: Installation of embedded parts for a) Rubber Gate and b) SR Gate

Following the installation of embedded parts, remaining reinforcement needs to be installed and the concrete has to be poured. After concrete pouring the visible part of embedded components should be checked regarding their position and possible damages. Another leak test of pipes is recommended, especially, if a damage of pipes during the installation of reinforcement or concrete pouring is suspected. Depending on the phasing of works, visible threads require temporary protection during further construction.

Prior to the installation of the rubber membrane or air bladder, the geometry of the civil construction and the concrete surface finish have to be controlled. As the rubber membrane or air bladder is always in contact with the concrete surface, a smooth finish is extremely important to avoid abrasion of the rubber. A coarse concrete surface at the contact area requires grinding.

Generally, the rubber body is delivered to the construction site in a single piece, folded or rolled on a drum. The rubber membrane or air bladder can be relatively heavy and bulky. Therefore, its handling requires a careful planning. Unrolling or unfolding as well as the placing of the membrane can be facilitated by using a load beam (Fig. 4). In addition, special clamps are required to attach the membrane to the lifting equipment. Due to the flexibility of the membrane, a stepwise installation is possible. Starting the installation at one side of the span and gradually moving to the other side allows for the use of much smaller lifting equipment, such as e.g. excavators. Weights for rubber membranes or air bladders depend on the size of the gate and on the thickness of the rubber material and can range from some hundred kilograms to several tons. However, compared to traditional steel gates, inflatable gates can be considered as light-weight structures. The membrane is fixed to the civil construction with clamping plates and anchor bolts along the weir sill. As opposed to SR Gates, Rubber Gates also have to be clamped to the abutments. Anchor bolts for rubber gates normally have a spacing of roundabout 20 cm. This means a large number of nuts have to be torqued. Due to the properties of the rubber material, relaxation has to be taken into account. All nuts therefore have to be re-torqued several times in consideration of required waiting times. Depending on the site conditions and the functioning modes of the inflatable gate, deflectors might need to be attached to the membrane. Typically, these are solid rubber bodies that are normally vulcanized to the rubber surface. Their installation can only be executed in dry conditions and in a certain temperature range. In the case of a steel rubber gate deflectors are attached to the steel gate panel. At the end of the second installation phase the bolt torqueing and tightness of the membrane has to be checked. In addition, the shape and especially the size of the membrane have to be evaluated.

a)   b)

Figure 4: Handling of a) membrane for Rubber Gate and b) bladder for SR Gate

Normally, all the electro-mechanical equipment (pumps, compressors, valves etc.) is located in a control-house. The installation of this equipment is not specific for inflatable gates. Yet, it goes without saying that a careful installation and commissioning of this equipment, based on established regional regulations or practice, is of equal importance as for the (steel) rubber gate. Also, it should be noted that special care needs to be taken for a waterproof wall traverse of all incoming pipes.

3. COMMISSIONING

The checks and tests that take place at the end of each installation phase are usually regarded as a preliminary acceptance. Therefore, these tests are part of the commissioning process. Typical further checks and tests include the operation of the electro-mechanical equipment (pumps, level meters, safety release valves, etc.). During final commissioning, all functions of the inflatable gate have to be evaluated. In order to perform the necessary tests, the inflatable gate should take over control of the upstream reservoir. Especially the calibration and evaluation of the control parameters can only be performed under real flow conditions.

4. WARRANTY

Warranty should cover the functioning of the complete scope of delivery, including the rubber body. The warranty covers a period of 12 to 24 month after commissioning. However, warranty periods can be prolonged if required by the customer. This may cause additional costs or strict maintenance procedures performed e.g. by the supplier.

References

PIANC. (2018). Report of Working Group 166: Inflatable Structures in Hydraulic Engineering. PIANC, Brussels.