MITRE GATES: DESIGN AND FABRICATION – PIANC WG 154

**by**

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1. **INTRODUCTION**

Mitre gates are by far the most common navigation lock gate type in the world. They have a long and reliable history dating back to 15th century Italy and Leonardo Da Vinci. Despite good performance, there have been a number of problems which have plagued mitre gates leading to occasional failures. Since mitre gates are an essential component of lock operation, long-term successful operation of these gates is very important to the reliability of the navigational system. Therefore, there is a critical need to identify these problems and provide improved designs and practices from around the world. The recently published PIANC WG Report No. 154 covers international mitre gate design guidance and summarizes the current state-of-the-practice and best practices in mitre gate design and fabrication.

1. **MITRE GATE GEOMETRY AND STRUCTURAL SYSTEM**

A double-leaf mitre gate forms a three-hinged arch in the mitred position to hold back water at a high water level from water at a low water level – thus enabling navigation lockage of vessels. This arrangement uses the force of water to keep the gates closed during a lockage and this arching plan is structurally efficient in transferring hydraulic loads. While all mitre gates utilize arching, there are different geometries and structural framing systems that are utilized for different scenarios. The most common framing is horizontal framing where there are a series of horizontal girders stacked along the height of the gate which span the hydrostatic loading directly through the heel posts (quoins). Another framing type is vertical framing where vertical girders span the hydraulic load between the top and the bottom horizontal girders of the gate leaf. The top horizontal girder transfers the load directly to the lock crown (monolith). The bottom horizontal girder transfers the load directly into the gate sill. Horizontal framing is good for all gate heights especially tall gates and vertical framing is good for shorter gates.

The components of mitre gates include main framing members, skin plate, hinges, anchorages, heel and mitre blocks, valves, diagonals, and operating mechanisms. For all these components there are variety of designs that can be utilized which are discussed and summarized.

1. **DESIGN AND GUIDANCE**

Mitre gates are typically designed for a various loading scenarios that it is likely to experience in its service life. Loading scenarios include normal hydrostatic loads, vessel impact, waves, ice, obstructions, lifting, seismic, and other environmental loads. In addition to designing the gates for sufficient strength, they are also designed such that the stress levels in the material, usually steel, are kept low enough so that material fatigue does not occur in the intended life of the gate. The structural support conditions and load paths can change over the life of the gate as the gate becomes worn and misaligned with age and use. Structural analysis of the mitre gate can be performed using 2-dimensional and 3-dimensional modeling depending on the matters being investigated. 3-dimensional modeling offers insight into more complicated behaviors, loading, and support conditions.

Design guidance specialised for mitre gates and specific hydraulic structures is needed. It is recommended that designers review the national design guidance documents listed in the report and use the guidance document(s) applicable to their design situation. Design should also accommodate ease of future maintenance.

1. **FABRICATION**

There are many important aspects of how the mitre gates are fabricated that can affect the performance of the gate over its service life. These include materials used, geometrical detailing of structural framing and connections, type of connections, and quality control. For materials used, carefully consider the structural demands of various mitre gate components and match them with materials based on the advantages and limitations that have been discussed within this report that have the best properties to meet the need and longevity requirements. Newer and innovative materials can serve mitre gates well. Usage applicability depends on the material properties, performance history, limitations and specific conditions. Care taken in detailing connections can help to avoid high stress concentrations that can lead to premature failure of the gate due to cracking and fatigue. Finally, quality control in the fabrication process is critical to ensure quality materials, welding processes, and coating system application processed are used which in turn results and a long-lasting and successfully performing mitre gate.

**REFERENCES**

PIANC. (2017). Report of Working Group 154: Mitre Gate Design and Operation, PIANC, Brussels.

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