Control of Fatigue in Hydraulic Steel Structures

Ryszard A. Daniel

RADAR Structural, Gouda, The Netherlands

Contact: r.a.daniel@xs4all.nl

Abstract

Hydraulic Structures, like lock gates, movable river weirs, tide and flood barriers, are subject to varying loads that may lead to fatigue damage. These loads are primarily generated by differential water heads, but also by waves, gate drive forces, vibrations in flow and other actions. The existing guidelines in the field of fatigue did not sufficiently cover the specific operation conditions and demands that apply to hydraulic structures. An improvement in this matter was the investigation report by a Working Group of PIANC, the International Association for Waterborne Infrastructure. The intention of this paper is to describe the practices followed by designers, constructors and maintenance crews of hydraulic structures with respect to fatigue control; and to evaluate the applicability of existing codes and regulations in this regard. The discussed subject constitutes a challenge for both existing and prospective hydraulic steel structures.

Keywords: structural engineering; hydraulic structures; lock gates; service life; load cycle; stress range; fatigue; notch; crack; maintenance.

1 Introduction

Since the early 1980s, a number of serious fatigue damages particularly to navigation lock gates (see Fig. 1) indicated the need for specific guidelines in this field. Such guidelines already existed for other steel structures, like bridges, offshore structures or cranes, but they were not specifically focused on the operation demands, low maintenance and other conditions for hydraulic structures.

One should realize that, for example, a navigation lock gate, like the one depicted in Fig. 1a, cannot be taken out of service and set dry for inspection and maintenance as frequently as most other steel structures. On the other hand, it experiences very significant variable loads during operation. Therefore, the strategy of its fatigue design and fatigue control during operation will substantially be different than, for example, for a steel bridge.

This was the reason why PIANC called a group of experts, to review the existing codes, regulations and practices for fatigue design and construction; and to specify recommendations in this field for hydraulic steel structures. This Working Group no. 189 (WG-189) completed its studies in 2019. The final report [1] was issued a year later.

The author of this paper was the initiator and one of the members of this Working Group. The paper is illustrated with examples from the engineering practice from Europe and America.

Hydraulic steel structures form a relatively narrow group of civil engineering structures of steel. In the absence of specific codes for these structures, designers often follow the codes and practices for structures that are somewhat similar, in this case for steel bridges. Therefore, the author hopes that this paper will contribute to more interest for hydraulic steel structures within IABSE.