International Journal of Offshore and Polar Engineering
Vol. 2, No. 1, March 1992 (ISSN 1053-5381)

Ice Forces on Light Piers in the St. Lawrence Seaway

R. Frederking and M. Sayed
National Research Council Canada, Ottawa, Ontario, Canada

G. Penney
Memorial University of Newfoundland, St.John's, Newfoundland, Canada

ABSTRACT

Over the past 8 years ice force measurements have been made at 5 different light piers in the St. Lawrence Seaway System. The technology of ice force sensing and data acquisition systems have been advanced. The maximum total global force on light piers of 4-m water line diameter and steep 4 on 1 conical form or 45° conical form was about 1200 kN. No significant reduction in ice forces was seen for the 45° cone. Slightly lower forces were observed in areas with milder winters. Lognormal distributions were found to best describe the maximums of ice load events.

INTRODUCTION

Loads that floating ice can exert against structures such as bridge piers or light piers are often a significant factor in their design. The past two to three decades have seen considerable effort in the way of field measurements, analytical model development and physical model tests to better define ice loads. There is still uncertainty, however, due to a lack of understanding of the processes by which ice loads are developed on structures and natural variability in the environmental conditions that lead to ice loading.

Field measurements of ice forces on structures in rivers and lakes include those reported by Neill (1976), Gerard (1978), Lipsett and Gerard (1980), Danys (1981), Sodhi and Gagnon (1989), and Sodhi and Haynes (1983), who also gave a comprehensive review of available literature. There are also field measurements of ice forces on light piers in the Baltic Sea: Määttänen (1977), Englebrektson (1989) and Wessels et al. (1989), to name a few. These field measurements have been carried out at a variety of locations and for a range of ice conditions.

A maximum ice pressure of 2.8 MPa (400 psi) has been specified by design codes for calculating ice loads on bridge piers. However, the Canadian Standards Association (1988) and the Ministry of Transportation and Communications (1983) present more refined methods for calculating ice loading, taking into account the likely strength properties of the ice and the effects of pier geometry and size in modifying ice failure behaviour. As a result, lower effective ice pressures can be justified for design purposes. The codes, which are deterministic, have been developed from field experience on a limited range of structures and extrapolations derived from results of analytical or physical models. Considerable judgement is required in applying the code recommendations. There is a need for further field measurements to generate data for regional and seasonal variations of ice forces and to form a basis for probabilistic design.

Received May 29, 1991: revised manuscript received by the editors February 10, 1992. The original version (prior to the final revised manuscript) was presented at The First International Offshore and Polar Engineering Conference (ISOPE-91), Edinburgh, United Kingdom, August 11-16, 1991.

KEY WORDS: Ice forces, light piers, measurement systems.

A collaborative research project between the Canadian Coast Guard and the National Research Council has resulted in an extensive program of ice force measurements in the St. Lawrence Seaway System. The measurements started in 1983 and have involved 5 different light piers. This paper will describe the measurement program, highlight some of the instrumentation used, and present an overview of the results.

LOCATION AND DESCRIPTION OF LIGHT PIERS

Five piers have been instrumented in the St. Lawrence Seaway System, from the St. Clair River to Lac St-Pierre (see Fig. 1 for the locations). The piers are thus exposed to a range of ice and climatic conditions. In the St. Clair, the winter ice conditions are quite mild and there is winter navigation. Heavier ice originates in Lake Huron and is carried down the river. Lake St. Francis is on a section of the Seaway where there is no winter navigation, so a fast ice cover forms over the winter, reaching a maximum thickness of about 0.6 m. The ice cover on the lake is broken up with an icebreaker in late March to allow the start of the shipping season. Navigation is conducted in Lac St-Pierre throughout the winter. Level ice reaches a thickness of about 0.6 m but, because of extensive traffic, the ice is often broken up into small floes.

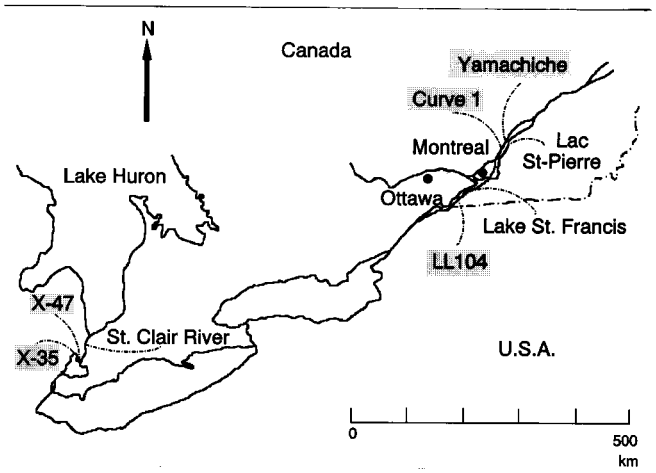

Fig. 1 Locations of instrumented light piers in St. Lawrence Seaway System (pier locations highlighted)