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Effect of Impact Load on the Ice Cover During the Landing of an Airplane

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This paper analyzes the deflections of the ice cover caused by the combined action of the impact load and the subsequent decelerating load during airplane landing. It analyzes the influence of the impact load and the thickness of the ice cover on the possibility of the safe use of the ice cover as a runway. It was found that the impact load produces a deflection with a magnitude no greater than that produced when the decelerating load passes through the critical speed.

INTRODUCTION

In several countries there has been in recent years increasing interest in the Arctic shelf due to its huge amount of natural resources. It is therefore necessary to create regular navigation to these remote areas. The use of airplanes increases the possibilities of the exploration and development of remote polar regions. Cargoes and equipment for the Russian Arctic expeditions are delivered by The Ministry of Emergency Situation through the use of the IL-76TD and An-74 airplanes by The Utair Aviation. Over the years, the Antarctic station McMurdo has been provisioned through the use of the C-130 Hercules airplane (Squire et al., 1996; Milinazzo et al., 1995). Building airfields in these regions is difficult, however, and requires considerable economic expense. The use of the ice cover as a runway can reduce this expense.

Landing is a difficult and dangerous flight maneuver. At the moment when the undercarriage touches the runway surface, the most intense loading of the ice cover occurs. This can lead to the destruction of the ice cover. Therefore, it is necessary to define the parameters of the ice airfield to enable safe air navigation.

The problem of load motion on the floating ice plate is being examined widely and developed actively in the present scientific world due to extensive applications to the creation of an artificial platform for different purposes, the destruction of the ice cover, and so forth. The works of Kheisin (1967), Kerr (1976), and Squire et al. (1996) are fundamental in this field. Milinazzo et al. (1995) considered the steady motion of a rectangular load on a floating ice plate. Schulkes and Sneyd (1988) studied ice plate deflections caused by a suddenly starting line load. Nugroho et al. (1999) and Wang et al. (2004) investigated the time-dependent response of a floating elastic and viscoelastic plate to an impulsively started moving load. Miles and Sneyd (2003) considered an accelerating line load on an elastic plate.

Nonlinear effects in the response of a floating ice plate to a moving load were considered in Parau and Dias (2002). It was found that the nonlinear effects have an impact on the ice cover deflections at a load speed slightly lower than the minimum phase speed. Bonnefoy et al. (2009) calculated the nonlinear response of an infinite ice sheet to a moving load. It was considered that the inclusion of nonlinearities can lead to effects that are not observed in the linear formulation of the problem.

It should be noted that the problem of the moving load on the ice plate is similar to the investigation of the use of a Very Large Floating Structure (VLFS) as a runway. Kashiwagi (2004) investigated the elastic deformations of a VLFS caused by a plane (a Boeing 747-700 jumbo) during takeoff and landing. Pogorelova et al. (2014a, 2014b) obtained the theoretical results of the ice plate deflections and stresses caused by the landing and takeoff of the IL-76TD and C-130 Hercules airplanes. However, Pogorelova et al. (2014a, 2014b) did not investigate the effect of the impact load on the ice plate deflections and critical stresses at the moment when the undercarriage touches the runway surface.

The behavior of the ice cover under the influence of shock loading has been studied extensively over the past decades. Recent works devoted to the impact of the shock pulse on the ice cover include Meylan (1997), Lu and Dai (2006, 2008), Tkacheva (2004, 2007), Kozin and Pogorelova (2006), and Zhestkaya and Kozin (2008). In addition, Pogorelova and Kozin (2013) reviewed the unsteady behavior of an elastic plate (floating on water of variable depth) under the action of a shock pulse. In parallel with the research on the action of pulsed loads on infinity plates, Tkacheva (2005), Sturova and Korobkin (2005), Sturova (2006), and Korobkin and Khabakhpasheva (2007) actively studied the flexural-gravity deflection of the finite-size elastic plate subjected to periodic load. Kozin and Pogorelova (2004) presented experimental research on the impact of one or several shock pulses on the floating ice cover, i.e., a modeled viscoelastic plate.

Most of the above works, however, presented solutions to the plate deflections under the influence of various types of pulse loads

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KEY WORDS: Airplane landing, ice airfield, ice cover, impact load, elastic plate.