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Analysis of the structural behavior of an innovative reinforced ski boot

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Abstract

The effect on the boot structural behavior of a stiffening aluminum bootboard has been investigated by laboratory and field tests. Stiffness tests on the boot with the bootboard screwed to the shell (state ON) showed a 20 % increase with respect to the unscrewed state (OFF). Lateral stiffness tests conducted on a servohydraulic test bench together with motion capture techniques did not show significant increases due to the bootboard. Strain gauges applied to the bootboard for measuring torsion and bending moments in the field confirmed the intervention of the bootboard torsional stiffness at the edge changes during slalom turns.

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1. Introduction

The ski boot is a very special piece of footwear that has been evolving since the early development of skiing. The different functions of the ski-boot can be stated as (i) transmitting control loads to the ski, (ii) enabling a quick connection and a safety release of boots from bindings, (iii) protecting the foot-ankle-shank complex from injuries due to overloads during falls and (iv) maintaining the foot pressure, thermal and humidity optimal conditions.

The effort of manufacturers is towards the maximization of all performance and comfort parameters of ski-boots with mass and cost reduction. A crucial role in the field of performance is played by the boot stiffness parameters as they influence the ability of quick transmission of control loads from the foot to the binding-plate-ski assembly.

The present work was carried out for evaluating the structural behaviour of an innovative ski-boot presenting an extruded aluminium bootboard (known also as “zeppa”) having not only a simple support function to the foot but also a reinforcing function due to the presence of four screws that can be connecting the bootboard to the shell sole. When connected (state “ON”), the overall stiffness of the boot was much higher that when not connected (“OFF”).

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The positive effect on the athlete of the new ski-boot was already studied in a previous work by means of a comparative EMG analysis of the same subject in special slaloms [1], leading to a reduction of main muscle activations when performing similar time trials.

2. Instrumentation

A pair of racing boots was equipped with a set of innovative bootboards made of an extruded aluminum profile with an additional upper layer of molded high density foam. The bootboard can be fixed to the plastic shell sole by means of four nuts inserted into the profile engaging with four screws that can be tightened (state ON) or un-tightened (state OFF) from the outside, as shown in Fig. 1.a. The bootboard will therefore be able to add a structural function to its usual function of supporting the inner boot sole.

On the lower face of the two bootboards a strain gauge rosette HBM 3-120-RY43 was placed with $0^\circ/+45^\circ/-45^\circ$ gauge arrangement (Fig. 1.b), whereas on the upper face a longitudinal 0° strain gauge was placed in correspondence of the rosette (Fig. 1.c). The four strain gauges were connected as four single quarter bridge to a portable data logger.

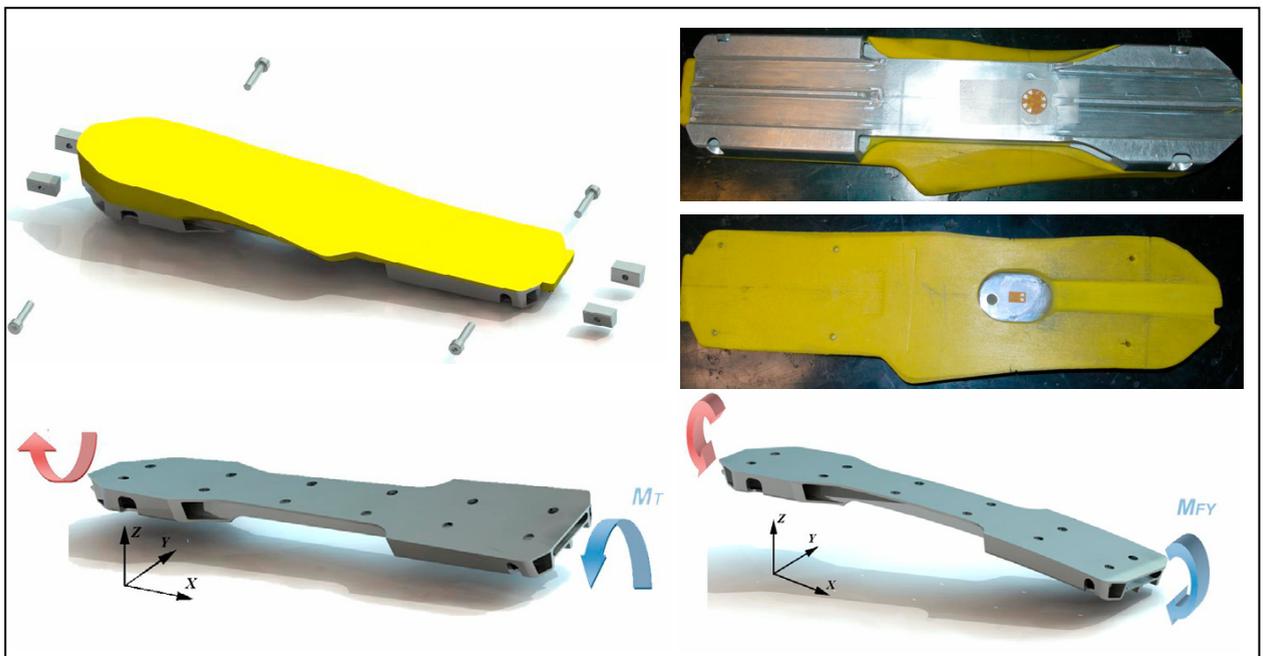


Fig.1. The instrumented bootboard used in the study. (a) Bootboard; (b) Lower face rosette (c) Upper face single strain gauge; (d) Torsional Calibration Mt. (e) Bending Calibration Mf.

The strain signal were measured by means of a Somat[®] 2300 Card Corder portable system, used both in the laboratory and the field tests: during the field tests on the snow, also a couple of MTI Xsens sensor was connected to the data logger to record the skis roll angles during the slaloms.

The Laboratory stiffness tests were performed by means of a test bench enabling to lock the heel of the boot and to apply a known torque by deadweights to the front sole (Fig. 2.a): the relative rotation was measured with a calibrated LVDT applied to the loading lever arm.

Cyclic tests on the boot were performed in the lateral direction by means of a servohydraulic MTS 242 cylinder under force control. The boot sole was fixed onto a Bertec force platform placed on the test bench (Fig. 2.b).

The boot deflection patterns under cyclic loading were recorded after installation in the test area of a Motion Capture system Smart BTS[®], calibrated for measuring 1 m^3 volume around the boot. A set of 46 semispherical markers (6mm diameter) was placed on the boot surface to define a reticular mesh of control nodes (Fig. 2.c). This allowed a resolution of 0.1 mm in the spatial positioning of the reflective markers.

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