Finite element model and ergonomic pertinent choice for stirrup sensors location

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1. Introduction

The scope of this paper is to export our results to create a device able to quantify the forces applied on the stirrups. The subject is to determine the ergonomic and pertinent choice for sensor location. French research in equine sports performance publishes articles that present significant results, such as the 43rd Equine Research Days organized by IFCE in partnership with “The French Equine School”. We haven’t found any scientific paper that has validated the proposed experimental methodology. Some experimental results only used sensor to determine the specificity of the stirrup sensor without any valid test (Cosson 2012; Van Beek et al. 2012; Martin et al. 2016; Biau 2017). The difficult is to discover the strain and the real frictions applied on the different parts of the stirrups fasteners.

2. Methods

2.1. Simulation

To obtain the ideal strain gauge location, we realized a finite element model to calculate longitudinal stress due to the connection (a horse strap) between the stirrup and on the saddle knife. Given the dimensions, the small thickness makes it possible to use in 2D, the theory of plane stresses two-dimensional Constant Strain Triangle elements using three nodes (CST). All these calculs were carried out using the code Aster (https://www.code-aster.org).

2.2. Experimental methods

The mounted bracket on the chassis of the traction machine is tied to the knife with a horse strap. A displacement imposed by a crosspiece is applied to the knife, which makes it possible to apply the assembly in a coherent, realistic context until reaching the limit load of 1500 N, using a load in the strap axis with a 100 N increment (0–1500 N) with an INSTRON 8872 traction/compression machine. The soft used is Instron Weave maker-Editor. Three set of strain measurements were used. To satisfy our needs we used little and pertinent strain gauges adapted to the constraints friction load during horse riding [encapsulated gauge WA 350 (CEA-06-250UW-350) strain ±1.5% non-linear at strain level over ±0.5, correctly glued on the substrate. The gauge factor announced is 106. In constant temperature, we performed comparative experimental results using strain gauge on the lateral caliper’s parts (gauge 3, see Figure 1), one on the upper parts of the caliper (gauge 1) and on the external face of the saddle knife (gauge 2). We have used a half Wheatstone bridge for the connecting input of the gauges 2 and 3 and a quarter Wheatstone bridge for the gauge 1. The gauges were connected to deltalab strain gauge type EI 616. The values were read step by step on the digital bridge and transcribed on a spreadsheet file.

3. Results and discussion

The data associated with the lateral gauge located the stirrup (gauge 2 on Figure 1) and shown in red symbols in Figure 2 presented an approximately constant strain value equal to zero when varying the load from 0 to 1500 N. We conclude that this site is not suitable for laying gauges. It would seem that our gauge rental is in the middle part of the structure that works in bending stress. In this case, the set of stretching stresses of the upper part of the assembly is compensated by the set of stresses of the lower part which works in compression. We note that the sum of the constraints remains at zero, so the outputs are constant. For the gauge located on the upper edge of the stirrup...
The difficulties of using the strain gauges related to the methodology and the precision of installation (adhesive, time and temperature of bonding, protective varnish, friction and contact with the rider’s legs) do not allow easy use outside laboratories. The choice is made by the alternative to use dynamometers mounted in series between the strap and the caliper. Our research also turns on the encrustation of a gauge inside the strap, or even the creation of a conductive fabric with force capture.

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