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Dynamic Analysis of Cables on Pulleys Using the New Algorithm

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Abstract: This paper demonstrates application of a new algorithm for calculation of cables on pulleys. This brand new algorithm enables taking into account the magnitude of radius of each pulley. It has been implemented in the RFEM program because of its significantly higher accuracy and high efficiency compared to the previous algorithm. The paper contains the comparison of the commonly used algorithm, which ignores pulley radius, and the new algorithm. The solutions obtained by explicit finite element method are presented.

Introduction

Pulleys are used for their mechanical advantage (Fig.1). That is why pulleys are a part of many building and machine structures, they can be seen e.g. at crane structures, cableways and even in a car engine. The set of pulleys is often a complex system too complicated for hand calculation and therefore there is an effort to enable calculation of such structures with the aid of computer programs. For pulleys which are part of load bearing structures and dynamic effects are taken into account, manual calculation is completely impossible.

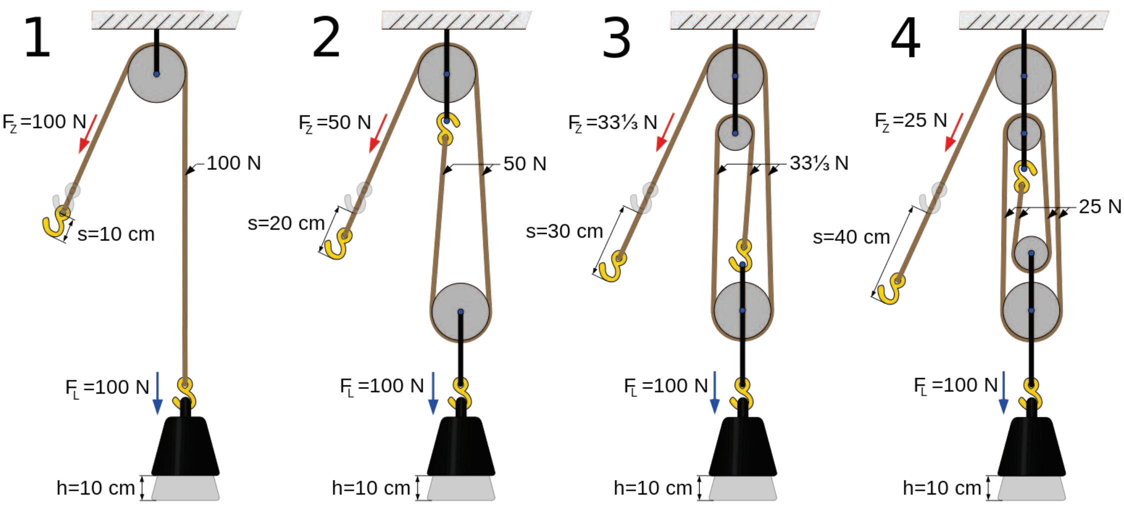

Fig. 1: Efficiency of pulley system [1]

Algorithms for the calculation of cables on pulleys

Besides simulators like MapleSim, which do not allow detailed static and dynamic calculation of pulleys and structures connected to them, there are two possible approaches for solving cables on pulleys.

The first approach is a connection of pulleys by 1D elements only in the centre of each pulley (Fig.2a) or at the intersection of real cable sections (Fig.2b) and defining behaviour of such system to find equivalent solution [2, 3]. Such a solution lacks any consideration of the radii of pulleys, which inevitably leads to inaccurate results. In the first case (Fig.2a) spatial geometry of cables in the model is changed and in the second case (Fig.2b) reaction occurs in the node located out of the structure. This approach is used in programs such as LS-DYNA or RFEM.

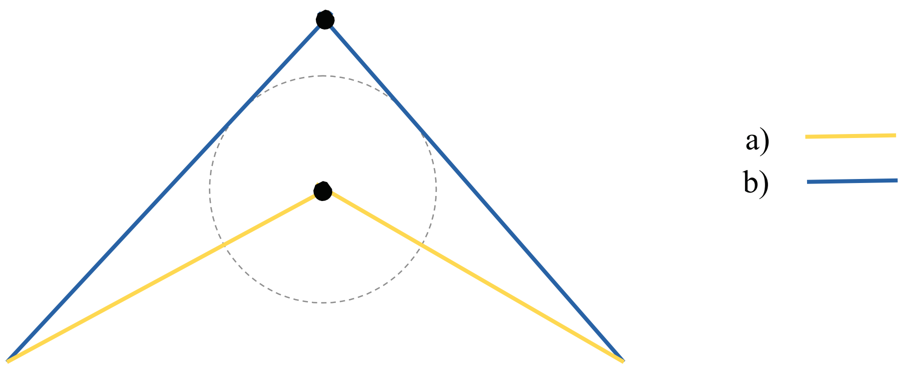

Fig. 2: Connection possibilities of two cables in node for the first approach

The second approach is modelling of each pulley and cable using 3D elements and between these elements adding other contact elements for correct behaviour of multibody system. This solution is indeed accurate for the correct model, but it is extremely laborious to create a mathematical model and calculation is also extremely time-consuming. Because of the difficulty mentioned above, use of this approach is impossible for large structures. Such approach can be used with programs like ANSYS, Nastran and Abaqus.

The current algorithm, used in the RFEM program, utilizes the first approach and for some input parameters too many iterations are required, which leads to long computing times. That is why the new algorithm was developed. The new algorithm, implemented in the RFEM program, combines advantages of previous two approaches mentioned above. These advantages are simplicity and speed of pre-processing and processing in the first approach and more accurate geometry in the second approach. This enables fast and accurate solution of pulleys using 1D elements.

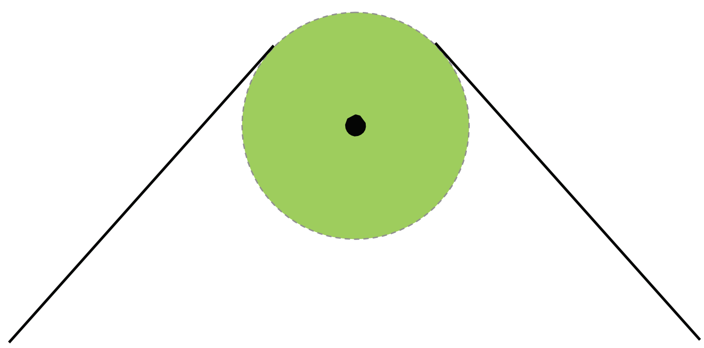

Fig. 3: New algorithm geometry

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