Skin friction concept

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Concept: Skin Friction

Skin friction represents the frictional resistance between soil and a structure or between soil and a pile being driven in it [1]. This very simple principle stands behind the deep pile foundations used to support structures build on sand. The experiments below demonstrate the concept in two different situations.

Experiment 1

Materials needed: Cylinder (glass, cardboard) – approx. 30cm tall, uncooked rice, knife (Figure 1).
Method of conducting the experiment: The rice is poured in the cylinder leaving 3-4 cm of empty space at the top (Figure 2). The whole blade of the knife is inserted in rice, confined by the cylinder (Figure 3). When the knife is lifted the cylinder is attached to it and the two components act as a single structure (Figure 4).

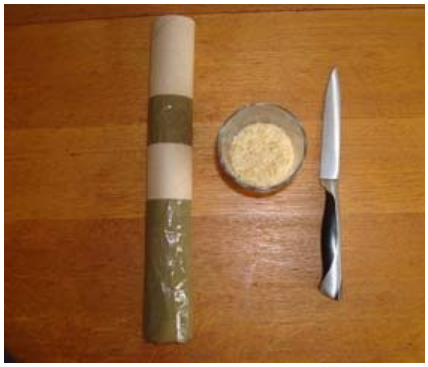


Figure 1: Materials for experiment

Figure 2: Cylinder filled with rice

Figure 3: Knife inserted in the rice

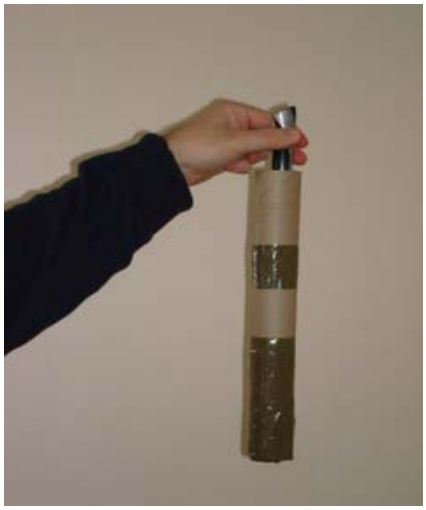


Figure 4: Lifting the knife together with the cylinder

The only force that is holding the knife attached to the cylinder is the friction between the rice and the blade of the knife. During the experiment, it was observed that there was an increased resistance due to the skin friction when the knife was pushed the last 3cm even if the force applied was the same. This experiment simulates driving a pile into a compacted sand soil. The resistance that stops the two rough materials slipping past each other increases with the length of the pile.
Due to this principle the construction of Burj Al Arab in Dubai was possible. Its foundation consists of 250 steel reinforced concrete piles, having a diameter of 1.5m, driven 45m in the ground. The skin friction enables the foundation to withstand the loads generated by the structure.

Experiment 2

This experiment illustrates the skin friction between the pages of two registers. The resistance between two pages is not very significant, but when the layers are increased a few hundred times it is able to support a considerable load.

Materials needed: Two registers (Figure 5), rope, weights, one nail, hammer.
Method of conducting the experiment: The pages of the two registers are folded on top of each other (page by page) (Figure 6). A nail is inserted at the bottom of one of the books to provide support for the rope that will hold the weights. The weights are attached to the rope in increments and the behaviour of the two books is observed (Figure 7).

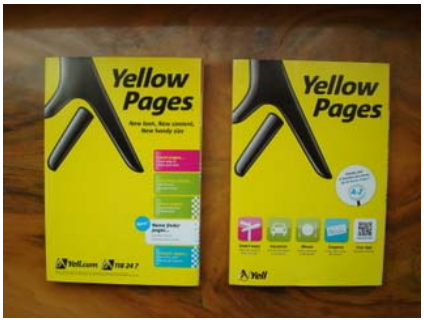
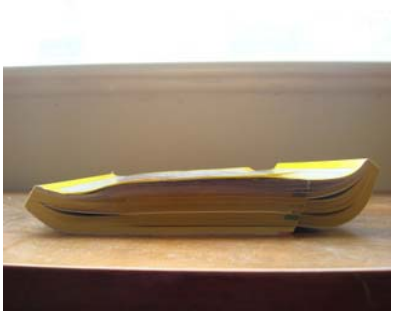


Figure 5: Two registers of similar size



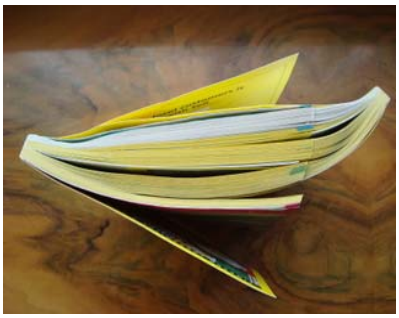


Figure 6: The pages of the registers are folded on top of each other

Figure 7: Weights supported by registers

In the experiment the two books having their pages (350 pages) folded on top of each other were able to resist an applied weight of 7kg (68.67N) before there was any movement between the books. This load was only supported by the skin friction between the pages of the two registers. It could be observed that the contact area between the books is very important in providing the necessary resistance. This experiment demonstrates that the concept is also valid for objects made from the same material.

References:

1. http://www.answers.com/topic/skin-friction [1]
2. Richard Hammond's Engineering Connections (S03E01) – Burj Al Arab, available on: http://www.youtube.com/watch?v=E_dXsr0WfxQ
3. Seeing and Touching Structural Concepts: www.**structuralconcepts**.org
4. National Geographic- Megastructures – Burj Al Arab, available on: http://www.youtube.com/watch?v=79-Yi5IYiVQ&feature=related –part 1