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P2_4 Up, Up in the Atmosphere

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Abstract

This paper is an investigation into the physical feasibility of Mary Poppins flying away using the lift generated on her umbrella from a natural wind source. The best case scenario used was adapted from the film such that the umbrella's dimensions were greater and there was no drag force. A vertical wind speed of 37mph or a wind speed of 118mph at an inclination of 18.3° would be required to lift a 60kg Mary Poppins off the ground. Taking into account that the pressure exerted would most likely destroy normal umbrellas, it was determined that materials with a greater tensile strength such as aluminium and polyester would be required to withstand the force of the wind.

Introduction

In the 1964 film Mary Poppins, the leading actress Julie Andrews leaves the film by seemingly floating away on the breeze by being lifted up by an umbrella. This paper is an investigation into a best case scenario adaptation of this phenomenon, not the exact scenario used in the film. Rather, this paper is a test of the feasibility of this scenario and what limits would be placed on parameters such as; the structure and tensile strength of the umbrella, the wind speed required and the dimensions of the umbrella.

Analysis

Since the scenario has been adapted, there are several assumptions that must be made before any calculations. First is that the mass of the umbrella must be negligible. Secondly, that the umbrella is circular and has a radius of 0.85m. Lastly, given the height and age of Julie Andrews when she portrayed the character, it was estimated that her mass would have been roughly 60kg.

Newton's 2nd law was used to calculate the force *F* that was required to lift Mary Poppins off of the ground given the previous assumptions (the acceleration due to gravity was taken to be 9.81ms^{-2}) was found to be 589N. To find the air pressure generated by this force the equation

$$P = \frac{F}{\pi r^2}, \qquad (1)$$

was used, where *P* is the pressure in Pascals and r is radius of the umbrella. Note that this pressure is distributed across the entire underside of the umbrella. From this, *P* was calculated as 259Pa. The wind speed required to lift Mary Poppins can be calculated using the equation

$$P = \frac{1}{2}\rho {v_w}^2 C_d. \quad (2)$$

This is a variation on the Bernoulli equation where ρ is the density of air (1.25 kgm^{-3} [1]), v_w is the velocity of the wind and C_d is the drag coefficient which was taken to be 1.5 [2]; equal to that of a parachute. From this, v_w was calculated as approximately 16.4 ms^{-1}. This is equivalent to a vertical wind speed of 37mph. Instead, many winds consist of a vertical and horizontal velocity component relative to the ground. Given the maximum wind speed recorded in southern England, (118mph in Gwennap Head (Cornwall) [3]), and using basic trigonometry, the wind would have to have an inclination of 18.3° from the ground in order to generate enough vertical lift. It must be noted that most winds of this speed and inclination do not occur naturally outside of hurricanes and thunderstorms [4]. Note also that this is neglecting any drag forces that might be experienced by either Mary Poppins or the umbrella.

Research conducted on umbrellas in wind tunnels [5] showed that most umbrellas collapse when subjected to wind speeds of 30mph. This indicates that Mary Poppins' umbrella would need to be constructed in such a manner as to negate this effect. One such possibility is that instead of having a jointed system commonly found in most

umbrellas, the skeleton would instead consist of a solid structure akin to Japanese parasols, see *Figure 1*.

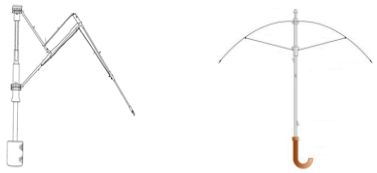

Figure 1: **Illustrations of the two types of umbrella discussed in this paper. The diagram on the left shows the structure of a typical jointed umbrella (adapted from source [6]), whereas the other shows a solid structure (adapted from source [7]). The jointed structure is more susceptable to collapse.**

Considering the tensile strength of materials it was found that an aluminium skeleton directly woven into polyester vinyl fabric (a typical umbrella material) would be able to withstand the forces in this scenario. These materials have a tensile strength of *90 Mpa* [8] and *40.4 MPa* [9] respectively. This demonstrates that the materials are strong enough to endure the forces involved.

Conclusion

From the analysis, it is clear that this scenario would be possible given extreme weather conditions. It must be noted that the wind speed would have to be constant and consistently at an inclination of 18.3° or higher; assuming the aforementioned wind speed 118mph. Upon consideration of existing materials that could be used to construct an umbrella durable enough to withstand the forces involved, it was found that an aluminium skeleton with a polyester vinyl fabric would be sufficient. Although this would add mass to the currently idealised system, further work would most likely find that the weight of the umbrella would make a very small difference compared to the weight of Mary Poppins. However, due to the horizontal component of the wind, it is likely that there may be aspects that would prevent the ascent of Mary Poppins due to counteracting forces caused by drag.

References

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