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P2_9 The animals float two by two, hurrah!

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Abstract

Genesis, 6:13 – 22, God commands Noah to build an ark, and to do so God provides exact dimensions. Ultimately the ark will home at least two of all the Earth's animals. Using Archimedes principle we conclude that the ark will be of sufficient buoyancy to withstand a mass of 50.54x10^{6}kg and therefore can safely support the mass of the animals.

Introduction

In 'The Book of Genesis', chapter 6:13 - 22, God commands Noah to build an ark as he promises to 'bring the floodwaters down on Earth' [1] and rid the Earth of all its sinners. This would unfortunately mean that the animal kingdom would perish also, however as most primary school children could tell you, the ark was to accommodate at least two of every animal on Earth to ensure the survival of each species. God gives Noah exact instructions, describing the dimensions of the ark, 'the length of the ark should be 300 cubits, its width 50 cubits, and its height 30 cubits' [1]. Now, whilst God is often regarded as infinitely wise, we wonder whether God paused to consider the physics behind such a request. What would the buoyancy force be for an ark of such dimensions and therefore could the ark support the weight of all the animals? Using Archimedes principle and simple buoyancy equations, we investigate.

Theory

As previously described, God gave Noah exact dimensions to which the ark should be constructed; 300 by 50 by 30 cubits. Furthermore, God states the ark should have a roof, and it should be made out of 'gopher wood' [1]. The first issue arises when we consider what the metric equivalence of a cubit is. The cubit is an archaic length based on the distance between the elbow and the tip of the middle finger; however various ancient cultures disagree on the exact length of a cubit. The lengths range from 44.5cm, the lower limit given by the ancient Hebrews, to 52.3cm, the upper limit from the ancient Egyptians [2]. Since the original cubit length is uncertain we take an average length over each culture; 48.2cm [2].

A second complication involves the term 'gopher wood'; as such wood doesn't actually exist today. Many articles speculate over the exact translation of the word 'gopher' [3], comparing it to pine or cedar, each of which are also mentioned in the bible. We assume 'gopher wood' is most similar to cypress wood, as most English versions of the bible use this translation. The Jewish Encyclopaedia argues that the identification as cypress is arbitrary [4] however as the densities of each of the suggestions are similar anyway; we assume cypress as a suitable approximation.

Using the dimensions of the ark, and the density of the material the ark is made from, we can calculate its buoyancy force. Archimedes principle states that the upward buoyancy force that is exerted upon a body in a fluid is equal to the weight of the volume of fluid that the body displaces [5]. Therefore, at equilibrium the magnitude of the weight of the body acting downwards, will equal the magnitude of the buoyancy force opposing it, such that;

$$m_B g = V \rho_w g, \qquad (1)$$

where m_B is the mass of the body, or in this scenario the ark, g is the acceleration due to gravity, ρ_w is the density of the fluid displaced; water, and V describes the volume of the fluid that is displaced.

For simplicity we assume that Noah took God's instructions literally, and built a box-shaped ark. As such, the volume of the water displaced can be given by dA where d is the depth to which the ark sits in the water and A is the surface area of the bottom surface. Using equation (1) where $V = dA$, we first calculate the depth d to which an empty ark would sit in the water in order to identify if the buoyancy force could support the weight of the ark, and then later take d to the extreme; 30 cubits, to calculate the total mass the ark could support before sinking.

Results and Discussion

The dimensions of the ark in metres are calculated to be, 144.6m in length, 24.1m in width, and 14.46m in height. We assume the width of each panel of the box shaped ark to be 0.2m. Therefore we can calculate the total volume of 'cypress' used to make the ark by calculating the volume of each panel; 2369.7m^3. Using the density of cypress, 510kg/m^3 [6], the ark has a mass of 1.2x10^{6}kg.

Rearranging equation (1) for d, and using the density of sea water, 1027 kg/m^3 [7], we calculate that the 'box-shaped' ark sits at a depth of merely 0.34m.

Alternatively, if we assume that the base of the ark sits at 14.46m below the sea level, i.e. the ark rests as equilibrium at a depth equal to its height, we can estimate the total mass the ark can support before the gravitational weight overcomes the buoyancy force, and the ark sinks. The volume of the water displaced is now equal to 50391m^3. Using equation (1) the total mass of the ark that could keep the ark in equilibrium with its buoyancy force is, 51.75x10^{6}kg. Subtracting the mass of the ark we find the maximum weight of the animals on-board before the ark sinks; 50.54x10^{6}kg.

A previous investigation conducted into the feasibility of Noah's ark suggests that an average mass of all the animals aboard the ark is approximately equal to the mass of a sheep [8]. As such, assuming the average mass of a sheep is 23.47kg [9]; our calculations prove that buoyancy force of the ark could support the weight of 2.15 million sheep.

Conclusion

According to the World Book Encyclopaedia, scientists have classified over 1.5 million animals to date [10]. Furthermore in *The Genesis Flood*, Doctors Morris and Whitcomb claim that only 35,000 individual animals needed to go on the ark [10], and John Woodmorappe, the author of *Noah's Ark: A Feasibility Study* claims that as few as 2,000 animals may have been required on the ark [10]. Our calculations show that ark was of necessary size to provide a buoyancy force to support the weight of 2.15 million sheep, (of which the sheep represent the average size of the animals). Therefore, regardless of which figure is correct, we believe the ark to be of sufficient buoyancy. Of course, this does not conclude whether logistically Noah's ark was possible, it remains to be concluded if the size of the boat is sufficient to house all the animals.

References

[1] http://books.google.com.au/books?id=WW31E9Zt5-wC&pg=PR3&dq=Genesis&cad=3#v=snippet&q=cubit%20upward&f=false.

[2] http://www.answersingenesis.org/articles/am/v2/n2/original-cubit.

[3] http://christiananswers.net/q-eden/gopherwood.html.

[4] http://www.creationtips.com/gopher_wood.html.

[5] P. Tipler, G. Mosca, *Physics for Scientists and Engineers*, (W.H. Freeman and Company, New York, 2008), 6th edition.

[6] http://www.engineeringtoolbox.com/wood-density-d_40.html.

[7] http://hypertextbook.com/facts/2002/EdwardLaValley.shtml.

[8] H. Morris, J. Whitcomb, *The Genesis Flood*, (Presbyterian and Reformed Publishing, 1961)

[9] http://www.fao.org/wairdocs/ilri/x5522e/x5522e06.htm.

[10] http://www.cbn.com/spirituallife/BibleStudyAndTheology/Discipleship/Noah-HowManyAnimals.aspx.

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