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A5 7 Life under Plastic, is it Fantastic?

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Abstract

This paper calculates the minimum thickness of the polyurethane dome that the character Sandy Cheeks from *SpongeBob SquarePants* lives in to withstand the pressure on the seafloor of Bikini Bottom, and the minimum thickness of the dome to withstand the pressure at the deepest point in the ocean, Challenger Deep. We find Sandy's dome would need to be at least 0.031 m thick to withstand the pressure at Bikini Bottom, and at least 5.6 m thick to withstand the pressure at Challenger Deep.

Introduction

In the animated comedy television series *SpongeBob SquarePants*, the character Sandy Cheeks lives in a giant dome on the seafloor of Bikini Bottom. In this paper, we calculate how thick the dome must be to withstand the pressure on the seafloor of Bikini Bottom, and how thick it would have to be to withstand the pressure at the deepest point in the ocean, Challenger Deep.

Bikini Bottom

The main location of *SpongeBob SquarePants* is Bikini Bottom, which is located on the seafloor underneath Bikini Atoll in the Pacific Ocean. The average depth h of the seafloor around Bikini Atoll is approximately 50 metres [1]. Using this information, we can calculate the pressure on the seafloor of Bikini Bottom using the hydrostatic pressure equation:

$$P = P_0 + \rho g h \tag{1}$$

where the atmospheric pressure $P_0 = 1$ atm $= 1.013 \times 10^5$ N m^{-2}, the density of water $\rho = 1000$ kg m^3, and the acceleration due to gravity $g = 9.81$ m s^{-2} [2]. Substituting these values into Equation 1 gives the pressure at Bikini Bottom as being equal to 5.918×10^5 N m^{-2}. If we model Sandy's dome as a hemisphere of radius $r = 10$ m, the total force F of the water on the surface of the dome $F = 2\pi r^2 P = 3.718 \times 10^8$ N.

The minimum thickness of the dome t_{min} can be calculated using the equation:

$$t_{min} = \frac{Pr}{2\sigma_{max}} \tag{2}$$

where σ_{max} is the maximum tensile strength of the dome [3]. In the episode "Help Wanted/Reef Blower/Tea at the Treedome" [4], Sandy says her dome is made out of polyurethane:

> "This dome is made of the strongest polyurethane. That's just a fancy word for plastic. Ain't that just the bee's knees?"

The strongest polyurethane has a maximum tensile strength of 96 MPa [5], so by using Equation 2, the minimum thickness of Sandy's dome

required to withstand the pressure on the seafloor of Bikini Bottom is 0.031 m.

Challenger Deep

The deepest point in the ocean is Challenger Deep in the western Pacific Ocean, which has a depth h of approximately 10 935 m [6]. Substituting this depth value into Equation 1 gives the pressure at Challenger Deep as being equal to 1.074×10^8 N m^{-2}. Substituting this pressure value into Equation 2 gives the minimum thickness of Sandy's dome required to withstand the pressure on the seafloor of Bikini Bottom, which is calculated to be equal to 5.6 m.

Conclusion

We have calculated that Sandy's dome would need to be at least 0.031 m thick to withstand the pressure at Bikini Bottom. This value, equivalent to 3.1 cm, is small enough that a dome of such size as Sandy's would be realistically feasible to construct at the depth of Bikini Bottom. We have also calculated that Sandy's dome would need to be at least 5.6 m thick to withstand the pressure at Challenger Deep, which is a substantial fraction of the dome's radius. This means that a dome of such size as Sandy's would not be realistically feasible to construct at the depth of Challenger Deep unless it is made of a material with a greater tensile strength or it has a smaller radius. One material that could realistically be used to construct a dome of such size as Sandy's at the depth of Challenger Deep is fibreglass, which has a maximum tensile strength of 3033 MPa [7]. A dome of such size as Sandy's made of fibreglass would need to be at least 0.18 m thick to withstand the pressure at Challenger Deep, which is more realistically feasible to construct, although getting to Challenger Deep would be difficult due to the extreme pressures at that depth.

References

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