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P1_7 The Supervillain Struggle

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Abstract

This paper investigates the energy requirements to vaporise famous landmarks if a super-villain were to decide to destroy one. By investigating the material composition of landmarks such as the Pyramid of Giza and the Cloud Gate monument, the energy required to completely vaporise them has been calculated. The landmark with the lowest energy value was found to be an Easter Island head but this may not have the largest international impact.

Introduction

The recent cost of living crisis has hit every member of society hard, not least the super villain community, with budgets tight and enthusiasm low it is important to select the highest impact, lowest effort target. In this paper, we investigate the energy required to vaporise one landmark from each continent. We have selected the Great Pyramid of Giza, the Taj Mahal, the Sydney Harbour Bridge, the Eiffel Tower, the Cloud Gate sculpture (The Bean) and finally an Easter Island head. For the investigation we have excluded Antarctica due to the lack of famous landmarks. Each landmark's main material constituent has been modelled to be its only component.

Theory

The energy absorbed or released by a material when it undergoes a phase change or physically changes its state is referred to as latent heat [1]. The latent heat of vaporisation is the heat transfer required to convert 1 g of solid or liquid into a vapour without changing the temperature [2]. The energy to vaporise an object can be found using Equation (1):

$$E = mL_V \tag{1}$$

where E is the energy, m is the mass and L_V is the latent heat of vaporisation.

Results and Discussion

Name of Monument	Main Material	Mass (kg) (2 s.f)	Latent Heat of Vaporisation (kJ/g) (2 s.f)	Energy (GJ) (2 s.f)
Cloud Gate (The Bean)	Stainless Steel	$1.0\text{x}10^5$	2.1	0.22
Easter Island Head	Basalt	$1.3\text{x}10^4$	4.1	0.052
Eiffel Tower	Puddle Iron	$9.2\text{x}10^6$	2.1	19
Pyramid of Giza	Limestone	$6.0\text{x}10^9$	0.062	370
Taj Mahal	Marble	$8.0\text{x}10^7$	1.53	120
Sydney Harbour Bridge	Concrete	$5.3\text{x}10^7$	5.1	2.7

Figure 1: To summarise the characteristics of each monument compiled from sources [3] to [14]. The final column shows the energy values we have calculated using Equation (1)

Based on the energy data in Figure 1, vaporising an Easter island head requires the least amount of energy. While it is made of basalt rock, which has one of the highest latent heats of vaporisation values, it is still expected to require a small amount of energy since it has the smallest mass in comparison to the other landmarks considered. This would be the most energy efficient landmark for a supervillain to destroy requiring only 0.052 GJ of energy. Given that they are made from the same alloy family, the Cloud Gate and the Eiffel Tower have very similar latent heats of vaporisation. Since the Cloud Gate is much smaller in mass than the Eiffel Tower, the Cloud Gate only requires 0.21 GJ to vaporise it compared with 19 GJ for the Eiffel Tower. The Taj Mahal and the Sydney Harbour Bridge have the similar mass values. Both would require a significant amount of energy to be completely vaporised. Since the Sydney Harbour Bridge is made of concrete, it has a much higher latent heat of vaporisation and thus requires 270 GJ of energy, whereas the Taj Mahal only requires 120 GJ. Due to their large masses and significant latent heat values, both of these landmarks require a significant amount of energy to vaporise. Finally, the Great Pyramid of Giza has one of the lowest latent heat of vaporisation because it's comprised of limestone. Since it is so much larger than any of the other landmarks in consideration, the low vaporisation value has little effect, requiring an estimated 370 GJ to vaporise it.

Conclusion

To conclude, while vaporising an Easter Island head would require the least amount of energy, there are thousands of these heads over the island. It is likely that one missing head would go unnoticed by tourists and so wouldn't have the large impact a super-villain would wish for. Therefore, we would instead suggest a supervillain should opt for vaporising the Cloud Gate out of this list of landmarks because it would have a larger impact on tourism while only using 0.21 GJ (2 s.f) of energy.

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