
The Longest Lasting Sandcastle

A variety of sandcastles can be found on the seashore, range from simple mounds of sand to complex castle replicas. Over time, there is no doubt that rain and waves will gradually erode the sandcastle. However, the degree of erosion of different types of sandcastles is different. Even if the building size and the distance from the water on the same beach are roughly same. Therefore, we wonder if there exists an optimal 3D geometric shape to use as sandcastle foundation.

In task 1, in order to identify the best 3D geometric shape of sandcastle foundation, firstly, our team choose six common geometric shapes to analyze. Then, we introduce Mohr-Coulomb Yielding Criteria to check the strength of sandcastle foundation, Horton's equation to calculate infiltration rate of seawater, further Van Genuchten Model to obtain water retention curve. Based on the study of water content, we use internal friction angle to determine whether the sandcastle is stable or not. Finally, we work out the cuboid is the best, of which lasting time is 50min. What's more, by traversing the aspect ratio of the cuboid, we find that the narrower the width of the water surface is, the longer lasting time is.

In task 2, take sand-to-water mixture proportion into consideration. Because the sand-to-water ratio is related to the structural stability of the sandcastle, by establishing the function relationship between sand-to-water mixing ratio and internal friction angle, then programming traversal, we find that the optimal solution is when the water-to-sand ratio is 15%, and lasting time of the sandcastle 64.43min.

In task 3, we divide the impact of rainwater on the sandcastle into two parts: scour and infiltration. We find that the cuboid is still the optimal geometry, confirming the reliability of our model. Besides, ANSYS simulation analysis is used to verify the theoretical results, and results are very similar.

To sum up, by consulting a large amount of data, we establish wave erosion, tidal immersion, rain scour, and rain immersion models. The model establishment has a gradual optimization process, and the results of rain immersion are analyzed using ANSYS simulation. It is in good agreement with the theoretical calculation, which verifies the correctness of our model.

Keywords: Mohr-Coulomb Yielding Criteria, Horton's equation, Van Genuchten Model, Internal friction angle, ANSYS simulation.

