Optimized structure for Ice Stupa - Architecture that supports nature to resist climate change

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Abstract

Natural life and human populations in high-altitude arid regions depend solely upon streams from natural glacial meltwater. Due to climate change, population growth, modernization and sudden surge in tourism, water scarcity becomes a pressing challenge. This led local innovators to develop the technique of glacier grafting, expanding water storage as tall ice structures during the winters. This work proposes an optimized structure for artificial glaciers to meet the water demands of high-altitude arid regions which face sub-zero temperature during winters.

Artificial glacier or glacier seeding is a grafting technique to freeze and hold water in the form of ice, received due to melting of natural glaciers.[1] This method requires no pump or external pressure to freeze the water but rather adapts to the environment. Ice Stupas are a type of artificial glacier, created by freezing the stream water vertically on a structure in the form of huge ice towers or cones of 30 to 50 m height that look very similar to the local sacred mud structures called Stupa or Chorten. Previous designs are difficult to build, using of primitive methods of construction that lead to uncertainties and excessive material consumption. Moreover, replicating the structure was always challenging due to lack of modularity in design.

We leverage precision and fast emulation capabilities of computer-aided modelling and 3D printing to propose an optimized design. The design considers extreme terrains and climate conditions of such regions. Hence it has been proposed as plug and play modules which ease on-site assembly, even by a non-expert local resident. The structure was designed as the modules of elongated pentagonal pyramid of which all the vertices or nodes were 3D printed which hosted locally available barks of a willow tree. This module can be assembled at base station and transported to higher altitudes for final assembly into a geodesic dome.

For this work, Leh-Ladakh was naturally chosen as a test site as it is located in the trans-Himalayan range with insufficient annual rainfall of 100mm. As this was the first attempt to modularize the base structure of the stupa, each process i.e. designs, manufacturing, and construction had their own challenges, but overall assembly of the structure took about 20 hours while engaging 6 volunteers on an average. Thus, dodecahedron dome formed the base and was wrapped by a fine synthetic cloth net to allow glacial melt-water to freeze upon. As of now it has grown about 60 feet in height and is expected to grow till mid-April before it starts melting.

The paper presents the research problem, background, design, prototyping, results, conclusions and future work.

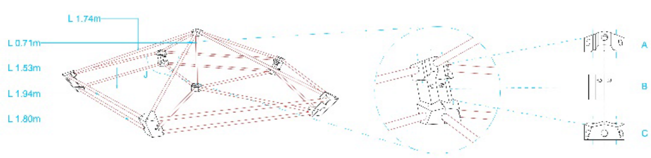

Fig. 1 – Detail of one module

Fig. 2 –On-site assembly

Fig. 1 – Structure with water sprinkler

References

[1] Carey Clouse (2014) Learning from artificial glaciers in the Himalaya: design for climate change through low-tech infrastructural devices, Journal of Landscape Architecture, 9:3, 6-19, DOI: 10.1080/18626033.2014.968411