

# Engineering Excess

# Inside Eden the greatest greenhouse

Studying and understanding structures is often overlooked in D&T. Every aspect of practical work and design work embraces or requires a shell or frame structure as an inclusive aspect of work, as an enclosure or support. To that end this issue of **Engineering Excess** focuses on The Eden Project. Eden has been open 5 years now and for many pupils is not something familiar to them unless visited on holiday.

Eden is of course a triumph not just of engineering but of people and organisations. Cornwall's gulf-stream climate and rich history of plant and botanic ecology meant it was and is the ideal location for such a venture. With a focus on conservation and stewardship Eden has become a great national asset. Eden is an ecological mission with a difference, providing a permanent home for plants from across the world as well as a showcase and focus for biodiversity.

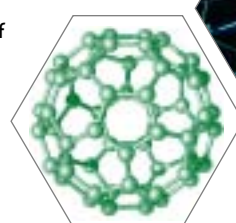
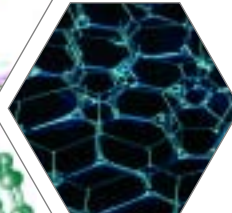
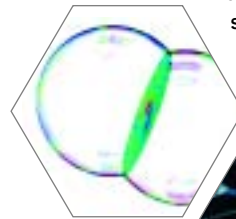
The granite backbone of the Southwest of Britain runs from Dartmoor to Lands End. Over time granite decomposes into fine china clay particles called mica and quartz. This rich 'White Gold' resource dominated mid Cornwall's industrial economy once local Plymouth Chemist Cookworthy had established that Cornish clay was ideal for making hard white porcelain. In fact the Cornish clay industry was a microcosm of the industrial revolution. Thus over time much of mid Cornwall was left mildly 'scarred' with man-made moonscapes of big pits and spoil heaps from the China clay process.

The Bodelva site on which Eden is situated is 5km from St Austell. It is quite literally the largest conservatory ever. For many readers its memorable geodesic domes are of course not a new idea. Buckminster Fuller's Lower Manhattan proposal and the very real Climatron at the Missouri Botanic Gardens are typical historical pointers to using geodesic structures. Geodesic domes provide a structural concept for least weight and maximum surface area for strength.

Many aircraft and performance cars use such 'spaceframe' concepts. The scale of Eden means that the pentagons that Fuller proposed would not suffice. The variations in the site and size dictated that the strongest structure would need to be built from hexagons of varying sizes. The final design proposal was model tested to Gale Force 12 too.

The key feature of Eden is undoubtedly the two greenhouses or Biomes. One environment housing humid tropics and sub tropics zones, the other more Mediterranean, warm temperate zone. Constructed with Concrete base 'Ring Beams and ground anchors to support the Biomes.

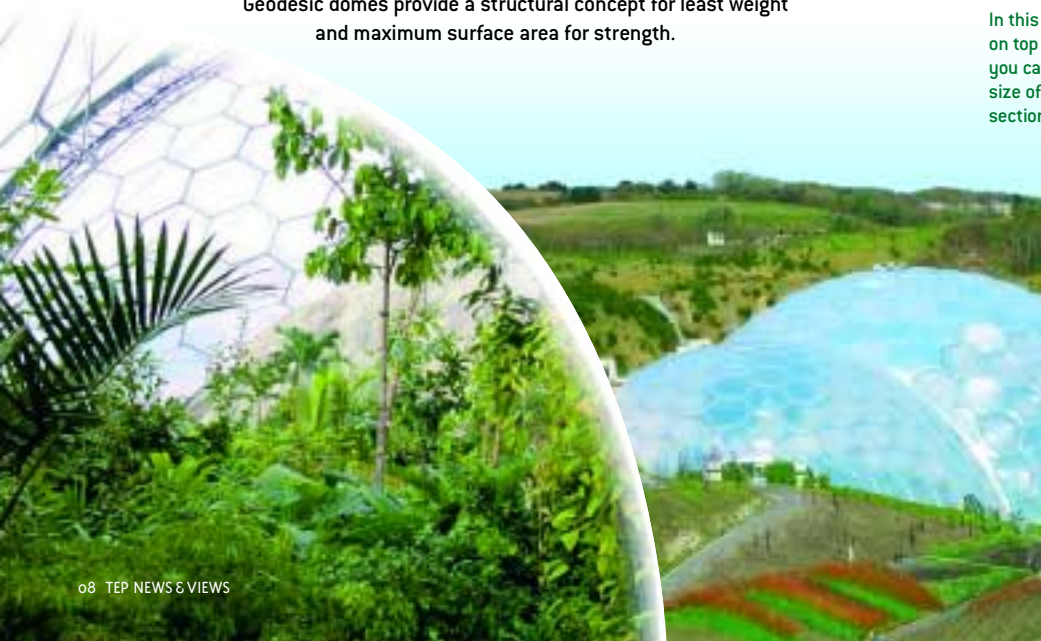
If we observe how 'blown' soap bubbles settle and adapt to a surface and intersect when a second bubble adopts to it with a precise perpendicular joint, some of Eden's roof inspiration becomes clearer. The simple honeycomb structure mimics nature too, the hex-tri-hex arrangement of the panels is also a model of the organic carbon ring molecule.



📌 Soap bubbles squashed between two layers of glass

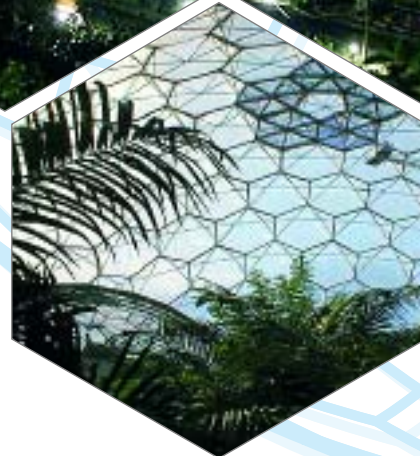
📌 Carbon molecule

In this picture of a worker 📌 on top of one of the Biomes, you can clearly see the size of the hexagon sections.





Eden illuminated at night



A view from inside the Humid Tropics Biome looking up at the roof

Ordinary glass panels sufficient to take the projected winter 'Snow Loading' would be too thick and heavy creating impossible demands on the structure. The final structure was snow load tested by suspending 150 tons of water below it. In any event traditional glass cuts out a large range of the spectrum including ultraviolet. The concept of using ETFE – Ethylene Tetrafluoroethylene, Clingfilm to you and me, was born as a result. Creating triple glazed 'pillows' or cushions of ETFE held apart by compressed air provided a living, breathing building. With a life span of between 10-20 years the pillow can be adjusted for pressure in response to external air temperature. The edges of the material are held in place using a 'luff' groove system taken from sailing technology.

Just putting up the scaffolding took four months and more than 200 miles of scaffold and is a record for the largest freestanding scaffold in the world, standing 57metres high and covering 16,000 sq metres. The pit site required the walls of the facing cliffs to be stabilised with over 1200 bolts, some of them up to 15metres long. Movement tolerance for the whole structure is only 25mm in 1km. The pit bottom is 30 metres below the water table and with the desire to recycle water and create a closed water cycle great demands are placed on a unique large-scale filtering system to remove the clay and fine particle sediments that accrue. A sealed system for collecting and using rainwater was required too for irrigating plants, just as the Victorian conservatories of an age ago did.

The World's largest conservatory ever built



Some really interesting systems and control issues are raised by Eden's Biomes in respect of the sheer heating capacity of the spaces involved. Humidity and air temperature are maintained with enormous air handling units (Air Flues) that are fed sampling data and misting units to provide water spray. Irrigation and water management, bacteria control, disease and pest control associated with fragile and exotic plants and collections. Rainforest trees generally don't have deep root systems most are concentrated in the first few feet of soil, again placing unique expectations on the irrigation systems.

Eden biome under construction showing the geodesic framework



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Continued

Even engineering visitor numbers is interesting – drawing a circle describing 2 hours travelling time (called an Isochrone) from Eden on a map of the South West and calculating the number of people who live in that zone is a good indication of the potential annual footfall or audience.

Eden is truly a great engineering and ecological success story with great scope for product analysis as well as the detailed structures and systems in place.

A really useful resource is the TEP publication: **Structures 14 – 16** recently added for download on the TEP Members publication area on the TEP website. This book will introduce you to the world of structures by looking at some important structural principles and applying them to design and making things. As well as learning about structures, it provides a good background to learn about new materials and the methods engineers use.

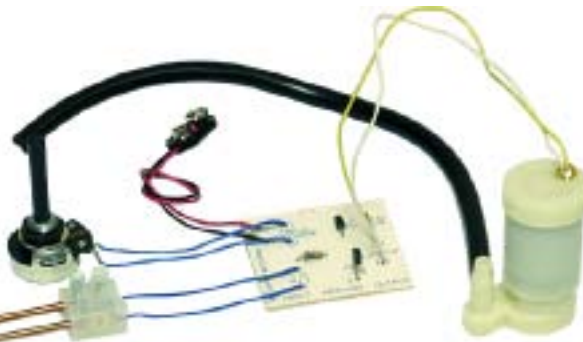


Inside the Humid Tropics Biome



TEP Structures publication

TEP resources to mimic and model many aspects of Eden include:



- Low cost water pump – Stock code BLC 036 or the pump and moisture kit complete:
- Irrigation Kit – Stock code IRR 001
- Geodesic and Space Frame Pack – Stock code GEO 001



## More information

You can find out more about engineering at Eden on the following websites :

- [www.edenproject.com](http://www.edenproject.com)
- [www.galinsky.com/buildings/eden](http://www.galinsky.com/buildings/eden)
- [www.projects.ex.ac.uk/pwh201/eden.htm](http://www.projects.ex.ac.uk/pwh201/eden.htm)
- [www.grimshaw-architects.com](http://www.grimshaw-architects.com)

