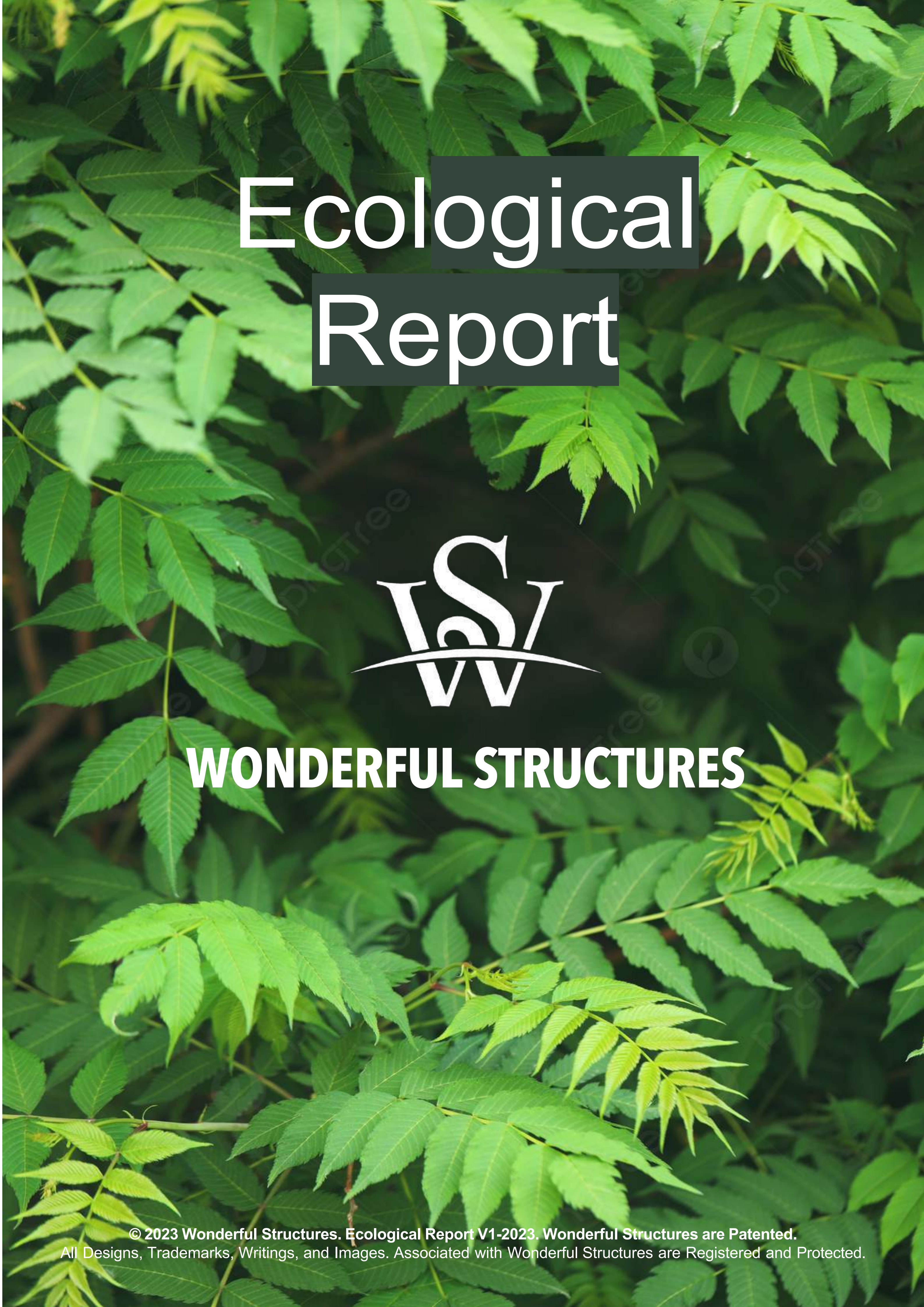


Ecological Report

WONDERFUL STRUCTURES

Table of Contents

1.0 Introduction

The world faces a particular moment in history; the Anthropocene has made many natural flow changes from human activities. If we could compress the planet's existence in a year, on September 22, life rises. On December 31 at 11:58 pm, modern humans evolve, since then the human race has made enormous changes in the atmosphere, the water in the ground. That's why the present generation has an extraordinary responsibility to consider how we relate to our environment as humankind.

The planet has faced a lot of natural disasters before, and it is tremendously resilient. Still, human impacts have changed the ecosystems since the last century. The damage is not because of the local effects but because of the large number of places where humans are present. Humanity doesn't have to make things with the objective of earth recovery, but stop using the old paradigm and create new alternatives to develop products that lead the environmental and technological change through innovation.

We are looking for alternatives to blend our lifestyle with nature better and take advantage of the resources, going back to the roots without sacrificing comfort thanks to applying advanced technology to building systems.

This document aims to be an evaluation of the environmental impacts derived from the W.S. building system. We use scientific data of the effects, performance, and use of resources distributed in inputs like energy, water, raw materials, and outputs like environmental emissions and benefits from the homes' immediate environment until the whole planet.

2.0 What is **Wonderful Structures Technology?**

Wonderful Structures™ is a building system based on structural modules prefabricated in lightweight composite materials in sizes that allow for easy transportation and manipulation at the site and make up a durable, super-strong waterproof shell. We cover the shell soil and vegetation in various forms. The system has different shape components carefully designed to generate multiple design possibilities, lighting, ventilation, and access to and connecting spaces. Its basic configuration will allow for numerous widths, with modulation in increments of 4.26 feet (1.30 meters) to generate areas of any length required following each project's needs. The structure consists of a collaboration between the robust and watertight shell working in conjunction with a system of soil berms reinforced with geotextiles and completed soil and vegetation roof. A geotextile wraps the shelves and ceiling in a geotextile mesh with an open weave through which grass or other vegetation can grow. In the long run, this vegetation will complement and replace the geotextiles' effect, stabilizing the earth with the roots' action.

The Wonderful Structures™ system requires very simple footings: A running concrete beam, which provides a basis for anchoring the modules, provides enough support in most cases. We can set the system on a concrete slab or over a conventional basement system.

*House in Puerto Morelos, Cancún, México.

*Resort in Puerto Morelos, Cancún, México.

3.0 Technical aspects

3.1 Geometry

The Wonderful Structures System derives a wide variety of possibilities of design from a few primary geometric forms. It is based on a vaulted arch having uniform characteristics: straight vertical walls up to 3.93 ft (1.20 meters) high, crowned by a two-point arch that has a total height of 11.48 ft (3.50 meters) at its highest point and a full width of 19.22 ft (5.86 meters) maximum width.

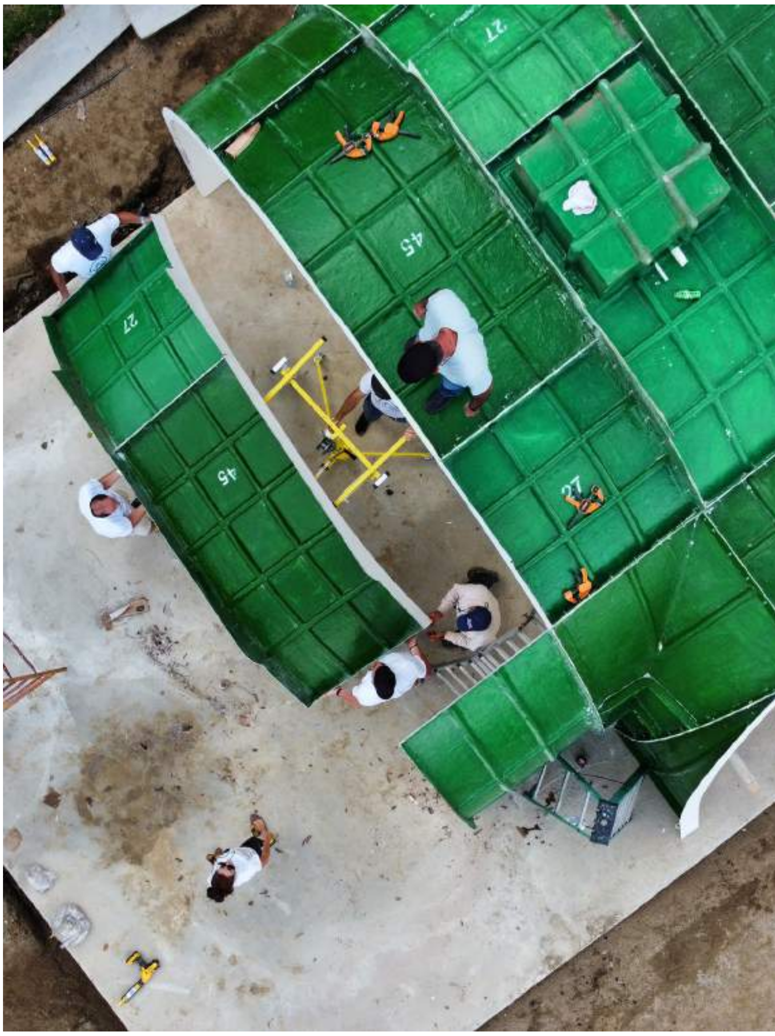
*Brewery under construction in El Valle, Panama.

*Certified Builder Training in Kuwili Lani, Hawaii.

3.2 Materials

The use of earth as a building material in adobe, rammed earth, and earth-sheltered construction is gaining renewed acceptance because of all the reasons mentioned above. In particular, the idea of covering a structure with living soil and plants, and using the thermal stability and security provided by the proximity to the ground, is very appealing. However, this type of construction has always been difficult and expensive to achieve, with questionable results. Achieving adequate ventilation and adequate waterproofing in this type of construction has never been comfortable with traditional methods. The product is often overbuilt, requiring a robust structure that does not collaborate with its surroundings. The Wonderful Structures System has addressed these problems in an entirely new way by using the age of 5 old building methods with earth in conjunction with composite materials' space-age technology. The inner shell of the buildings is stable, light, waterproof, and modular. The ground covering is constructed to collaborate structurally with the surface because of its layered construction and the system's vaulted geometry.

Compared to other traditional materials such as concrete, brickwork, metals, or wood, the total lifecycle assessment of fiberglass composites (FRP) contributes to its viability as a green building product. When consideration is taken for the energy consumed in production and installation, FRP composites generate a much smaller impact than other traditional materials, and they can be used in less energy or carbonintensive. The lightweight of FRP contributes to overall savings, starting with lower transportation costs. There is no need for heavy lifting equipment, and installation is faster, which results in less disruption to the environment. FRP's rigidity and structural integrity, as used in the Wonderful Structures System, means there is less dead weight, and less material is required. It eliminates unnecessary resource consumption and bringing down costs. By contrast, a similar product made of concrete could require up to 200% more material to produce than FRP and would weigh far more. The process of refining cement, from extraction to fabrication, or firing brick and terracotta in high-temperature ovens, generates a large amount of carbon dioxide and other gases. FRP has a life cycle that exceeds other building materials by remaining resistant to rust, rot, and corrosion. FRP's durability reduces the need for replacement, repair, or repainting by increasing the useful lifespan compared to other products. Its durability, low maintenance, and low heat transfer index mark it as environmentally sustainable on its own. Besides, the Wonderful Structures System is based on a lamination process that is formulated with certified green resins. Coupled with the multi- ple benefits provided by the organic earth cove- ring, in terms of thermal inertia, carbon cycling and oxygen production, and airborne pollutant removal. The Wonderful Structures System has the lowest possible carbon footprint through its lifecycle and the highest sustainability of any industrialized system that we know.

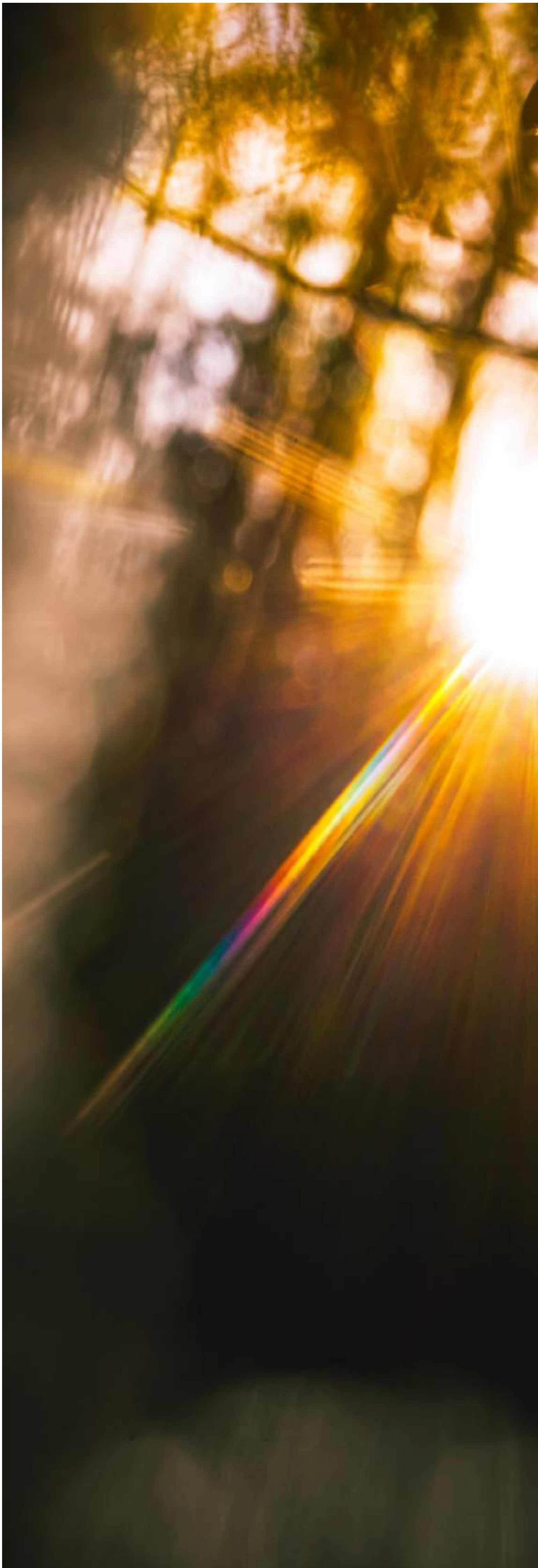


*Certified Builder Training in Puerto Rico.

Wonderful Structures

3.3 Fire Resistance

The modules of the Wonderful Structures System adhere to the International Building Code (IBC) since 1996 concerning fire resistance: SECTION 2612 FIBER REINFORCED POLYMER AND FIBERGLASS REINFORCED POLYMER 2612.6 Exterior use. Fiber-reinforced polymer or fiberglass-reinforced polymer shall be permitted to be installed on the exterior walls of buildings of any construction when such polymers meet the requirements of Section 2603.5 and are fire-blocked following Section 717. The fiber reinforced polymer or the fiberglass reinforced polymer shall be designed for uniform live loads as required in Table 1607.1 and for snow loads, wind loads, and earthquake loads as specified in Sections 1608, 1609, and 1613, respectively. 2603.5.7 Ignition. Exterior walls shall not exhibit sustained flaming where tested by NFPA 268. The material is intended to be installed in more than one thickness, and tests of the minimum and maximum thickness intended for use shall be performed. Exception: Assemblies protected on the outside with one of the following: 1. A thermal barrier complying with Section 2603.4.2. A minimum 1 inch (25 mm) thickness of concrete or masonry. 3. Glass-fiber-reinforced concrete panels of a minimum thickness of 3/8 inch (9.5 mm). 4. Metal-faced boards have minimum 0.019 inches thick (0.48 mm) aluminum or 0.016-inch-thick (0.41 mm) corrosion-resistant steel outer facings. 5. A minimum 7/8 inch (22.2 mm) thickness of stucco complying with Section 2510. In other words: the structural system of composite material Wonderful Structures System is effecti- vely fire blocked as installed against a fireproof substrate.



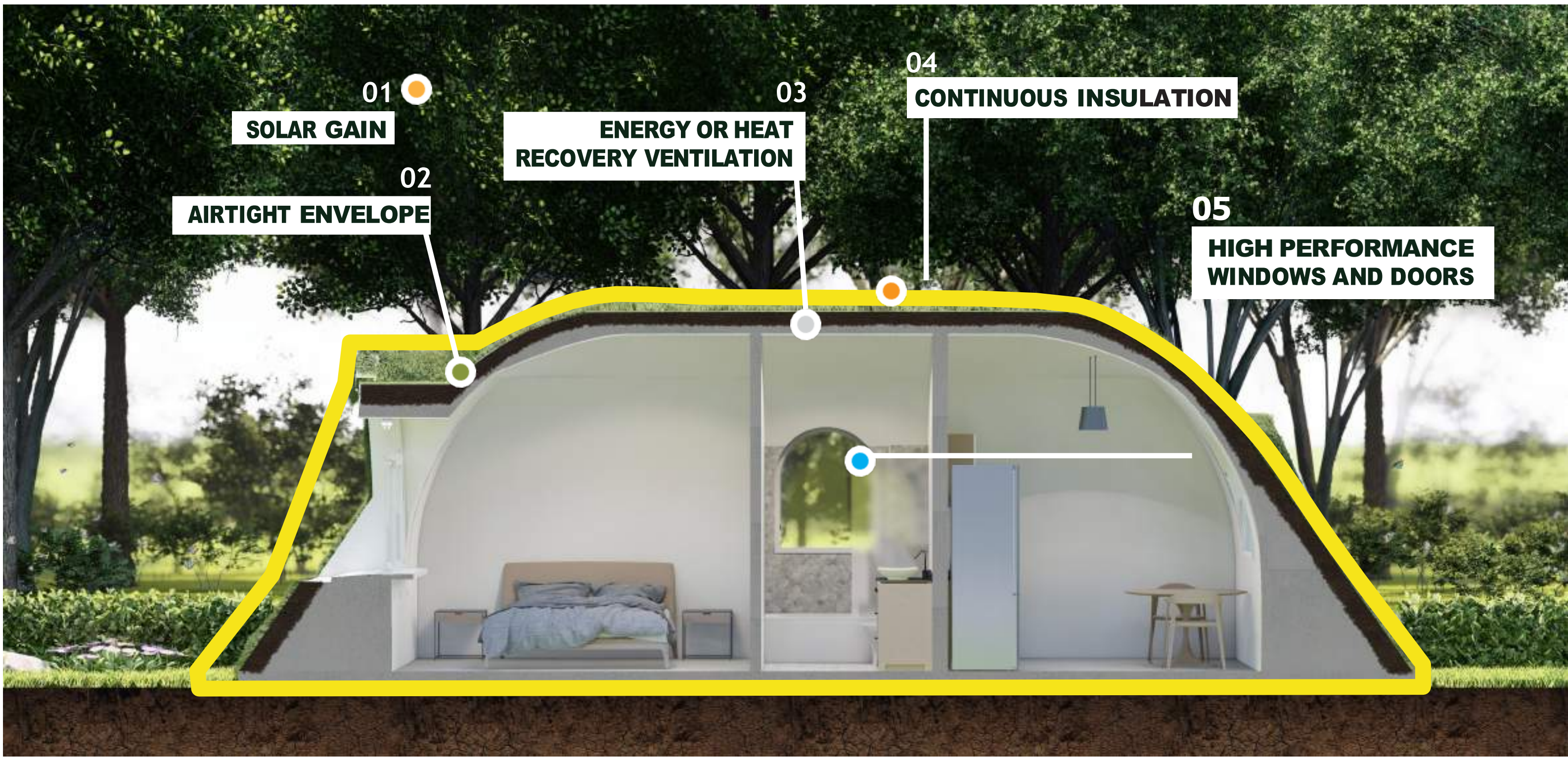
3.4 Resistance to **humidity**

The Wonderful Structures System panels are made from fully waterproof composite materials. However, over time, usually after ten to fifteen years, this material can be prone to hydrolysis or deterioration caused by moisture. This is due to fibers reinforcing the material; sometimes, they will come up to the surface of the elements and form micro-conducts through which wetness can penetrate tiny quantities. The water slides on the inside of the composite material because the moisture cannot pass inward in any case. The structures are fully covered (before applying the soil envelope) with asphalt emulsion or other bituminous type coatings. This ensures the long life of the material through time without any further maintenance.

3.5 **Seismic** resistance and **load-bearing** properties

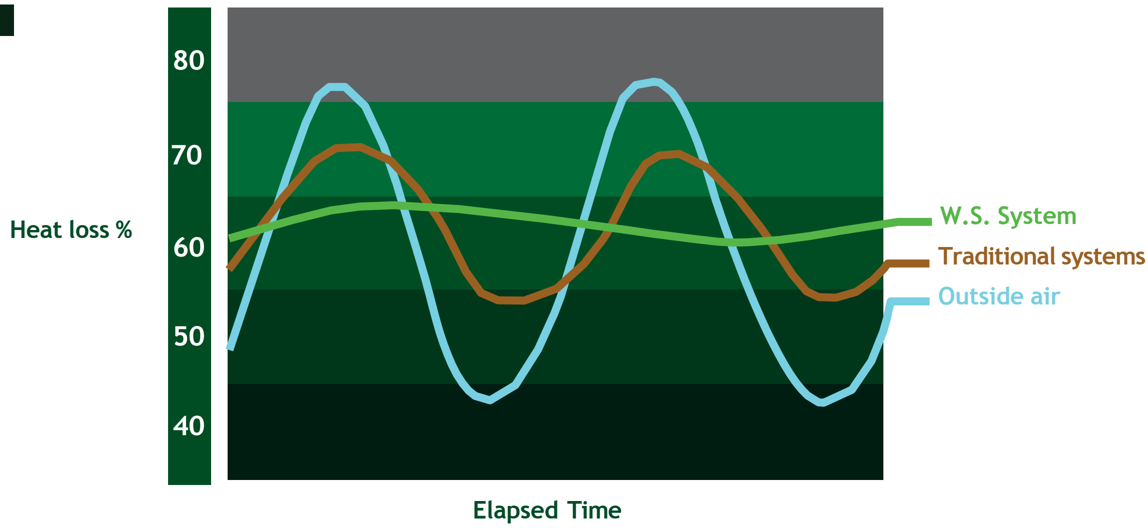
Wonderful Structures buildings are ideal for high seismic risk areas since they are one-story constructions, intimate- ly linked to the land, and laterally confined integrated with the terrain itself and berms, which provide optimal lateral stability. We designed the system to support the top layer of soil (7.87 inches = 20 centimeters) plus 200 kg/m2 live load, which allows for the installation of lightweight structures (such as wooden pergolas), all this supported by structural studies (as well as actual tests) that ensure structural stability. We provide structural calculations and all other essential support reports for the necessary documentation to obtain building permits and approvals.

4.0 Space-age-technology in conjunction with ancient methods



The use of the earth's relatively stable temperature can provide occupant comfort at minimal energy costs. The ground moderates the temperature swings that occur daily, and it has been determined that a time lag of approximately 133 hours occurs at a two-foot depth. The time lag occurs proportionately so that an 8 or 10-foot depth has a time lag of 2100 to 2200 hours or about 90 days. A reduction of 50 to 75 percent of the average heating and cooling load requirements can be achieved due to the earth's temperature moderation and time lag. Temperature moderation effects on an earth-sheltered house with a large thermal mass are shown schematically in Figure 1.

FIG 1



Wonderful Structures

FIG 2 Effects of PAHS and passive cooling on Wonderful Structures earth-sheltered indoor space in summer.

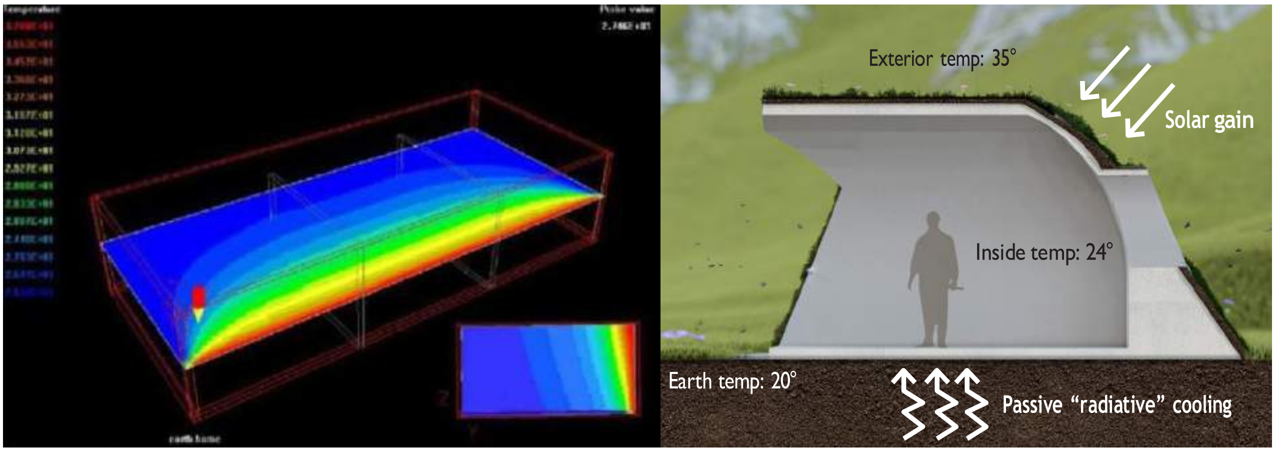
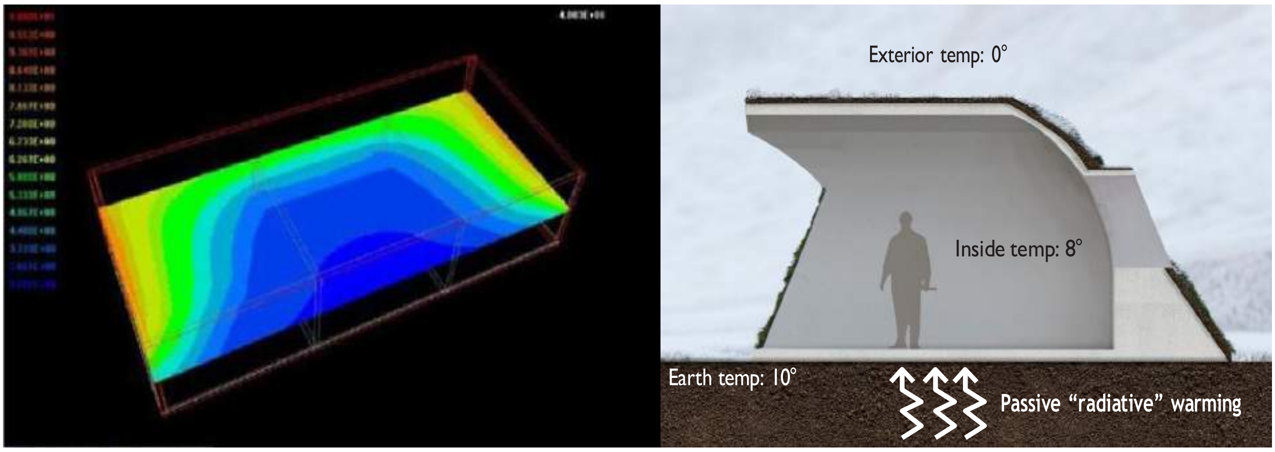


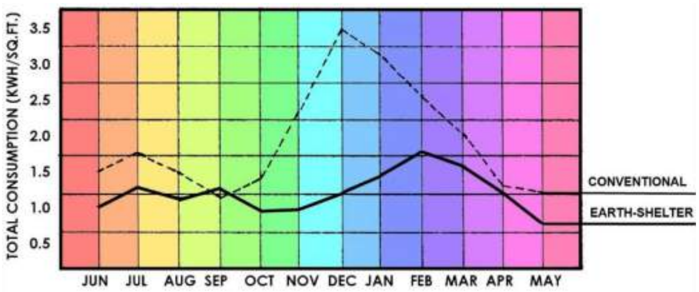
FIG 3 Effects of PAHS and passive cooling on Wonderful Structures earth-sheltered indoor space in winter.



An important question, then, is whether additional insulation is required to optimize the Wonderful Structures System’s energy perfor- mance in a seasonal environment. In general, the more insulation is added, the better the understanding in wintertime, and the poorer in summer. The figures are as follows: During the heating season, heat losses from earth-shelte- red buildings are about 14%, 8%, and 5% smaller for: 1.96 inches, 3.93 inches, and 7.87 inches (5 cm, 10 cm, and 20 cm) of thermal insulation thicknesses. Increasing soil cover thickness over 19.68 inches (0,5 mt) decreases heat losses about 20 to 25%, 10 to 15%, 5% for 1.96 inches, 3.93 inches, and 7.87 inches (5 cm, 10 cm, and 20 cm) of thermal insulation. Heat gains during the heating season are about 40% higher in earth-sheltered houses than in aboveground homes. In aboveground houses, heat gains are 3% of heat losses. In earth-sheltered houses, heat gains are about 15% of heat losses during the heating season. During the cooling season, heat losses from earth-sheltered buildings are about 20 - 35% greater than from aboveground structures, while heat gains are nearly 80% lower. Every 1.96 inches (5 cm) of thermal insulation lowers the heat losses by about 20% during the summertime. In aboveground buildings, heat gains during the heating season are comparable in the range of analyzed thermal insulation thicknesses. It may be concluded that in aboveground structures, the thickness of thermal insulation does not significantly influence heat gains. In the earth-sheltered houses, heat gains are more significant with increasing thermal insulation thickness. Each 1.96 inch (5 cm) of thermal insulation increases heat gains by about 40%. In aboveground houses, heat gains are 35% of heat losses, while in earth-sheltered houses ratio of heat gains to heat losses are smaller. If heat losses are 100%, then heat gains are only 5%. This is why earth-sheltered buildings need less cooling energy.

It can be stated that the heating and cooling consumption of earth-sheltered buildings is definitively smaller than that of aboveground ones. The difference between them gets smaller with the increase of the thermal insulation thickness. Earth-sheltered buildings require more extended heating periods than conventional aboveground ones, while total heating loads are still smaller. This is due to the lower temperature of the soil surrounding earth sheltered houses. The cooling period is nearly the same. When analyzing the heating energy consumption, it can be noticed that the most considerable difference in heating consumption of an aboveground building and an earth-sheltered one is seen for 0.5 meters of soil cover.

Further increasing of the soil cover thickness doesn't produce such large differences. This relation is also smaller, with increasing thermal insulation thickness. The first 19.68 inch (0.5 mt) of soil cover reduces heating consumption by about 25 % compared to a conventional aboveground building.



4.1 Temperate climates

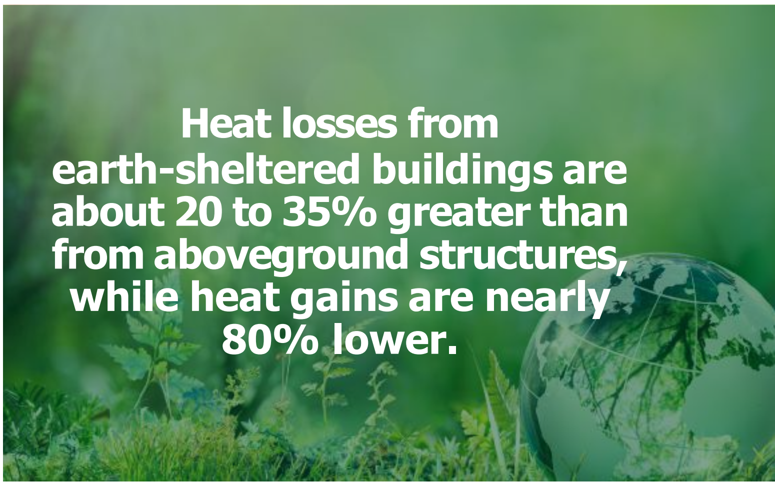
The temperate and seasonal environment poses the biggest challenge to any building system generally above 35 degrees North and 35 degrees South latitude. The annual temperatures can fluctuate from below freezing in the winter to very hot in summer, and living spaces must be designed for comfort in a continually changing environment. The Wonderful Structures System of earth-sheltered construction, coupled with passive solar principles, will provi- de energy saving solutions (as in other) environments. All facts and figures given in this section will apply to different climates, as they include the extremes of hot and cold conditions and their relationship to the built environment.
So, the thicker the thermal insulation is, the lower heating energy savings can be obtained. It may be noticed that from the heating energy load's point of view, the thicker soil cover and insulation are, both aboveground and earth-sheltered buildings naturally consume less heating energy. With increasing thermal insulation thickness, soil's influence gets smaller, which causes insignificant differences between aboveground and earth-sheltered structures for large insulation thickness. For cooling loads, the soil cover thickness does not have a significant influence. Thus the thinner the thermal insulation is, the greater the cooling energy savings are than the aboveground ones. This is because thermal insulation acts as a coat. It protects a building from colder outside soil temperatures during wintertime, but it does not allow the soil to cool a building down naturally during summer.

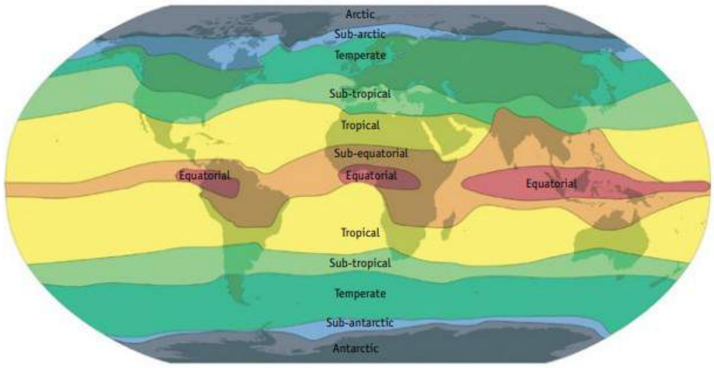
*W.S. House in Norway.

4.2 Subtropical climates

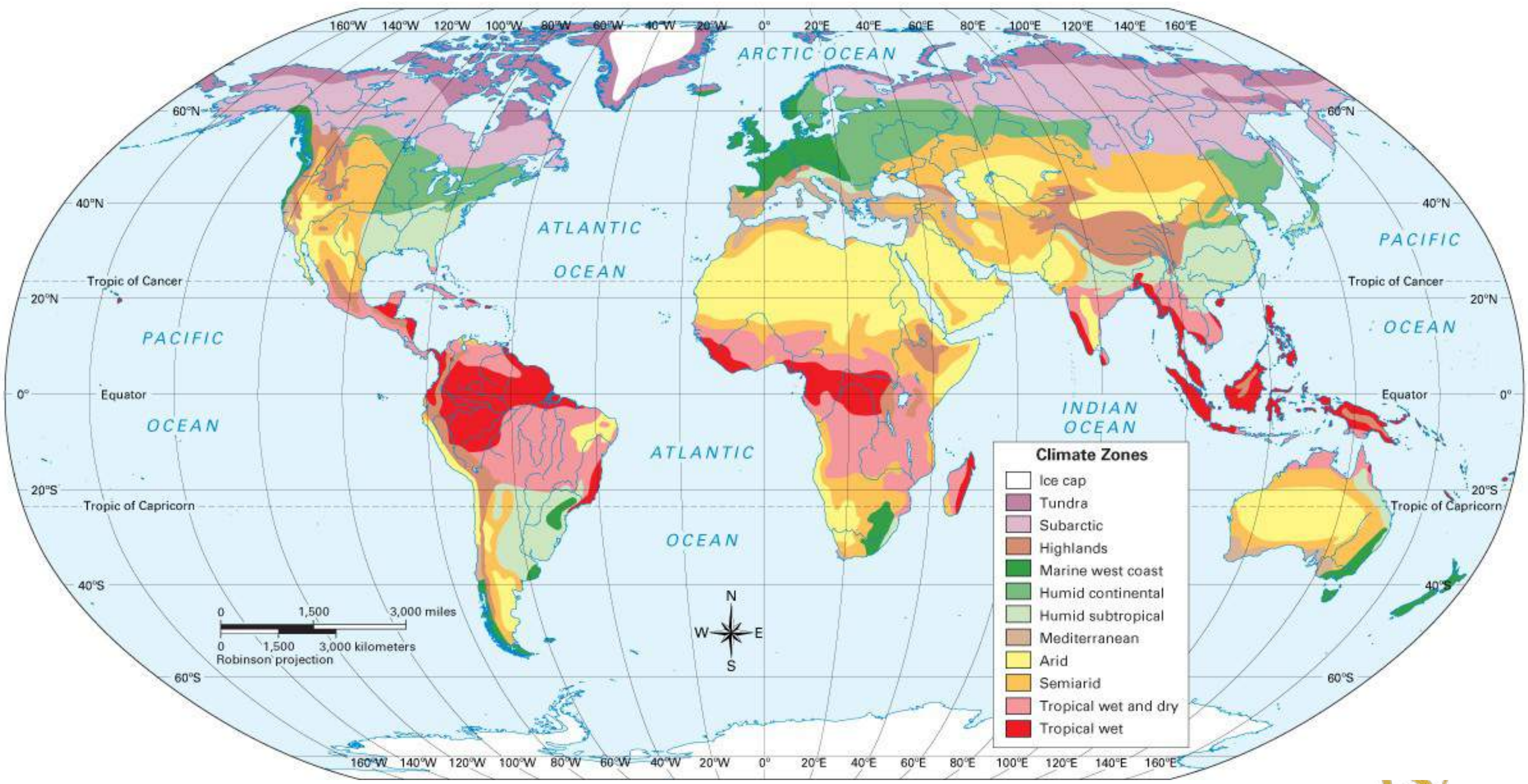
The interest in earth's use to save energy dates back to over 5000 years ago, these cultures built under the ground the whole towns. Examples are: the town of Matmata in Tunisia, the Goreme Valley in Turkey, and the Henan Province in Shanxi (China). All the ancient underground structures are located in hot countries, such as Turkey, Tunisia, or northern China, which means that earth was initially used instead for cooling than heating. This is highly significant if one considers the fact that over one-third of the continents (about 4.7 million km2) is situated in hot-dry climate (i.e., between 15° and 35° respectively north and south of the equator) and only 12% of the continents are situated in the temperate climates (about 1.55 million km2). Considering other climatic conditions, one can say that half of the continents are located in hot climates. Thus the use of earth as the building's cooling component is of major significance, particularly considering that 15% of the world population inhabits desert and semi-arid areas.

The Wonderful Structures System is genuinely ideal in these conditions. The low humidity, high temperatures in summer with little clou- diness, and moderate temperatures in winter make the Wonderful Structures System worthy of serious consideration on a large scale.





*Climate zones in the world.

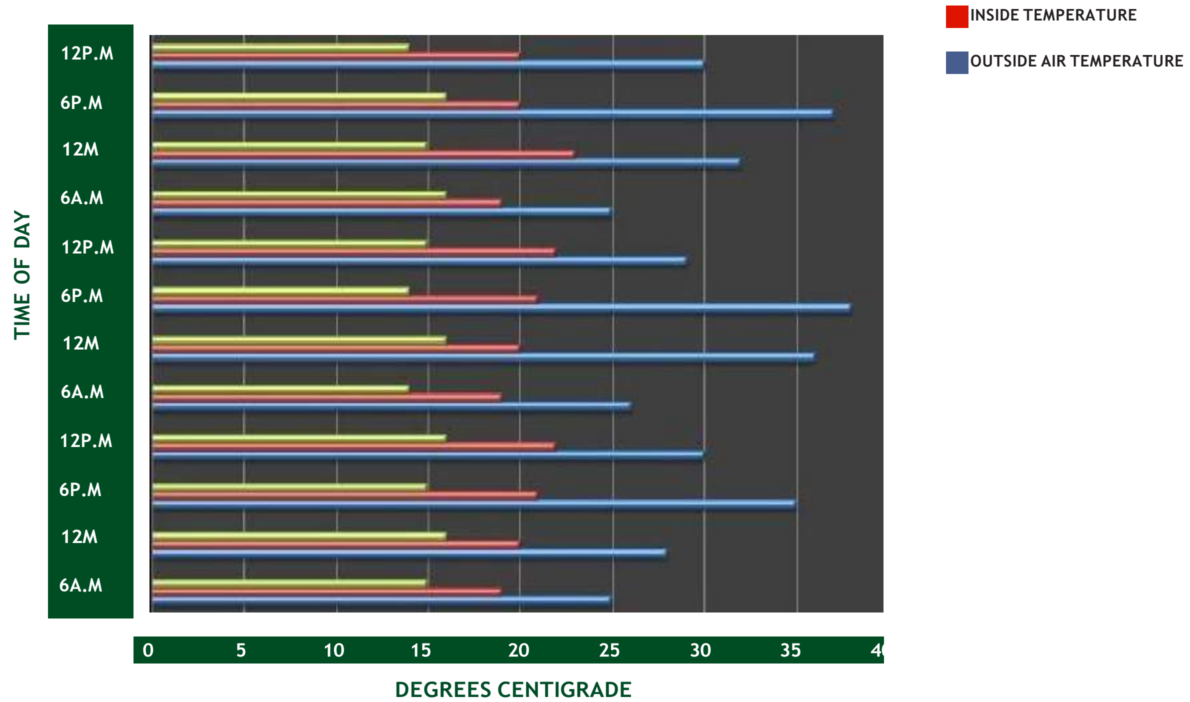


4.3 Tropical climates

In tropical regions (roughly from 15 degrees north to 15 degrees south), temperatures are more or less unchanging throughout the year, as the weather conditions are governed mainly by location and altitude. In Humid environments, an important issue that has to be taken into account with the Wonderful Structures Sys- tem (as in any other building system) is the ju- dicious placement of windows and skylights to ensure adequate ventilation of interior spaces.

In scorching and humid areas, the most critical factor in naturally achieving a comfortable inside temperature is ventilation, as heat is usually carried by air and does not depend only on the sun's effect. However, in these areas, even the smallest air conditioning system's efficiency will outperform any conventional building, as it will be aided by the heat loss caused by the surrounding earth.

WONDERFUL STRUCTURES SYSTEM OBSERVED DAILY FLUCTIATION IN TROPICAL ZONE



5.0 Use

W.S. evaluates some aspects and gives recommendations about the best way to maximize the Wonderful Structures system's bene- fits, aiming to extend the lifespan and provide advantages, enjoyment, and satisfaction when installed on the location.

3.3 Green Roofs

An extensive green roof is an entirely natural form of roof covering that uses a low maintenance planting scheme, consisting of hardy, drought-resistant plants. The plants used in the system must be self-regenerating and predominantly short growing. It should also be densely planted and exhibit a high degree of adaptability to survive in relatively extreme climatic conditions (drought, sun, wind, etc.). Ideally, when choosing the plants, regional variations, and local climatic conditions must be considered.

The plants selected should require minimal moisture and demand little from the substrate in the way of nutrients. An extensive green roof is chosen primarily for aesthetic and ecological reasons and, as such, is not designed to be walked upon, except for occasional maintenance and control purposes. Since the types of plants used to make comparatively modest demands on the layer configuration, the overall weight, the composition depth, and the loading of the extensive green roof is relatively small.

*W.S. House in Norway.

3.4 **Orientation** according to the sun location

According to the season, the sun's angle of incidence directly affects the performance of the dwellings. Wonderful Structures recommend orient houses looking at the sun's path in each hemisphere, especially during the summer and winter. During these stages, the sunlight is perpendicular or parallel to the ground.

It looks to optimize the daylight use providing breadth, depth, and visual comfort to the residents. It also helps regulate the temperature and take advantage of the clearness by reaching savings of over 70% in light resources.

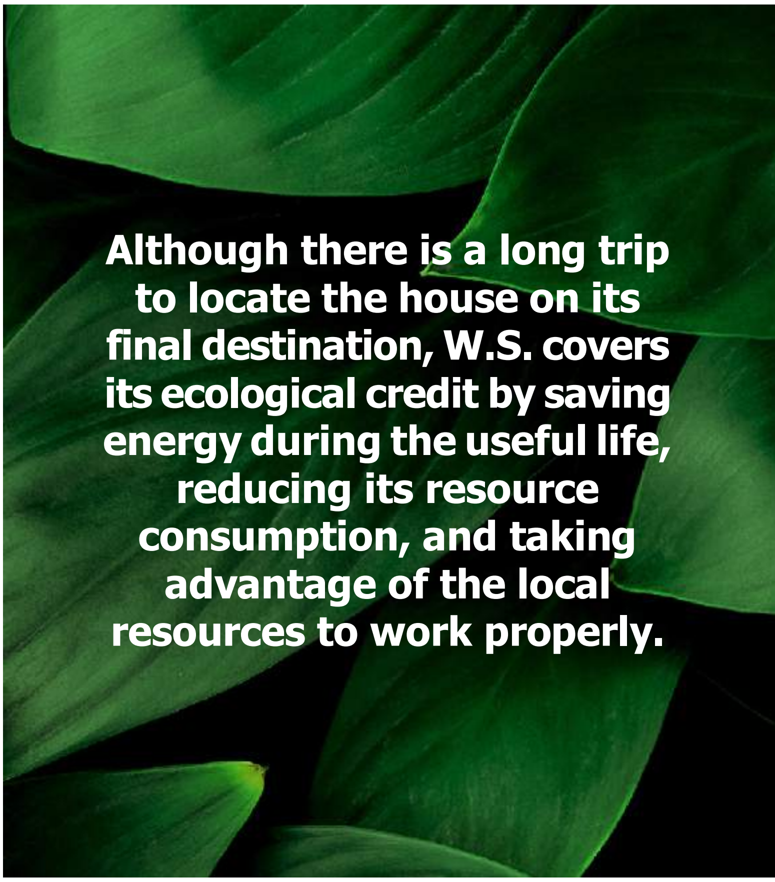
* W.S. Eco-Shell built on the edge of a rock quarry in the Appalachian Mountains of Tennessee Johnson City, USA.

6.0 Use

6.1 Reduce impact on site

Nature without humans has its flow. When human settlements occur, there is a permanent ecological disturbance in the ecosystem that affects the environment's normal processes, causing imbalances and undesirable future changes. That is why the less this equilibrium is perturbated, the faster the dwelling becomes part of the ecosystem. That is one of the main objectives of W.S.; to connect with nature by blending with it in a respectful relationship. W.S. system has many ecological benefits like allowing the free transit of the species around the area, reducing the competition for space and resources, favoring ecological succession for first and small species, and giving a favorable habitat for endemic species.

It also brings enormous benefits for the residents like allowing continuous transit from the indoor to the outdoor, crossing from a comfortable space to the natural environment in only one step. We can see this in reducing symptoms associated with the fast lifestyle of nowadays, increasing wellbeing.



6.2 Modular design

This system allows a significant number of possibilities of sizes and distributions with a moderate amount of pieces. Some advantages are being highly flexible and customizable according to the specific purposes or adapting to the terrain.

The modular system reduces material at the construction site by 60% and can reduce building time up to 80% compared to traditional construction. Thanks to high-tech composites, there is no need for heavy lifting equipment to build up the homes, which gives advantages in construction speed.

Those modules result from in-depth investigations to archive structural and morphological optimization with high-performance materials in each piece and a cohesive unity system.

W.S. system has a very long term life and durability through adequate maintenance, but, like any other product, it has end of life; thanks to modularity, it can be separated into pieces for its right final disposition.

Wonderful Structures

6.3 **Reduction** of transportation resources

During the transport, the resources expended include the fossil fuels to transport the vehicle and int increases with the distance traveled and cargo's weight. Being modular and made by lightweight composites, The transportation the fossil fuel used to transport the cargo is reduced because fewer trucks needed because 60% less material required than the traditional construction systems W.S. doesn't have massive distribution centers but is carried by demand; this traduces fewer distribution paths, fewer contaminant emissions, less spare parts, and chemicals derived from the vehicles' repairs and maintenance.

Some locations are remote and are challenging to build there. W.S. systems are perfect for this intention because heavy lifting equipment is not needed to be transported until that location. It saves many resources (money and fossil fuel); besides that, it is unnecessary to transport heavy materials, just very lightweight composites. Reduction in the transport of material because local materials such as soil are used.

*Modular components packed in a container.

*Hawaii, Kuwili Lani, Oct 2021.

7.0 CONCLUSIONS AND ACKNOWLEDGEMENTS

There is a growing body of evidence that visual and physical contact with the natural world provides a range of benefits to people. These include both mental benefits such as reducing stress and physical benefits, including cleaner air. Access to green space can bring about direct reductions in a person's heart rate and blood pressure and help general wellbeing. A Texan study of post-surgery recovery in hospitals demonstrated that recovery was quicker and less chance of relapse if patients could look out onto green space. Several American hospitals have subsequently been redesigned to bring these benefits to patients.

The adverse effects of 21st-century life can be reduced in many ways by earth-sheltered, green construction. Sound insulation of a 7.87 inch = 20 cm thick earth wall or a roof with vegetation is in the neighborhood of 63 decibels, virtually sound-proofing interior spaces. The increased production of oxygen, reduction of many types of pollution, added to the decrease in energy waste are irrefutable arguments for the cause of earth-sheltered construction. We can envision a world where human presence is once again hidden, and man's negative footprint on the planet's surface is reduced. The many arguments for the sustainability of earth-sheltered housing cannot be denied, and the Wonderful Structures System will solve many of the impediments to achieving this goal.

8.0 REFERENCES

It contains observations and measurements performed by Wonderful Structures. Still, it is primarily a compendium and summary of respected scientists and professionals in biology, Earth Sciences, Architecture, etc. The sources we have used are listed here, not necessarily in the order, they are referred to.

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