2020

New Shipment Just in! The Earthship

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Final Research Paper
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December 4th, 2019

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No house should ever be on a hill or on anything. It should be of the hill. Belonging to it.[i]

Earthships are an underrated aspect in architecture and design because they not only challenge the status quo, but because they also create new options for sustainable living that integrates structures within nature. Although they are extremely energy efficient and environmentally friendly, earth homes can be further improved. Architect's need to investigate options that include building with more light and open spaces so that residents don't feel as if though they are living in one large dark basement. Ventilation and lighting difficulties can be prevalent, as well as the risk of mold and possibly radioactive material build up. An architect's own level of environmental awareness greatly affects earth architecture, reflecting the designers' individual personality, in addition to site specific issues that controls each decision. The solutions result in many different types of earth architecture found across the globe, or better yet, *within* it.

The world's first signs of earthships were much like the earth sheltered homes of today. Caves provided protection from the heat of the sweltering sun and the numbness of the ice-cold winters. Earth architecture is an innovation that originated thousands of years ago, when the Native Americans of North America dug their homes inside of the ground. This was their only means of protection from the scorching sun during the summers and the harsh weather the winters. They then covered their sunken homes with nature itself, leaving openings in the roof to allow for the necessary admittance of light and air. Additionally, the Vikings created mound houses, constructions that were above ground that were then covered over in soil.[ii]

There are two main types of earth ships integrated within the earth: an underground structure and a bermed construction. The underground shelter is built entirely underground or below grade and is often designed with an atrium or courtyard within it to accommodate a

feeling of openness. A bermed earth sheltered home is built above or moderately below grade with the earth acting as insulation on one or more walls. The south facade of the house is usually exposed, in order to allow in the necessary ventilation and sun.[iii] Typical cases of underground structures include full, single, combined and semi underground constructions.

To be successful in architecture, especially earth architecture, one must study the areas of the site and the geographic approach uniquely suited for the specific location, in order to optimize the sustainability options. Certain measures must be taken into account for each particular area, as one needs to evaluate the surrounding environment, climate, weather, humidity, fixed topography, frostline and groundwater levels. The physical relationship of these factors to their site guides the designer's choices and provokes the necessary solution that will vary with each individual. “Earthworks and site specific projects turn context into content - by drawing the setting into the active creation of an aesthetic experience.”[iv] Once this is taken into consideration, new and different living accommodations are created with the surrounding natural environment acting as the structure's beautiful facade. Instead of taking away from the natural world, the construction is integrated within it, enhancing and flowing with its elegance.

Additionally, earthships uniquely use green energy to regulate temperature and almost completely replace the use of machinery to regulate electricity. Earth sheltered homes are much more cost-effective, especially in areas with extreme temperatures. They are environmentally friendly, energy efficient, and significant because the earth absorbs the extra heat coming from the structure yet also offers insulation from the cold. These factors will be interpreted by the architect and lead to incorporating core elements into the eventual building. For example, long winters require more heat thus the architect will most likely place the windows on the south facade to let in direct sunlight. In contrast, a region with hotter summers will most likely have a north facing slope to block the heat from entering. The concept of insulation is taken to a whole new level because the structure becomes integrated within the land.

Topography also plays a crucial role in the designer’s choices, dictating how easily the structure can be placed within its site and deciding whether to move forward with a slight or a steep slope.[v] Earth architects take full advantage of their site’s particular conditions and shape

those constraints to the benefit of the ultimate finished construction. Soil is another critical aspect that the designer needs to consider in earth architecture. The site specific type of soil determines the structure's load-bearing capacity. The architect will most likely use soils that are very permeable, allowing liquids to easily pass through it and drain out. In order to avoid water pressure against the underground walls, natural drainage or installed drainage systems away from the constructions are necessary.[vi] Thus each architect considers factors pertinent to the soil when they choose their methods of designing the structure's waterproofing, insulation and ventilation necessary for a livable earth habitat. By integrating structures within the earth itself the fixed conditions formed by the sites specific temperature and soil create new ways of sustainable living and useful insulation.

Earth architecture has continued to inspire and evolve over the years. In 1974 Peter Vetsch, a Swiss architect, developed a new trend by creating sustainable earth homes. Not only did he create a more energy efficient structure, but he also used environmentally friendly materials to do so. By using nature's own raw substances, the building becomes even more connected to the earth and its surrounding environment. "When infiltrating structures with greenspace one must be very careful, one must conserve nature by allowing the landscape into and through the space by building in and around it."[vii] His arched constructions are composed of many different materials such as a metal mesh for reinforcement, shotcrete, polyurethane, recycled glass and a layer of soil. This layer acts as a protectant from the cold, long storms and strong winds, and the metal reinforcement shields the structure in the case of the event of an earthquake.[viii] Vetsch's innovative ideas of integration within the earth are so successful that it becomes indistinguishable from the land without the negative effects of a "basement" feeling, as natural sunlight is allowed in through rooftop windows.

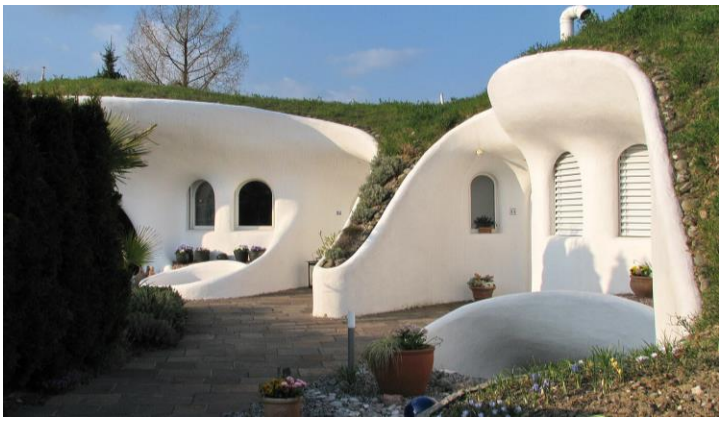

Figure 1: Example of Vetsch's arched structure integrated within the earth

A prime example of organically integrating living space within nature is Vetsch's Earth House Estate Lättenstrasse. It is located in Dietikon, Switzerland and alludes to the comparison of hobbit holes. It is a combined underground complex of nine houses perfectly fit within the earth that one would only notice it if they knew about it. They are private dwellings covering about 43,000 square feet, surrounding a U-shaped hill with a pond.[ix] Through his amazing designs the building *becomes* the earth. Vetsch placed the daytime areas towards the South and the nighttime areas towards the North, and joined them together with stairs in the middle of the complex.[x] Water protection is also added directly onto the concrete, to avoid molding. The use of sustainable natural materials protects the construction from environmental influences, and gives its interiors a healthy level of humidity.

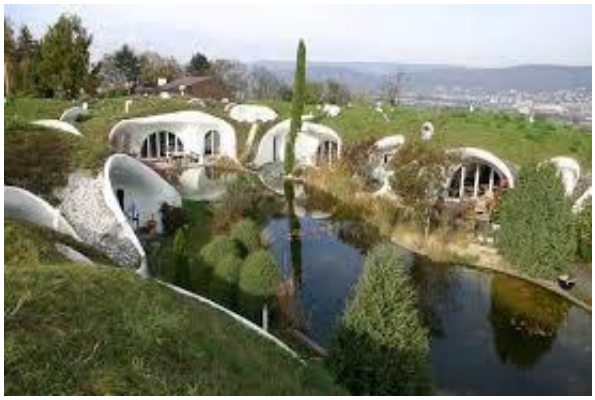

Figure 2: Vetsch's Earth House Estate Lättenstrasse

A different type of earthship is found in the hidden Villa Valls, also located in Switzerland and created by the architects of SeArch, CMA, Bjarne Mastenbroek and Christain Müller. The designer's goal was to conceal the house inside of the mountain slope while leaving the stunning views and surrounding nature completely untouched. They successfully did so by placing a central patio into the steep incline to create one large facade.

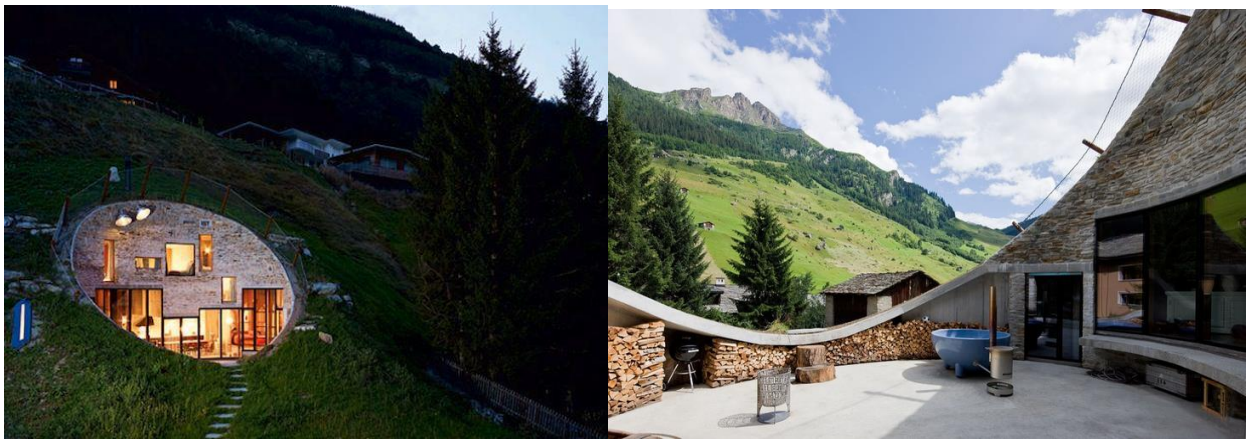

Figure 3 (right – view of facade in mountain slope) and Figure 4 (left – view from facade): The hidden Villa Valls

The Villa Vals is a great solution for that particular area, as it ensures that it doesn't attract unwanted attention because of its sensitive location.[xi] With its entrance of a wide oval opening preceded by a pathway of stone stepping, the single underground villa is set below ground level, mainly built of concrete and wood. The interior is soaked in natural light and because it's so far underground, the need for heating and cooling is almost completely eliminated, creating an evolved living environment.[xii] Because the architects paid close attention to the site-specific issues they were able to design an extraordinarily sustainable and integrated piece of work.

With advancements of modern day technologies, earth architecture is becoming increasingly more abundant and practical. Underground Villas, like the ones in Switzerland, include all the advantages of cave living and eliminate the disadvantages of darkness and dampness. Because some governments want to protect the limited natural land resources it is almost impossible to build a new structure on a Greenfield site. "Underground Villa shows the breakthrough and innovation of the way human beings think of buildings."[xiii] These types of structures not only produce new ways of removing city noise, but also act as an escape from the ordinary urban life, promoting the optimization of living one with nature.

The Sedum House located in North Norfolk is an award winning earth sheltered home and a wonderful example of a semi-underground dwelling. It is an eco-friendly low maintenance cost dwelling designed by architect Tom Ground. The earth over the roof is waterproof and covered with vegetation, and a few sections of the house, including the bedrooms, are underground. Ground's main focus was on sustainability; thus, the structure includes ground heat pumps as a green energy source. He also constructed the building with photovoltaic panels as the home's energy and ventilation system. In order to make for low energy usage, he used highly insulating concrete forms in the walls. Additionally, the glass wall on the front side of the house is designed to let in the necessary light.[xiv] Ground's concepts take advantage of the sun and the land to form the structure by using the natural hill and surrounding environment to his advantage, important goals to sustainable earth architecture.

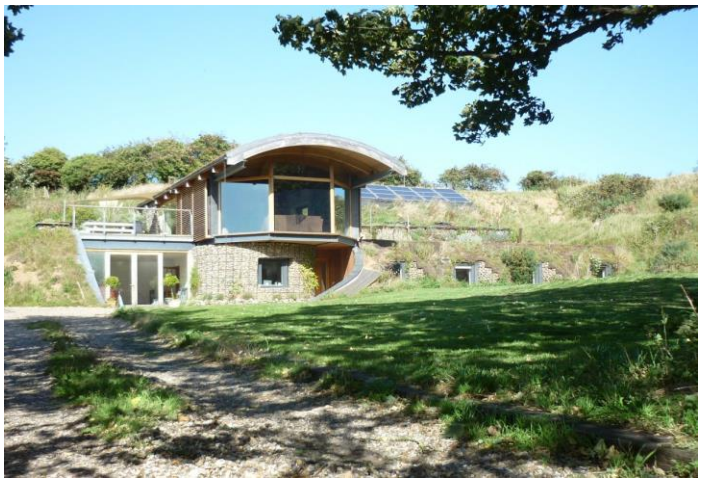

Figure 5: The Sedum House

In contrast, Michael Reynolds is an architect whose main focus is on surviving climate change, overpopulation and limited resources. He created Earthship Biotecture, a company that designs and constructs low-impact, off the grid houses that are self-sufficient in energy water and waste systems. Reynolds' designs concentrate on the reuse of materials and include, thermal/solar heating and cooling, on-site sewage treatment, water harvesting and food production. His theory is that people need to change their behaviors and realize that resources are becoming more and more scarce, before it is too late. "The overall abuse of the planet by humanity is about to leave our ever growing population "flooded" with survival emergencies, on many levels."[xv] Reynolds' believes that the only way to survive the future is by increasing people's awareness on the limitations of our natural resources. To do so, they must live with nature, in buildings that power themselves, so that they get firsthand experience of how deficient these resources are becoming.

Reynolds' earthship walls are composed of recycled automobile tires stuffed with soil to maximize the thermal mass of the home and stabilize its heat. Accommodating a family of four, it measures 1,690 square feet and consists of three bedrooms and two baths.

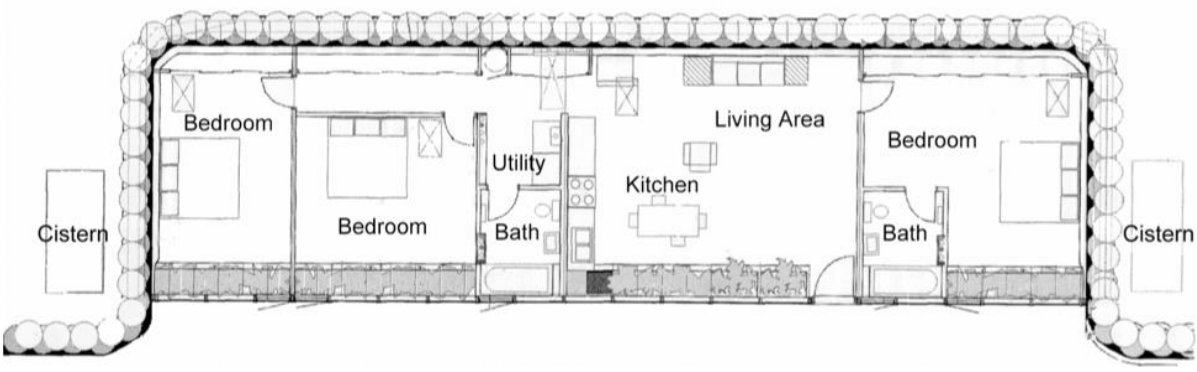

Figure 6: Michael Reynolds - Earthship Biotecture plan example

His concept includes small wind turbines and a battery bank to collect and store energy to fuel the house. The panel metal roof gathers up water that is then filtered and reused for the occupants of the home, through a catchwater and gray water system. Reynolds' visualized his earthship to be suitable for all climate zones and become the new face of sustainable architecture.[xvi] With his innovative conceptions, Reynolds is able to create various ways of integration within land and sustainability opportunities, furthering the options available for earthship structures.

Unfortunately, no matter how convincing Reynolds' concept for a better future is, it currently remains only a *concept*. A study done by Kruis and Heun, from the Engineering Department of Calvin College, Grand Rapids, Michigan, shows that his concept may not be very practical. They conducted research on a variety of earthships in four particular cities that correspond to different climate zones. Site specific details were a crucial element in the city choices, assuming that local winds aren't consistent with the climate zone, soil is readily available and there are almost no problems with the collection of solar energy. Kruis and Heun also compared their results on earthships to regular wood-framed housing in regards to costs, the thermal envelope, electricity and water supply. They found that the earthship may not be as feasible as one would think.[xvii] Kruis and Heun conclude that Reynolds' concepts fail to create a coherent living environment through solar heating, or a decent amount of electricity at a reasonable price, with which I agree. His use of recycled car tires is a great idea to increase

sustainability, but such materials tend to feel stuffy and dense, with not much sunlight. Yes, they are creative ideas for a more advanced living domain, but it is not as realistic as Reynolds' imagined.

However, Kruis and Heun did find savings in cost and energy when compared to a conventional wood framed home. The money saved is mainly derived from the earthship's thermal envelope. The thermal envelope is a key aspect in lowering energy consumption, because it prevents heat transfer through the outer walls, roof, foundation, windows and doors. It consists of the tectonic planes of the building that separates the enclosed environment from the above and below grades of the external environment. Additionally, the study concluded that Reynolds' ideas on heating, cooling and back-up water supply can certainly be used to improve sustainability in residential living. Although the initial cost output may be more than that of a traditional house, the savings over the life of the structure can significantly add up and are, in fact, realistic.

There are many other disadvantages in challenging the architectural norms, when it comes to earthships. There is a large initial cost for this type of structure, up to 20% more than that of a standard house. One must be prepared for this early cost burden and have the means to actually pay for it before the savings begin to accumulate over time. In addition, the level of necessary care increases after construction, in order to avoid any moisture issues or molding.[xviii] Since it's within the earth, there is a risk of radon, a radioactive material, build up in the room air. There are also the inevitable dark spaces that come along with any underground structure creating difficulties in air circulation and lighting.[xix] Constructions with dark areas tend to make residents feel caved in and claustrophobic, which no one enjoys and are not an ideal living environment.

Nonetheless many of these negative properties are easily solvable, further portraying the importance of site specific considerations. The architect must plan accordingly, integrating not only the structure into the earth, but the outside environment as well. Earth sheltered homes cost less to insure because they have better protection in the case of natural disasters. To avoid dark spaces a designer can include roof windows and other light sources, like Vetsch does. They have

to make sure that there is enough ventilation and an accurate draining system to prevent moisture build up. The use of natural materials protects the construction from environmental influences and gives its interiors a healthy humidity of around 50%.[xx] There is no need to rely on materials are machinery for energy, thanks to the infinite power of nature that don't require any outside maintenance. Earth architecture is a breakthrough in the way that one thinks of sustainable building and acts as a great solution to geographic locations of limited land resources. Not only does this innovation protect the earth, but it also provides a soundproof natural environment that our generation has taken for granted.

We are living in a time where the environment is changing rapidly because of human behavior. Small things such as recycling or composting can make a difference, but people either don't know or don't care enough to make the effort. The environment is impacted by human needs; we can alter how these needs are translated into architectural design.[xxi] Earth architecture is promoted by architects who want to make a change to the ever-downward spiral of the environment. Not only do most earth architects, like Peter Vetsch and Michael Reynolds, use earth's raw materials or recycled goods, but they also provide the home with the necessary means of producing its own electricity, heat and water supply. These alterations make earthship building and living a more sustainable and user friendly option for those who are aware of the dire future of our environment. Many more people would aspire to live in a sustainable eco-friendly home that doesn't feel like an underground vault.

Architects have the great opportunity to design a better tomorrow, and what can be better than creating a more sustainable earth structure? Our technology is becoming increasingly more advanced, leading to innovative ways in maintaining earth homes and conserving nature. However, architects can take this idea of earth-integrated living to the next level, furthering people's desires to incorporate living spaces within the earth. Currently basements and other underground spaces are very unpopular; they make people feel claustrophobic, like they are in a dark, damp bomb shelter. In order to improve earth architecture, designers must incorporate more light and open spaces. This is because most basements have little to no windows, but the structures can be changed by composing it with roof openings so that sunlight and air can enter unfettered. Future work can also focus on decreasing the cost of construction by using more

recycled goods and energy efficient materials. With preplanning, consideration of the site and its surrounding environment, the architect is able to control the “unavoidable” dark spaces and compact feelings, intelligently using site specific analysis of solar energy and wind implications. Earth architecture emphasizes the harmonious balance with nature, of being one with the land. This sustainable site specific innovation positively affects its surrounding environment and acts as an inspiration for the young architects in our generation as we advance to a greener future.

[i] https://www.goodreads.com/author/quotes/69188.Frank_Lloyd_Wright
[ii] Allplan. “Earth Houses - The New Trend in Sustainable Building.” ALLPLAN Blog - News zu BIM & CAD. Accessed October 31, 2019. https://blog.allplan.com/en/earth-houses.
[iii] “Efficient Earth-Sheltered Homes.” Energy.gov. Accessed October 31, 2019. https://www.energy.gov/energysaver/types-homes/efficient-earth-sheltered-homes.
[iv] Burns, Carol, and Andrea Kahn. *Site Matters Design Concepts, Histories and Strategies*. New York: Routledge, 2005. Page 165.
[v] “Efficient Earth-Sheltered Homes.” Energy.gov. Accessed October 31, 2019. https://www.energy.gov/energysaver/types-homes/efficient-earth-sheltered-homes.
[vi] Ibid
[vii] Richards, Michael A. *Regreening the Built Environment: Nature, Green Space, and Sustainability*. London: Routledge, Taylor & Francis Group, 2018. Page 158.
[viii] Allplan. “Earth Houses - The New Trend in Sustainable Building.” ALLPLAN Blog - News zu BIM & CAD. Accessed October 31, 2019. https://blog.allplan.com/en/earth-houses.
[ix] Parrack, Dave. “Switzerland's Earth Houses Resemble Real-Life Hobbit Holes.” New Atlas, May 2, 2015. https://newatlas.com/earth-houses-hobbit-holes/24534/.
[x] Lavinia. “Ecological, Friendly and Unconventional: Earth Homes by Vetsch Architektur.” Freshome.com, May 19, 2011. https://freshome.com/2011/05/19/ecological-friendly-and-unconventional-earth-homes-by-vetsch-architektur/.
[xi] Saieh, Nico. “Villa Vals / SeARCH CMA.” ArchDaily. ArchDaily, December 9, 2009. https://www.archdaily.com/43187/villa-vals-search-cma.
[xii] Pham, Diane. “Take a Peek at a Stunning Secret Swiss Villa Hidden Into a Mountainside!” Inhabitat Green Design Innovation Architecture Green Building. Inhabitat, July 14, 2014. https://inhabitat.com/a-luxury-swiss-villa-nestled-beneath-the-earth/.
[xiii] Liu, Xinrong, Zijuan Wang, Jun Liu, and Zhongping Yang. "Concept Design and Development Model of Underground Villas." *Journal of Engineering Science & Technology Review*8, no. 3 (2015).
[xiv] Ibid
[xv] Daly, Kegan. "Earthship Biotecture & Climate Change."
[xvi] Kruis, Nathanael J., and Matthew K. Heun. “Analysis of the Performance of Earthship Housing in Various Global Climates.” *ASME 2007 Energy Sustainability Conference*, January 2007. https://doi.org/10.1115/es2007-36030.
[xvii] Ibid
[xviii] “Efficient Earth-Sheltered Homes.” Energy.gov. Accessed October 31, 2019. https://www.energy.gov/energysaver/types-homes/efficient-earth-sheltered-homes.
[xix] Allplan. “Earth Houses - The New Trend in Sustainable Building.” ALLPLAN Blog - News zu BIM & CAD. Accessed October 31, 2019. https://blog.allplan.com/en/earth-houses.
[xx] Ibid
[xxi] Yeang, Ken. *Designing with Nature: the Ecological Basis for Architectural Design*. New York: McGraw-Hill, 1995.

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Figure 4 - https://www.archdaily.com/43187/villa-vals-search-cma
Figure 5 - Sedum House – CAM Architects
Figure 6 -http://www.calvin.edu/~mkh2/summer_student_research_pro/es_2007_kruis.pdf

Bibliography

Allplan. “Earth Houses - The New Trend in Sustainable Building.” ALLPLAN Blog - News zu BIM & CAD. Accessed October 31, 2019. https://blog.allplan.com/en/earth-houses.

Burns, Carol, and Andrea Kahn. *Site Matters Design Concepts, Histories and Strategies*. New York: Routledge, 2005. Page 165.

Daly, Kegan. "Earthship Biotecture & Climate Change."

“Efficient Earth-Sheltered Homes.” Energy.gov. Accessed October 31, 2019. https://www.energy.gov/energysaver/types-homes/efficient-earth-sheltered-homes.

Kruis, Nathanael J., and Matthew K. Heun. “Analysis of the Performance of Earthship Housing in Various Global Climates.” *ASME 2007 Energy Sustainability Conference*, January 2007. https://doi.org/10.1115/es2007-36030.

Lavinia. “Ecological, Friendly and Unconventional: Earth Homes by Vetsch Architektur.” Freshome.com, May 19, 2011. https://freshome.com/2011/05/19/ecological-friendly-and-unconventional-earth-homes-by-vetsch-architektur/.

Liu, Xinrong, Zijuan Wang, Jun Liu, and Zhongping Yang. "Concept Design and Development Model of Underground Villas." *Journal of Engineering Science & Technology Review*8, no. 3 (2015).

Parrack, Dave. “Switzerland's Earth Houses Resemble Real-Life Hobbit Holes.” New Atlas, May 2, 2015. https://newatlas.com/earth-houses-hobbit-holes/24534/.

Pham, Diane. “Take a Peek at a Stunning Secret Swiss Villa Hidden Into a Mountainside!” Inhabitat Green Design Innovation Architecture Green Building. Inhabitat, July 14, 2014. https://inhabitat.com/a-luxury-swiss-villa-nestled-beneath-the-earth/.

Richards, Michael A. *Regreening the Built Environment: Nature, Green Space, and Sustainability*. London: Routledge, Taylor & Francis Group, 2018. Page 158.

Saieh, Nico. “Villa Vals / SeARCH CMA.” ArchDaily. ArchDaily, December 9, 2009. https://www.archdaily.com/43187/villa-vals-search-cma.

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Yeang, Ken. *Designing with Nature: the Ecological Basis for Architectural Design*. New York: McGraw-Hill, 1995.