LIBRARY AWARD FOR UNDERGRADUATE RESEARCH

First Place
Social Sciences

UC SANTA BARBARA
Library

www.library.ucsb.edu

LAUR Reflective Essay

Sanjana Sujeet 2024 | Green Architecture | 700 words

Recently, I took a class I know I will remember even after graduation: ENVS40, a class encouraging students to explore any of their environmental interests through any kind of project. I recently read an article called “The Age of Average” about how as a society we have the opportunity to connect globally and share culture through the internet, yet instead we have homogenized into one ‘trendy/western/modern’ image. This is apparent when looking at buildings across the world- they all have a similar aesthetic despite being in different cultural and environmental climates. I wondered what we could do to bring back the artistic architecture that draws in culture and compliments the environment. So I came up with my project - an essay on ways to incorporate ancient green architectural techniques into modern architecture. I knew I wanted my essay to be easily accessible; there is an ever-growing gap between the public and climate science so I didn’t want any jargon. If the essay was understood by everyone, these sustainable solutions would seem just as achievable as they truly are. The idea was the easy part; however, as soon as I got to researching I fell flat.

I couldn’t get headway since there weren’t many sources on ancient building’s sustainability; there were a handful of popular topics but I wanted a diverse selection of designs that weren’t as well-known. Luckily, looking through the library webpage I found Kristen LaBonte, a subject librarian specializing in ES, and immediately signed up for a one-on-one consultation. This was the most important part of my research journey because I received so much guidance. After discussing the project’s premise, she directed me toward the search engine where we specified our search with keywords. A few books came up but they didn't have the details I needed. We brainstormed more keywords and through the advanced search I found more articles to dig through; this was the main way I found my designs. I also learned how the search engine worked: asterisks when you want any ending of a word, booleans to include and exclude certain words, and limiters to specify types of media. Next, she showed me the ENVS40 LibGuide where I looked into scholarly journals directly related to my topic. Here I found a lot

more sources on Green Architecture and learned a lot about sustainable city-planning. Chatting at the end of the consultation, she provided ideas she had read about recently. She mentioned seaweed Sarcobricks which prompted me to create an entire section on sustainable building materials, and Iranian architecture which was the first section I wrote.

After our discussion, I looked more into LibGuides and used Writing and Research Tools to fine-tune how I wanted to organize my sources. I found most of my design ideas from the library searches; however, to collect some information on how each design functioned I had to simply google search and use architecture journals and random articles. In ENVS40 we talked a lot about reliability but some of these sources weren't peer-reviewed academic articles or of the same caliber. I used the ACT-UP method from the LibGuide and found a lot of my sources satisfied all the categories except a listed author. I like how the LibGuides organize information in a step-by-step, simple manner so I also read the Literature Review guide which taught me about using Triangulation when studying an emerging topic. So, to give my project credibility, I ended up finding multiple discipline-diverse sources for each design that supported each other's information. This was incredibly time-consuming, my bibliography ended up being a lot longer than I expected, but necessary. The Literature-Review guide also introduced concept-mapping which I used to group information and organize my thoughts. This also helped me break down the structure of my essay into chunks: explaining a modern issue in architecture, listing ancient alternatives with pictures, and providing ways to incorporate them into modern design.

This project expanded my view of research and using the library as a resource almost as much as it expanded my view of my actual research topic. I loved the process of collecting and organizing information and now I know so many resources for my next project!

Green Architecture: Comparing Ancient Civilization's Techniques to Today's

Sanjana Sujeet | ES 40 Project Winter 2024

1. Introduction

We have entered the age of efficiency, everything is made to either reduce the amount of time for a consumer or reduce the cost for the producer; often things are made to do both. However, in this race to save time, save money, save our energy, have we spiraled into losing our planet and culture? In an eye-opening article, "The Age of Average", Alex Murell talks about how the interior design of coffee shops and Airbnb's across the world, brand logos, and even people have become almost indifferentiable from each other(Lefkowitz, 2021). Due to social media and the internet, the world has collectively gotten the opportunity to share their differences but has ultimately ended up removing those differences and becoming one homogenized 'trendy' image. Especially in developing countries where "globalization" often translates to "Westernization", this causes a trading out of local architectural practices and climate techniques for internationally used materials and high-tech designs(Henna, 2022). Cultures and ancient civilizations have each crafted the art of construction from creating simple but effective cliff dwellings and mud homes to grand structures like pagodas and Byzantine domes to work alongside the environment around them. The term for this is Vernacular Architecture, how cultures manifest traditions through buildings adapted to the environment with unique craftsmanship. However, new architecture prioritizes minimizing cost per square foot as land prices rise, minimizing time spent to create new designs by using the same building plans, and modern trends and fads. Think of the five-over-one type apartments that have popped up all over the place or the sprawling suburbs that have taken over since the 1930s. Although these new buildings meet the modern ideals of convenience and low effort/planning, "they have multiple consequences, including reduced thermal comfort, overdependence on electric controls, loss of traditions, increased urban heat, depletion of natural resources and increased emissions"(Henna, 2022). However, maybe we can bridge the gap between modern structures and ancient techniques to come to a happy, more sustainable medium.

2. Temperature Regulating

2.a The modern problem

Temperature regulating is a crucial part of building design; we like to keep warm in the winter and cool in the summer and this trait has been around long before our inventions of AC and heaters. Heating and cooling devices are significantly energy-consuming parts of a building's footprint. Heating an average home in the US with natural gas emits around 6,400 pounds of carbon dioxide and using electricity emits 4,700 pounds. Colder states would emit almost double the amount. To cool a home the emissions are similar around 6,000 pounds and air conditioning overall contributes about 117 million metric tons of carbon dioxide into the air (NPR, 2007). Worldwide, almost 25% of energy produced is used to temperature regulating buildings(Norford, 2022). Heaters and Air Conditioners also contribute to the Urban Heat Island effect- an observation of how heat pockets are created by human activities and urban structuring. This leads to the increased use of ACs to bring the temperature back down creating a feedback loop(EPA, 2023). But how did ancient civilizations tackle this need, especially those living in hot, equatorial, or cold, windy regions?

Courtesy of Gate of Nations - A Magnificent Cooling Structure Called Wind Catcher(Stouhi, 2021)

2.b Iran's Wind Catchers

In Iran, *badgirs*, or wind towers/wind catchers were the solution. These chimney-like structures topped most buildings and homes and pulled fresh air in and let hot air out due to its openings being on the side that faces the wind. Often designed to face North to catch the cold flowing winds from the North, the design even works without flowing wind by using buoyancy to channel hot air that rises out of the building and cool air downwards. Some towers even channel the air to a cooled pool of water underground to further chill the air(Stouhi, 2021). In a region where temperatures regularly went over 104 degrees Fahrenheit this completely carbon-free and cheap technique contributed to the prosperity of this caravan-stop city in the desert. In 2017, Yazd, Iran was listed as a World

Heritage Site for its ``living testimony to intelligent use of limited available resources in the desert for survival" by UNESCO. However, Iran's architectural customs have been left behind, as an owner of a building with a *badgir* interviewed in an article exploring Iran's wind catchers mentions, "Unfortunately, our ancestral heritage has been forgotten, especially since the emergence of air conditioner...house architecture imitates that in other countries, and cement-based construction does not correspond to the climate of Yazd." The author of the article traveling through Iran mentions how "the old houses stand in sharp contrast to modern cement buildings and multi-lane roads", and an architect studying the wind-catchers says, "bioclimatic architecture has waned due to economic constraints and modern construction methods that largely favor the use of energy and fossil fuel-intensive materials."(Rivet & Parhizi, 2023)

2.c Wind Catcher Modern Adaptations

Since this design is simply a hollow tower structure on top of a building, there are many ways to integrate it into modern architecture.

- *Louvers* are a part of modern wind towers that act as a cover to prevent rain and snow from getting inside.
- Fans could be added to the wind tower to further simulate wind.
- In Madrid, there are Air Trees that promote ambient temperatures outdoors by combining 16 wind towers together and adding a fan and water pipes.
- Wind tower combined with a chiller; this option would use energy but reduces it significantly by optimizing the cooling effect.

Some other advantages other than reducing emissions significantly are that there is less noise pollution and it is cheaper to install and maintain, the towers don't need to be fixed or replaced(Sangdeh et al., 2020). A visitor center for Zion's National Park in Utah, a plateau in the desert with a similar climate to Iran, has incorporated a windcatcher design into its architecture that has almost eliminated its need for air conditioning. Even though there is regular human traffic which generally makes indoor spaces warmer, there is almost a 30° F difference between inside and outside(Shokoohi, 2022).

2.d Anatolia's Corbelled Roofs

Corbelled roofs, also called Lantern roofs, or locally called *kırlangıç* or *tüteklikli* roofs, are dome-shaped roofs made of wood or stone overlapping each other that help protect residents from the cold in their distinct, changing seasons. Often, houses with these roofs were built almost into the ground and had a small opening at the top of the roof in order to let in light and airflow. This takes advantage of soil's natural insulation and storage of solar energy. Other versions of this structure have the houses built into a hill. Usually, these roofs are built over a hearth/fireplace so they also act as chimneys. The hot air would collect in the corbelling and block cold winds before slowly exiting through the

aperture. This style of building was widespread, with similar setups across the Middle East and Indus valley region. (Erarslan, 2022).

2.e Corbelled Roofs Modern Adaptations

- Cork houses-these buildings are modern designs of corbelled roof houses designed to be eco-friendly by minimizing heater use and reducing the amount of building material since it is easily assembled and disassembled and reused due to the lack of cement or mortar.
- Adding a central heater and a fan, maybe solar-powered, where the aperture would normally go to move the heat throughout the room/building would reduce the energy needed to regulate the entire space.

3. Air Quality

Air pollution is an issue inside and outside homes and cities. When we think of air pollution, the first thought that usually comes to mind is city smog and factory clouds but there are many types of air pollution. While we don't think of it often, modern homes are built from synthetic materials that emit chemicals and VOCs(Volatile Organic Compounds). Both poor indoor and outdoor air quality can cause serious respiratory issues; the World Health Organization even coined the term 'sick building syndrome' to characterize the multitudes of invisible issues caused by modern buildings. This air pollution has been linked to "worse cardiovascular disease; cognitive decline in older adults; higher rates of chronic respiratory diseases, lung infections, and cancers; and infectious diseases including measles, tuberculosis, chickenpox, influenza, and SARS. In schools, high levels of multiple pollutants and carbon dioxide were tied to lower academic and cognitive performance and worsened respiratory health" (Landman, 2022). A lot of air pollution is not easy to regulate and control, but there are methods to counteract it.

3.a Babylon's Hanging Gardens

(Credit: Baker 2020)

One of the seven wonders of the ancient world, the Hanging Gardens of Babylon were lush terraced plant beds in ancient Mesopotamia with almost 100,000 square feet of area and multiple water features. Once thought to be mythical, recent research has indicated that the gardens existed, just 300 miles north of Babylon in Nineveh(Klein, 2023). This feat of

architectural planning has inspired many people and can be described as one of the first feats of agri-tecture; “demonstrating technological … prowess with respect to urban planning, information technology, watershed management and of course state of the art utilization of intrinsic and extrinsic resources"(Baker, 2020). The gardens with vegetables, flowers, and trees all sustained by drip irrigation transformed the microclimate of the hot, desert region. The garden was likely built as a gift to an ancient queen, but urban green spaces weren’t a new concept in ancient civilizations. Green spaces in town hubs were used for religious and social purposes while also cultivating a connection with the natural landscape around them. (Salma, 2019).

3.b Roman Horti

Ancient Rome at its peak had about 1 million people living in the city center; they lived in apartment-like houses near industrial buildings like manufacturers and blacksmiths(Gunther, 2021). This setup was similar to our cities nowadays and they also faced similar predicaments like balancing older cramped neighborhoods and increasing urban sprawl as well as large amounts of pollution due to the industrial buildings. Especially when combined with the smoke from everyday fires used for heating and cooking, pollution was a concern. However, ancient Romans “adopted, adapted, invented and built their way through ecological roadblocks”(Gunther, 2021). Their culture was very tied to nature, with deities and practices revolving around the natural world around them. Ancient Romans were the first civilization to see the importance of intertwining rural and urban spaces, calling it ‘Rus in Urbe’ or the country in the city(Urban Rambles, 2016). Horti refers specifically to gardens around aristocrat’s houses but most Roman buildings often had gardens alongside or incorporated into them, in the form of atriums, filled with a number of diverse species, water features/fountains, and sometimes produce(Jasiński, 2023). These open, natural spaces contributed to better air quality and helped moderate the temperature. They also increased social isolation and improved personal well-being (Devlin, 2019).

3.c Gardens Modern Adaptations

The environmental benefits of green urban spaces are numerous; they improve the overall air quality, reduce the urban heat island effect, and mitigate climate change effects. (Salma, 2019). Gardens or green spaces in urban areas act like carbon sinks, taking carbon dioxide out of the atmosphere. They also contribute to supporting biodiversity and native species which improves resilience and reduces flooding issues by storing groundwater. This also prevents runoff which has many effects other than flooding like contaminating drinking water or causing eutrophication and algal blooms in bodies of water nearby. Their benefits extend past environmental moderation by improving people’s health and motivating people to be physically active, reducing the risk of chronic diseases by

enhancing immune response and reducing recovery time for patients. Nature in urban spaces also promotes social activity and has a significant effect on people's mental health, reducing stress and mental disorders effects. It even helps in children's development, reducing effects of ADHD, improving cognitive development, and instilling environmental stewardship and empathy. Nature in urban environments has so many fruitful effects and is an easy factor to incorporate into modern areas. (Israel & Wolf).

- City Gardens: These can take up as much or as little space as is available and can be used as educational tools for children in schools nearby or other communities to learn sustainability and gardening as well as promote food security by donating produce to food banks.
- Green Roofs: Roofs are the main exposed space and also play a large role in heat gain. Planting on roofs sounds intensive but there are extensive green roofs as well that just require substrate, are easily maintained, and have a low cost. It also acts as insulation and reduces the amount of energy needed to heat or cool a building(Irfeey et al, 2023).
- Green Walls: Similar to green roofs but with climbing plants, or shrubs and ferns, that require even less maintenance(Irfeey et al, 2023).
- Urban Canopy Cover: Planting more trees, especially in wide open spaces like parking lots or walkways.
- Parks: It can be as simple as incorporating parks and gardens into empty spaces.

4. Building Materials

Some of our most common building materials are unsustainable. Aluminum is highly popular because it is lightweight and strong, but it is also highly energy intensive contributing to 2% of GHG emissions or 1.1 billion metric tons of CO2 each year. The production of cement, the main component of concrete, contributes to 8% of GHG emissions, each pound releases almost 1 pound of CO2. Concrete is also not the most efficient in a lot of environments because it has less thermal inertia meaning more heating-cooling devices are needed. Steel also contributes to 8% and uses a significant amount of water. While it would be hard if not impossible to stop using these materials, their use can be lessened and other materials can be used for some applications.

4.a Sana'a's Mud Skyscrapers

(Credit: Alamy)

Ancient builders had no choice but to use the materials they found around them to build. For a lot of cultures, this was mud. Mud was a basic and effective material made of clay, sand, water and sometimes combined with other materials like hay or straw to be molded into bricks or plastered. It is not energy intensive at all and has a high thermal mass meaning it has natural insulation properties. Mud can absorb the sun's energy during the day and release heat slowly at night which helps keep indoors at a comfortable temperature. It is also very durable and can withstand fires and earthquakes. They even have soundproofing qualities making it perfect for locations with a lot of noise pollution. Yemen's ancient city, Sana'a, is a well-known example of mud architecture with a style so extraordinary and unique that it is a recognized Unesco World Heritage site. Called "The Manhattan of the Desert", the towering buildings are an amazing example of blending cities with the natural landscape. These buildings are thousands of years old yet they are still standing strong against the extreme weather events characteristic to the area like flash floods and intense heat waves. The buildings are still inhabited today and were easily adapted to modern use because of their craftsmanship techniques and resilience. They are also an important part of the culture; an interview with a peace advocate for Yemen says, " I cannot begin to describe the pride of living in a home preserved by generations of ancestors – they are our connection to the past"(Lemmin-Woolfrey, 2022).

4.b Mud Modern Adaptations and Examples

Building with mud is seen as regressing in some builder's mindsets nowadays but there are many architects who are incorporating it into modern designs. A lot of the techniques have been used for centuries but since they are still used and revamped today they are included in the modern section.

- Cob Houses- this technique is over 10,000 years old but is used today and refers to buildings made with clay, sand, and straw. The houses outlast hurricanes and are resistant to wildfires and thousands of years of weathering. No synthetic

components and a high thermal mass, meaning it requires less heating/cooling indoors, make cob buildings highly energy-efficient. Also, most of these components can be sourced locally so it is low-cost to builders and the planet(Schwerdfeger).

- Rammed Earth- Building with rammed earth has also been around for centuries and uses 1/40th the carbon footprint of concrete and it also has a high thermal mass to promote insulation and less energy use for temperature regulating. They are fireproof and can withstand earthquakes and storms when paired with reinforcement bars which can be made of wood or bamboo(Killip, 2020). They have a load-bearing capacity similar to concrete and will not crumble; many sections of the Great Wall of China are built with this technique(Hunter, n.d.).
- Adobe bricks- these sun-dried bricks are one of the most popular mud-building practices around the world. They are made with clay, sand/water, and straw/sticks/organic material. These have high thermal mass and provide insulation so they are most beneficial in hot climates, often used in Africa, West Asia, across Europe, and South America(Insider, 2020).

Traditional Dorze house, Ethiopia. Image Source: Re-thinking the future(Asilis, 2022)

4.c Bamboo Building across the world

Bamboo has been used for so many purposes like fabric, art, cooking, and construction. Its versatility is only one of its advantages as it has a lot of environmental benefits. First, the actual growth of a bamboo forest absorbs a lot of carbon dioxide and grows quicker and easier which makes it cheaper. Wood can take 40-150 years to mature but bamboo is ready in 3 years and can last for just as long. Chinese architecture has used bamboo for thousands of years and the material spread to India, Japan, and South America. Since it thrives in wet climates and is flexible, bamboo can withstand hurricanes, other tropical storms, and earthquakes. Bahay Kubo and Nipa huts are inexpensive houses that are built in the Philippines and Polynesia to withstand hurricanes(Greener Ideal, 2017);Bohios are circular huts layered with sand and clay to protect against all temperatures in Columbia; Mayan Bahareque structures used bamboo and soil; Kunas in Panama used bamboo for their skeleton and for thermal insulation; Gamo and Dorze peoples in Ethiopia used bamboo to strengthen structures and for roofing; Sumbanese houses in Indonesia used woven bamboo and coconut leaves for walls and bamboo for roofs and floors(Asilis, 2022). All these cultures saw the benefits of bamboo and integrated them into construction in the past.

4.d Bamboo Modern Adaptations

Because of its environmental benefits, stability, versatility, rapid growth/renewal, and affordability, bamboo has been called the “green steel” of the 21st century or the “material of the future”. Biomaterials are being integrated into modern designs and there are already many examples of bamboo architecture.

- Bamboo flooring is becoming more common as an alternative to hardwood. Since it is naturally termite resistant it doesn't require any chemicals to protect it. It also deters mold and doesn’t release toxic chemicals or VOCs into the air over time like hardwood floors. (Schwab, 2022)
- Kengo Kuma, a Japanese architect combines bamboo with carbon fiber to create structures and promotes its integration in city buildings to withstand earthquakes.

(The Arc by Ibuku and Hardelot Theatre credit: Hahn, 2021)

- Luum Temple in Tulum, Hardelot Theatre in France, Bamboo Pavilion in Taiwan, Bamboo Sports Hall in Thailand are all examples of artistic bamboo use in modern architecture(Hahn, 2021).
- Earl Forlales a Filipino architect modernized Bahay Kubo and won UK’s “Cities for our Future” award in 2018 and got his idea turned into a company called Cubo. Due to the Philippines' major housing crisis, the company provides affordable housing with designs that can be made in days but last up to 50 years; these houses have already withstood magnitude 6 earthquakes unscathed(Cairns, 2021).
- Ibuku, an Indonesian architecture company, has built the Green Village and the Green School made of bamboo; they are all large-scale, intricate, luxury complexes(Cairns, 2021).

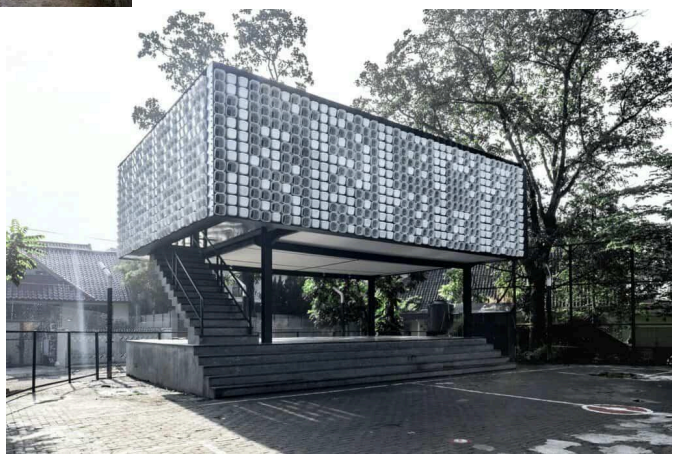
4.e Miscellaneous Modern Adaptations

Ancient Civilizations used mud, clay, and other organic materials like straw as their primary building materials since that is what they found around them. While the section

above covered how the same materials can be used in modern times, we also have more options. Nowadays we create a lot of products and materials that can be reused for construction. This method prompts creativity and can make a huge impact in recycling materials that would otherwise sit for thousands of years in a landfill.

- Earthships- the frame of these wholly sustainable houses are old car tires paired with rammed earth. The rest of the building is made of natural and recycled materials like glass bottles or phone books that create an alien-like artistic look to the building. Earthships are also functionally environmentally friendly, powered by thermal, solar, and wind energy and harvesting water and food nearby(Young, 2017). Earthship Credit: Young 2017

Indonesia Ice Cream Bucket Library Credit: Campbell 2020



- Indonesia's ice cream bucket micro-library- this building's walls are partially made from used ice cream buckets tilted to repel rainwater but allow daylight and natural ventilation inside. Some buckets are closed and some are open in a pattern that writes a message in binary code, "books are windows to the world." This building is the prototype of a series of small libraries planned across Indonesia to work towards increasing literacy. (Grozdanic, 2016)
- Sargassum is an invasive seaweed that has been washing up in tons on the coast of Mexico; it was detrimental to the tourism industry and cost a fortune to clean up since it would wash up so often. Omar Vasquez first used it as fertilizer but then developed "sarcobricks", bricks made of this seaweed and other local organic material, that are strong enough to withstand hurricanes and last about 120 years. He uses these bricks to build homes for low-income families(Mkrtichian 2020).

5. Biomimicry

Nature has been a source of inspiration for artists, poets, scientists, and even architects for as long as humans have been around. Biomimicry is the imitation of nature's way of solving problems in our own designs. This strategy can minimize negative effects on the environment by reducing energy consumption and optimizing natural elements like lighting, ventilation, and water. Also, since nature has adapted and thrived through changing environments, the buildings designs are resilient to extreme weather/natural disasters as well as adaptable to climate change. The designs also tend to integrate ecosystem elements and promote biodiversity and harmony with the environment. Media and art are important devices to influence the public and change perceptions about nature and by incorporating nature into city designs it influences people to think more about the environment in a way that is more relevant to their everyday lives. (Integration, 2023)

5.a Biomimicry in Ancient Architecture

Biomimicry's use in ancient architecture didn't contribute to a more sustainable design, it was more for aesthetic purposes like the temples in ancient Egypt with columns inspired by the lotus plant or Byzantine architecture which used floral embellishments for plain surfaces. Biomimicry was also used for building strength and stability. The world's tallest and oldest pagoda in China is inspired by tree branch structure and has survived many many earthquakes in its 900 years of existence. The Alhambra Palace in Spain was built using a honeycomb composition to increase stability to support its massive domes and brackets. The Colosseum in Rome imitates a spider's web which creates ventilation for the massive stadium(Rethinking, 2020). While most of the biomimicry designs in Ancient architecture promoted sustainability because of their use of local materials, modern design does a better job of bringing it to the next level.

5.b Biomimicry in Modern Architecture

Fan vaults in Gloucester Cathedral Credit: www.aleteia.com

- Gothic architecture's fan vaults. These structures were shaped like oyster shells to form a cross-network ceiling that brings in natural light and ventilation. Gothic architecture also features Rose windows for aesthetic

purposes and ribbed vaults which resemble the skeletal structure of turtles and bear a lot of weight while still being a lightweight structure(Al-Masri et al. 2023).

- The Council House in Australia mimics termite mounds to provide ventilation and regulate temperature and humidity. The Eastgate Center in Zimbabwe is also inspired by termite mounds because they are always at the same temperature; the shopping mall uses zero energy for heating and cooling despite its fluctuations between high and low temperatures(Campbell 2020).
- The Water Cube in China mimics the geometry of water molecules and allows sunlight in while insulating the interior, reducing the use of artificial lighting or air conditioning. (Arpitha, 2023)
- The Eiffel Tower uses thigh-bone lattice structure to hold the weight of the tower

Esplanade Theatre Credit: Arpitha 2023

- The Esplanade Theatre in Singapore is modeled after a Durian fruit with environment-responsive panels that adjust shading and light according to the sun(Arpitha, 2023)
- The Gherkin in London is mimicking a Venus Flower Basket Sponge to provide natural ventilation throughout the building(Arpitha, 2023)
- The Bullitt Center in Seattle has net-zero energy consumption by incorporating solar panels, natural ventilation and lighting, and rain harvesting systems in their tree-inspired design. (Integration, 2023)
- The Arc by Ibuku is a gymnasium school with a roof made entirely of bamboo. This structure is self-supporting and is modeled after the way the human ribcage is fastened by tension from muscles and skin(Griffiths, 2021).

6. Conclusion

In conclusion, exploring ancient sustainable practices in the realm of architecture offers a rich source of inspiration as well as practical solutions for contemporary challenges. As city planners and architects navigate the complexities of modern urban development and environmental concerns, looking back to the wisdom of our ancestors offers a valuable perspective. From the ingenious use of natural materials like bamboo, rammed earth, and cob, to the harmonious integration of buildings with their surroundings in ancient Rome or Yemen, there is so much scope to learn and apply in our current architectural practices.

Sustainable solutions and architecture do not have to be expensive or high-tech. Buildings are responsible for 40% of the world's energy consumption and ⅓ of GHG emissions (Holland 2017). This needs to change if we as a society want to build a better world and protect our planet. Indigenous knowledge is being valued more recently as people come to this realization that a lot of human activity has ended up corroding the Earth's natural balance and while this is a step in the right direction, we need to start integrating this knowledge. City planning is one of the best ways to make this change as they are the basis for how a community functions, by adding more natural elements and using sustainable techniques we not only reduce GHG emissions but change people's outlooks on how they can incorporate sustainability into their lives. Also just having more natural aspects around you promotes ideas of conservation, empathy, and caring for nature which is what we need more of.

The integrations themselves can be basic but integral changes. Taking lighting as an example, they can be as simple as just changing the ways windows are oriented to allow solar energy to heat and cool buildings, more natural lighting using large windows facing the right direction and skylights to maximize the sun to reduce the need for artificial lighting, or light wells like open courtyards to light up places far from the exterior facing walls(Ambegaonkar, 2024). Another simple integration is greywater recycling which is capturing rainwater to use for irrigation or washing. The Qanat system in Persia involved tunnels underground that moved water from high to low elevations to be collected in wells for use in homes. The Romans also had a famous aqueduct system to manage their water sustainably (Ambegaonkar, 2024). They can also be complex, creative designs using bioenergy like the Algae House in Germany. This is the first algae-powered building, freshwater algae in its windows produce biogas and bioreactors turn it into energy. The green facade provides shade to the structure while producing energy efficiently(Arpitha, 2023). The concept of biomimicry, drawing inspiration from nature's efficiency and resilience, emerges as a promising avenue for sustainable design. Similarly recycling used products like tires and cartons solves issues of mass consumption caused by waste and landfill GHG while promoting creativity in sustainable aesthetically pleasing designs. By embracing techniques such as windcatchers, green roofs, and passive heating and cooling systems, we not only reduce our environmental footprint but also foster a deeper connection between architecture and nature. Moreover, the utilization of traditional building methods, like those found in Anatolian houses or bamboo buildings, showcases the adaptability of ancient practices to modern challenges.

There are so many creative ways to design buildings and bringing back creative designs is not only aesthetically pleasing and embraces cultural differences but opens up opportunities to support sustainable businesses like "Sarcobricks."Integrating these time-tested methods into contemporary architecture requires a collaborative effort involving architects, engineers, and urban planners. By doing so, we can create built environments that are not only aesthetically pleasing but also ecologically responsible and

resilient. This synthesis of ancient wisdom and cutting-edge technology holds the potential to redefine the way we approach sustainable architecture, forging a path toward a more harmonious and promising future for our environment. As we bridge the gap between past and present, we unlock a sustainable legacy that benefits both current and future generations, honors past generation's knowledge, and fosters a holistic, enduring approach to architecture that respects the planet's resources. Redefining modernity to not have the connotation of "Westernization" and bringing in cultural practices can make huge differences in how we interact with the world. Looking to the past is integral for a better future.

Citations

1. Al-Masri, A., Abdulsalam, M., Hashaykeh, N., & Salameh, W. (2023). Bio-mimicry in architecture: An explorative review of innovative solution toward sustainable buildings. An-Najah National University.
2. Alev Erarslan (2022) A traditional wooden corbelled dome construction technique from Anatolia. The Eastern Anatolian Tandoor house with its wooden "swallow-dome" type of roof, Journal of Asian Architecture and Building Engineering, 21:4, 1275-1303, DOI: 10.1080/13467581.2021.1929243.
3. Ambegaonkar, R. (2024). How Ancient Engineers & Their Projects Can Inspire You To Create A Sustainable Building. Www.ny-Engineers.com. https://www.ny-engineers.com/blog/how-ancient-engineers-their-projects-can-inspire-you-to-create-a-sustainable-building.
4. Arpitha, S. (2023, January 17). *Biomimicry in architecture: Nature-inspired design*. Parametric Architecture. https://parametric-architecture.com/nature-inspired-design-biomimicry-in-architecture/
5. Asilis, L. M. (2022, August 3). Vernacular Bamboo Structures Around The World. Bamboo U. https://bamboou.com/design-vernacular-bamboo-structures-around-the-world/.
6. Baker, C. (2020, March 27). Green roofs: The new-old Hanging Gardens of Babylon. Green Roofs: The New-Old Hanging Gardens of Babylon. https://www.newprocontainers.com/blog/green-roofs-the-new-old-hanging-gardens-of-babylon/.
7. Cairns, R. (2021, November 22). Bamboo has been used for thousands of years in Asia. Now, it could help solve construction's sustainability problem. CNN. https://www.cnn.com/style/article/bamboo-sustainable-building-philippines-bali-hnk-spc-intl/index.html.
8. Campbell, T. (2020, November 13). Sustainable Architecture: Between Ancient Materials and New Practices. Artland Magazine.

https://magazine.artland.com/sustainable-architecture-between-ancient-materials-and-new-practices/.

9. Devlin, D. F. (2019, June). Understanding the lived experience of ancient Roman Gardens. Understanding the Lived Experience of Ancient Roman Gardens. https://digitalworks.union.edu/cgi/viewcontent.cgi?article=3288&context=theses.
10. Environmental Protection Agency. (2023, November 20). Heat Island Effect. EPA. https://www.epa.gov/heatislands.
11. Griffiths, A. (2021, July 24). *Ibuku completes "unprecedented" bamboo building in the Balinese jungle*. Dezeen. https://www.dezeen.com/2021/07/24/ibuku-the-arc-bamboo-jungle-bali-architecture/
12. Grozdanic, L. (2016, July 7). Microlibrary built with 2,000 recycled ice cream buckets tackles illiteracy in Indonesia. Inhabitat - Green Design, Innovation, Architecture, Green Building | Green Design & Innovation for a Better World. https://inhabitat.com/microlibrary-built-with-2000-recycled-ice-cream-buckets-tackles-illiteracy-in-indonesia/.
13. Gunther, S. (2021, February 8). Environmental choices the Romans made. Treehugger. https://www.treehugger.com/environmental-choices-the-romans-made-4863792.
14. Hahn, J. (2021, August 4). Ten impressive bamboo buildings that demonstrate the material's versatility. Dezeen. https://www.dezeen.com/2021/08/04/impressive-bamboo-building-roundup/.
15. Holland O.. (2017, December 27). What traditional buildings can teach architects about sustainability. CNN. https://www.cnn.com/style/article/vernacular-architecture-sustainability/index.html.
16. History of Bamboo as a Building Material | Greener Ideal. (2017, April 8). Greenerideal.com. https://greenerideal.com/news/building/0523-history-of-bamboo-as-a-building-material/.

17. Henna, K., & Mani, M. (2022). Transitions in traditional dwellings. Curr. Sci, 122, 29-38.
18. Hunter, K. (n.d.). Rammed earth is a sustainable, strong, and durable building material. Www.kristinahunterflourishing.com. https://www.kristinahunterflourishing.com/blog/an-ancient-building-technique-is-gaining-new-fans-rammed-earth-construction.
19. Insider, T. A. (2020, May 5). Mud: An Eco-Friendly Construction Materials. The Arch Insider. https://thearchinsider.com/mud-an-eco-friendly-construction-materials/.
20. Irfeey, Abdul Munaf Mohamed, Hing-Wah Chau, Mohamed Mahusoon Fathima Sumaiya, Cheuk Yin Wai, Nitin Muttil, and Elmira Jamei. 2023. "Sustainable Mitigation Strategies for Urban Heat Island Effects in Urban Areas" Sustainability 15, no. 14: 10767. https://doi.org/10.3390/su151410767.
21. Israel, J., & Wolf, K. L. (n.d.). The benefits of cities where people and nature thrive. Outside Our Doors: The benefits of cities where people and nature thrive. https://www.nature.org/content/dam/tnc/nature/en/documents/Outside_Our_Doors_report.pdf.
22. Jasiński, J. (2023, February 17). Gardens and gardening in ancient rome " imperium romanum. IMPERIUM ROMANUM. https://imperiumromanum.pl/en/article/gardens-and-gardening-in-ancient-rome/.
23. Klein, C. (2023, August 9). Hanging gardens existed-but not in babylon. History.com. https://www.history.com/news/hanging-gardens-existed-but-not-in-babylon.
24. Killip, S. (2020, April 29). Rammed Earth: the building material of the past, present and future - DesignCurial. Www.designcurial.com. https://www.designcurial.com/news/rammed-earth-building-material-past-present-future-7896641/.
25. Landman, K. (2022, October 17). Our buildings are making us sick. Vox. https://www.vox.com/the-highlight/23377638/buildings-indoor-air-quality-pollution-toxic-sick.
26. Lemmin-Woolfrey, U. (2022, August 10). Yemen's ancient, Soaring Skyscraper Cities. BBC News.

https://www.bbc.com/travel/article/20211004-yemens-ancient-soaring-skyscraper-cities.

27. Lefkowitz, C. (2021, June 2). Why everywhere looks the same. Medium. https://marker.medium.com/why-everywhere-looks-the-same-248940f12c4.
28. Mkrtichian, E. (2020, February 13). Sargablock. () for Tomorrow. https://fortomorrow.org/explore-solutions/sargablock.
29. NPR. (2007, August 27). The energy costs of cooling and heating a home. NPR. https://www.npr.org/templates/story/story.php?storyId=13941744.
30. Norford, L. (n.d.). Heating and cooling. MIT Climate Portal. https://climate.mit.edu/explainers/heating-and-cooling.
31. 15 Instances of Biomimicry in ancient architecture. (2020, June 4). RTF | Rethinking the Future. https://www.re-thinkingthefuture.com/rtf-fresh-perspectives/a950-15-instances-of-biomimicry-in-ancient-architecture/.
32. Sangdeh, P. K. (2020, November 5). Windcatchers and their applications in contemporary architecture. Energy and Built Environment. https://www.sciencedirect.com/science/article/pii/S2666123320301070#sec0019.
33. Salma, I., Dwidar., Salma, I., Dwidar., Walaa, Metwaly. (2019). The concept of green areas through various historical eras a case study for green areas in heritage areas of Egyptian and Saudi Arabian countries. 47(6):899-913. doi: 10.21608/JESAUN.2019.115752.
34. Schwerdfeger, E. (n.d.). Cob houses are the ultimate eco-friendly homes. Brightly. https://brightly.eco/blog/cob-houses.
35. Schwab, K. (2022, August 24). The Environmental Benefits of Bamboo Flooring. Greener Ideal. https://greenerideal.com/guides/0916-why-bamboo-is-an-eco-friendly-flooring-option/.
36. Shokoohi, K. (2022, February 24). The ancient Persian way to keep cool. BBC News. https://www.bbc.com/future/article/20210810-the-ancient-persian-way-to-keep-cool.

37. Stouhi, D. (2021, November 3). What is a traditional windcatcher?. ArchDaily. https://www.archdaily.com/971216/what-is-a-traditional-windcatcher.
38. The Integration of Biomimicry in Engineering for Sustainable Architecture. (2023, October 21). Utilities One. https://utilitiesone.com/the-integration-of-biomimicry-in-engineering-for-sustainable-architecture.
39. Urban Rambles. (2016, November 22). A brief history of urban green spaces. https://urbanrambles.org/background/a-brief-history-of-rus-in-urbe-1307#:~:text=The%20Romans%20were%20the%20first,by%20wealthy%20Romans%3B%20reaching%20its.
40. Young, L. (2017, February 6). Earthships, the Ultimate in Off-Grid Architecture. Atlas Obscura. https://www.atlasobscura.com/articles/earthships-sustainable-architecture.