



TRACE OF BUILDING MATERIALS FROM TRADITION TO FUTURE IN THE CONTEXT OF SUSTAINABILITY

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ABSTRACT

Throughout history, people have tried to make the world more relevant to life. He tried to control the nature and use technology to achieve this goal. Technological developments that started with the industrial revolution have made it easier for people to control their environment and create new lifestyles. The main aim of all technological recovery struggles is to maximize people's level of life. The increase in the use of fossil fuels and uncontrolled industrialization has resulted in large increases in atmospheric and terrestrial waste, pollution and greenhouse gas values; Damage to the ecological system was excellent. Facing the fact that damage to nature is rapidly advancing rapidly towards non-reversible hazards has been instrumental in spreading the ecological understanding of the environment and conservation of natural resources; The concepts of "Green Design", "Ecological Design" and "Sustainable Design" have started to be applied respectively.

The concept of sustainability, which has recently come to prominence, has found its meaning in the design concept called sustainable architecture. The buildings in sustainable design are environment friendly and have energy conservation by producing the resources they need. However, looking at the environment from an ecological point of view is as important as the comfort conditions required for users by the materials used. Preferable features in sustainable design approach with environmentally sensitive materials. Sustainable design principles that are thought to be more important in the selection of materials as the concept of this concept is understood. During the life of the material, the materials must be least harmful to the environment and the natural resources and the amount of waste should be minimized or recovered after the wastes have been processed. In this declaration, the developments in building materials and their suitability as sustainable architectural principles will be assessed.

Keywords: Construction Materials, Sustainable Architecture, Sustainable Materials

1. INTRODUCTION

Since antiquity, mankind has gained all benefits required for existence from nature and the resources embodies within it. Economic development and rapid growth beginning with industrial revolution have led to environmental problems as well. People started to seek solutions for these problems threatening human health in all fields and ecological awareness is raised. The problems manifested themselves as population growth, rapid urbanization and settlement at first, but recently they are threatening human health with ozone layer depletion, global warming and natural disasters. As these problems could not be resolved throughout many years, the science of ecology gained much more importance, and the necessity to deal with

these problems with a broader point of view has become evident. And within this context, “sustainable architecture” concept has been developed.

A big part of these ever-increasing environmental problems is caused by building sector. Buildings have more responsibility in generating a great deal of problems like energy source decrease, vanishing of natural resources, and release of greenhouses gases that cause global warming. Hence, designers should take more responsibility than ever before with respect to erection of cities and buildings and material and energy utilization. Their primary objective should be to shape cities and building to enable conserving natural resources and using renewable energy sources in a detailed way. And this is only possible through “sustainable architecture”.

1.1. “Sustainable Architecture” Concept

The desire of people to live in healthy environments increases with each passing day due to the negative effects of environmental factors on human life. Rapid consumption of energy and natural resources in the world, high carbon dioxide amount caused by fossil fuel consumption and climate changes happening in turn have forced societies to reconsider manufacturing and consumptions modes in all sectors.

The main purpose of sustainable architecture is to reduce the use of non-renewable resources in the design and application phases, to maintain the conservation of energy and natural resources in the first phase, and in the usage phase, to prevent the destruction of nature to build constructions that produce little energy, indirectly affect the pollution of the environment, or directly affect them as little as possible, and which do not damage the sustainability of the environment. (Sarıman, 2010).

Major improvements realized in the fields of industry and technology have caused a change in the comfort needs of people, and this, in turn, gave rise to an increase in energy consumption. The built environment satisfying the basic needs of people should be formed in a way not harming the environment. And consequently, environmentally conscious design approaches have been developed in the field of architecture. Concepts like environmentally conscious architecture, eco-architecture, ecological building, ecological architecture and sustainable architecture have come into being in order to create a high quality and healthy living environment and leave it to next generations.

While sustainable architecture concept is theoretically frequently mentioned in recent years, in practice this concept is inadequately reflected in applications. However, sustainable architecture notion shows itself since the beginning of human history. The first living unit examples are intuitively constructed according to sustainable architecture understanding. The common features of such buildings are local material utilization and designs harmonious with climate and topography. For instance, the angle of the sun’s rays coming to the earth is oblique in winters, and therefore, could be taken into buildings. But, since they are direct in summers, the sun’s rays come to the roofs of buildings. Socrates (c. 470-399 BC) made use of all these natural data, and suggested that; in order to let in the sun’s rays to houses with a south front in winters and to protect from cold winds, south front should be built high, and north front should be built low and sheltered (Bozdoğan, 2003).

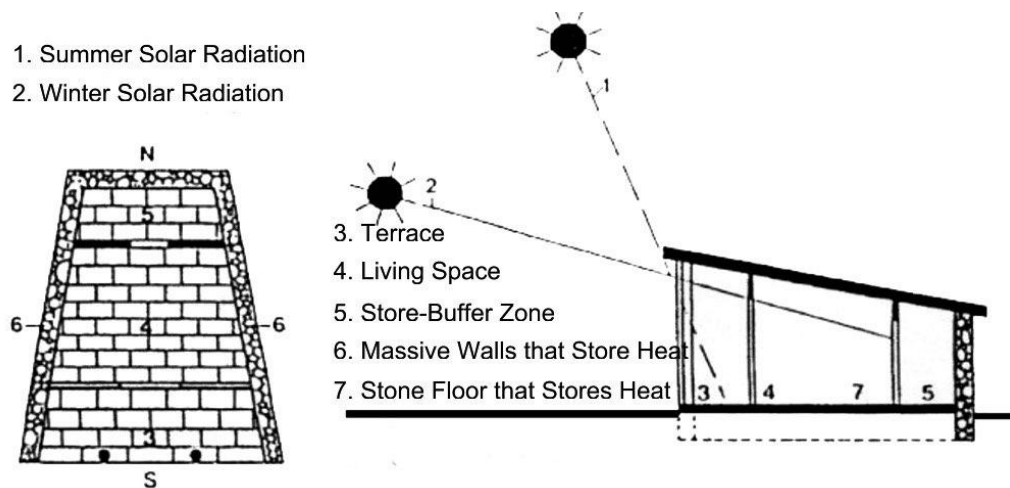


Figure 1. Socrates House (Bozdoğan, 2003)

Roman writer and architecture Vitruvius stated in his 25 BC dated book “De Architectura” that; designs should take climatic conditions of the country in the first place to achieve a proper result. Cities in Ancient Greece and Anatolia were planned in a way to benefit from the sun’s rays in winters. For example, all buildings in Priene, an ancient Greek city founded in IV. century BC, are oriented this way (Lakot, 2007).

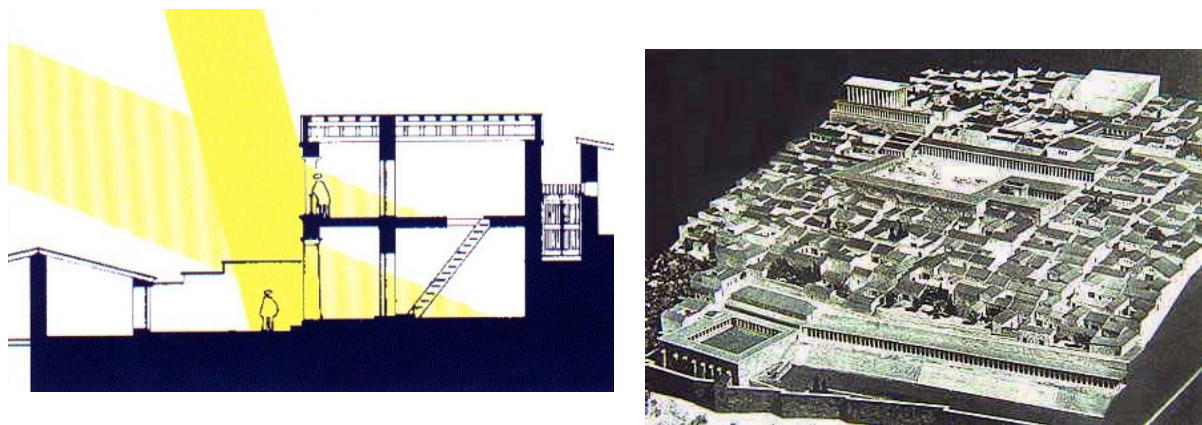


Figure 2. Antique Solar City-Priene (URL-1)

When we look up the word “sustainability” in a dictionary, we’ll come across the definition “processing and/or utilizing a resource without exhausting, depleting and extinguishing it forever” (Hoskara, 2007). Sustainability is one of the most important concepts of our age that protects natural resources and aims to provide a healthy and comfortable life to next generations; and it is used in conjunction with terms like ecology, environment, energy and material.

The term “sustainability” is used for the first time in the “Our Common Future” titled report of United Nations Brundtland Commission in 1987, and defined as “meeting economic, environmental and social needs without damaging living conditions of next generations” (Karşlı, 2008).

A huge part of environmental problems posing a threat upon human health and future are attributable to building sector. Buildings are one of the main energy consumption sources, and

innumerable harms are brought upon the environment both during production and also utilization. They form the basis of many problems like vanishing of natural resources, environmental pollution with constantly produced wastes and carbon emission release as a result of using fossil fuels to obtain required energy. It is now necessary to take joint decisions and permanent solutions for the solution of such problems. “Sustainable Architecture” term is asserted with the aim of solving building-based problems.

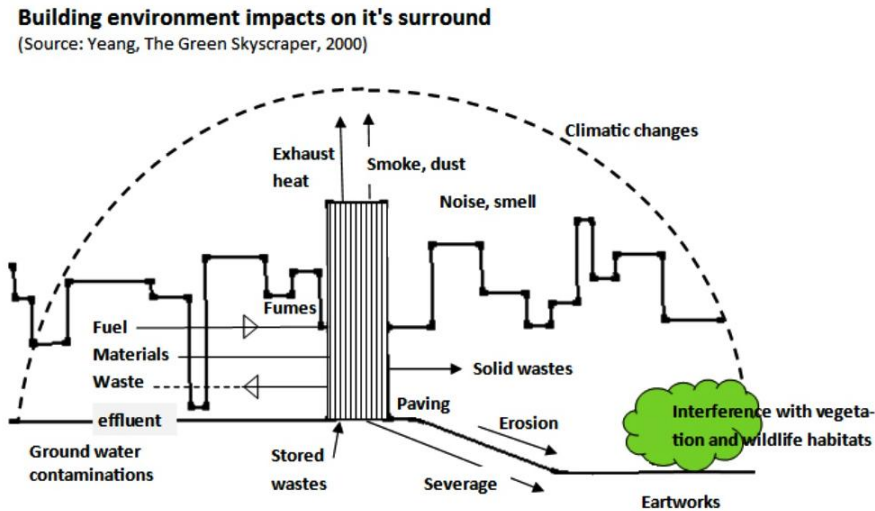


Figure 3. The Effects Of Buildings On Environment (Yeang, 2000)

While secure and comfortable places are designed for residents in sustainable architecture concept, it is also aimed to use natural resources economically and consume energy in a more efficient way. It is an eco-friendly architecture approach aiming to use local and recyclable materials during building constructions. Sustainable building is a building which has minimum effect on natural environment and resources, designed in harmony with nature and utilized energy-efficient and healthy systems.

The reflection of sustainability concept on building design is explained by five objectives in the guide prepared by Minnesota University: (URL-12)

1- Using the Landscape:

- Existing public areas should be preferred instead of green areas during land selection for building construction,
- Natural characteristic and ecology of building land should be protected and improved,
- A settlement reducing the area where the building is constructed should be administered,
- Orientation to sun should be achieved in building design for natural lighting and heating, and climate and environmental effects should be utilized in maximum,
- The existing infrastructure in the building area should be used,
- A landscape design reducing waterproof area formation in the land should be applied,
- Alternative transport options like bicycle path and stand should be supported,

2- Efficiency of Water

- Low water-consuming, water-efficient equipment should be used,
- Wastewater in the building should be treated and reused for irrigation, cooling, toilet cleaning, fire etc. purposes excluding drinking,
- A landscape design providing water conservation and using local plants should be created,
- Rainwater should be collected and reused in appropriate areas,

3- Efficiency of Energy

- Renewable energy sources should be used,
- Use of energy-efficient equipment,
- Reduction of heating and cooling energy consumption generated as a result of heat loss and gains in building shell,
- Efficient use of insulation materials,
- To have the building consume the least possible energy, energy-efficient heating, cooling and ventilations systems should be established,

4- Comfort of Space

- Use of low particle producing materials (adhesives, seals, paints, carpets, composite wood products),
- Contaminant sources should be checked, and
- Daylight receiving areas should be increased,
- Increase in ventilation performance,
- Control of harmful gas, toxic substance and CO₂ emission, carrying out all measurements, control of humidity and bacterial contamination,
- Providing appropriate thermal conditions,
- Proper ventilation during construction for good interior quality,

5- Materials and Sources

- Regional and local material use,
- Use of renewable resources,
- Use of durable materials and extension of renewal term of materials,
- Use of recyclable and environmentally favorable materials,
- Reduction of building wastes and reutilization in different ways

Providing water, energy and material conservation in buildings are important factors in terms of building sustainability. Constructing buildings that will bring minimum damage to environment need to be one of the most important aims of designers and producers. The scheme created by Kim and Ridgon (1998) to provide a sustainable design oriented guide is considered to be in parallel with the study conducted by Minnesota University (Kim and Ridgon, 1998).

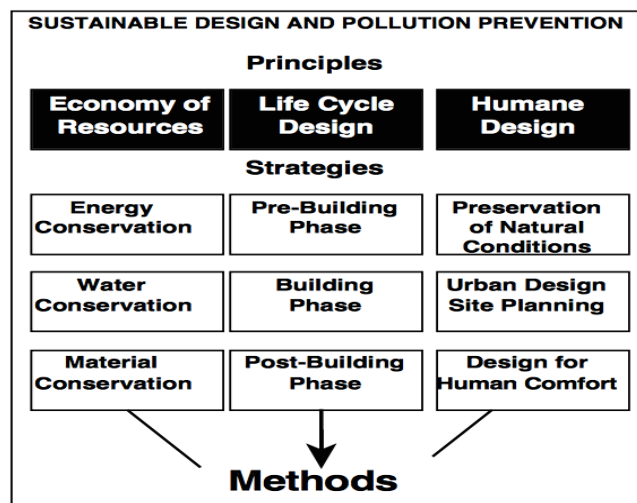


Figure 4. The Conceptual Frame of Sustainable Design In Architecture (Kim and Ridgon, 1998)

When we separately deal with the topics in the scheme, it stands out that; almost all of them are related to the natural resources and materials used. Building materials have huge influence on health, environment and economy. It is of critical importance to select environment-friendly and human health favoring materials. Thus, negative conditions caused by materials used during building constructions are to be known.

1.2. The Negative Effects of Constructional Materials

All building materials used in a building construction go through various stages and undergo many processes before entering the building. Building materials continuously interact with the environment they are located throughout raw material extraction, processing according to the needs, use in the building, demolition after expiry and recycling stages. Energy is consumed in all stages of this lifecycle and during transportation of these materials both production and construction sites, and wastes are generated as a consequence. Therefore, one of the most important factors determining a building's energy-efficiency is material selection. The materials to be used in a building's construction should be the ones selected among the minimum energy-consuming materials in the course of their lifecycle.

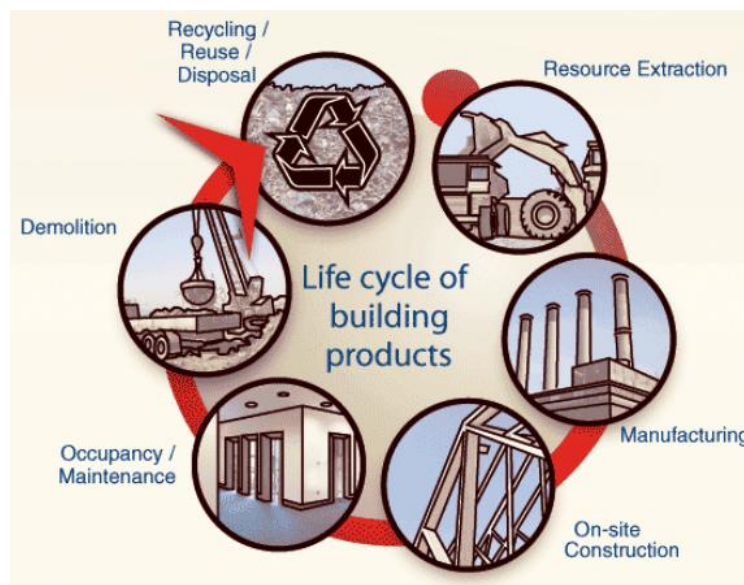


Figure 5. The Life Cycle Of Constuctional Materials (URL-15)

Building materials constantly interact with the user during their use within the lifecycle. Material has a profound effect in creating healthy and comfortable interior conditions for residents. Some building materials release harmful gases during their use. The amount of such gases emitted differs according to the type and application method of the material used. Hence, harmful gas and toxic substance emission rate should be observed carefully in material selection. A component that will harm indoor air quality should not be contained in materials. Wastes formed during demolition of buildings is another important problem, and such wastes are sometimes disposed to unsuitable places without permission and this causes environmental pollution. Therefore, it is critical to select recyclable materials.

Two approaches are prevalent in building material selection issue. According to the first approach, natural materials that do not harm the nature should be selected in sustainable design. However, selecting eco-friendly natural materials will reduce the already scarce resources and cause their total extermination. Raw materials necessary for such materials are mostly ex-

tracted from rural areas and damages the habitat. Process of these raw materials generally takes places in locations adjacent to cities and leads to air pollution. Moreover, a high level of energy is used as mentioned before. Thus, at second look, it is recommended to select and use artificial materials that do not bring harm to nature on energy and waste basis (Tönük, 2001)

Materials used in buildings differ depending on the function of building. Besides technical specifications, natural, environmental and human health-related sustainability features should also be taken into consideration during the selection of such materials.

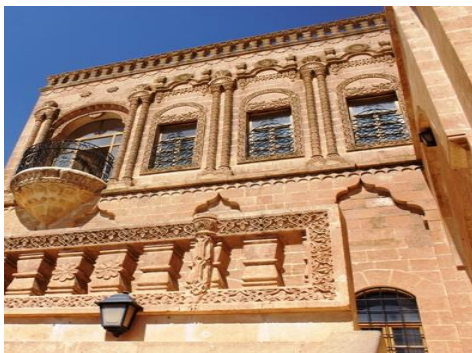
2. THE EVALUATION OF CONSTRUCTIONAL MATERIALS IN SCOPE OF SUSTAINABILITY CONCEPT

Evaluating the materials used in a building design in terms of sustainability and selecting them plays an important role in a sustainable architectural design. Some important building materials used from past to present are evaluated below according to the factors determined within the scope of sustainable features, and positive and negative properties of materials are designated.

- The factor of influence upon environment and natural habitat in building material selection
- The harm brought by local raw materials with sufficient resources to environment during their extraction, amount of waste produced by materials during their lifecycle and decomposition of these wastes,
- Energy factor in building material selection
- Energy amount consumed by raw materials during their extraction, processing, material production, transportation and lifecycle
- Recyclability factor in building material selection
- Recyclability of building materials
- Human health factor in building material selection
- Toxic substance amount generated during material production, application and use

2.1. Natural Stone

Natural stone takes an important place among the raw materials extracted from nature and then used. It is used as a building material throughout human history by way of shaping and carving it. It generally serves as the main component in foundations, walls and bridges, and coating material in floors, walls and roofs. Moreover, it is an important materials used in landscape designs like garden wall buildings, pavement and road paving, and also historical building restorations. **Marble** and **granite** are natural stones commonly used as coating materials in buildings.



(a)



(b)

Figure 6. The Usage Of Natural Stone As Structural And Facing Material (a: URL-3, b:URL-8)

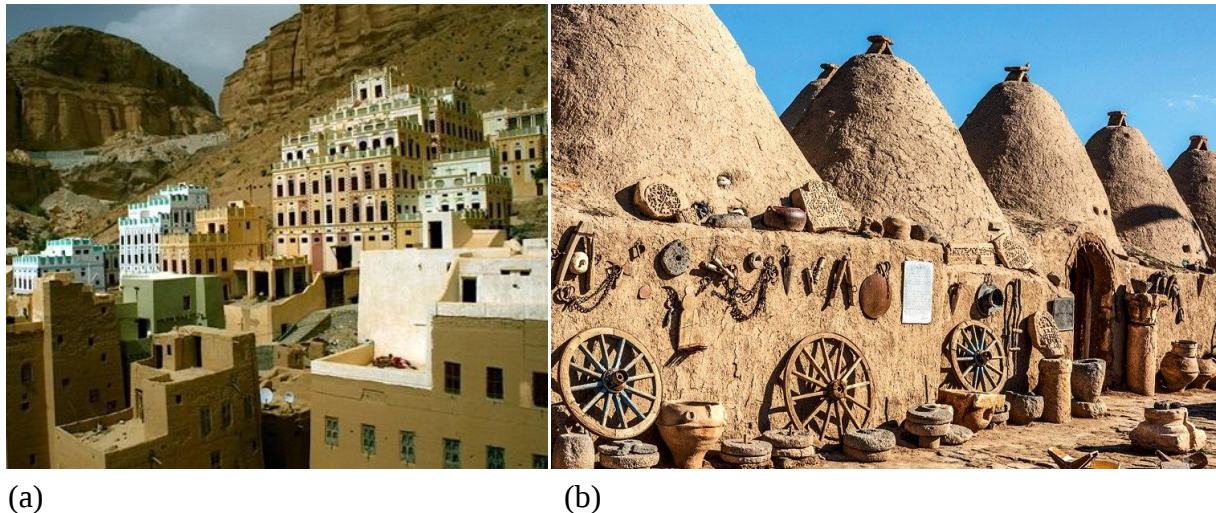
Turkey is rich in natural stone material reserves and diversity and it is not possible to exhaust them. Marble, travertine, onyx and granite can be listed among them. For instance, there are more than 150 marble reserves with different colors, patterns and qualities in 80 regions in Turkey. In this aspect, natural stones specified as local materials are extracted from quarries and used after processing them. They may harm the environment while being extracted from the quarries (distortion in land structure and natural vegetation, erosion etc.).

There is no need for a complex production plant for processing the stones extracted from quarries and the necessary energy amount is low. Wastes produced as a result of processing could later be used in various fields. Natural stone wastes emerging after demolition of buildings are reusable and recyclable. No harmful substance is released during their production and use and they do not harm human health. However, one of the natural stones, granite is harmful in that; it releases a high amount of radon gas. Natural stone materials have favorable characteristics in terms of sustainability concept.

2.2. Adobe

Adobe binding material, which is a traditional material, is a clay soil derived from nature. It is used both as a load-bearing element, and also as a plastering material. It is a cheap building material surviving until today and necessitating no plant building for its production. After adding materials like straw stems to a rich clay soil, the product is mixed with water and cast in molds, sundried and adobe blocks are made. Adobe blocks are bonded with a soil-based mortar. In Anatolian villages, we can still see adobe blocks in most houses (Tumer, 2010).

Mesopotamian architecture completely relied on adobe materials. Yemen, the place where Ād tribe once lived, is known as the country where skyscrapers are built for the first time in the world. The high-rise building in Shibam-Hadramaut region are known as “Manhattan of the Desert”. Today, the locals still continue to build adobe houses with the same method (URL-2).



(a) (b)
Figure 7. (a) The First Skyscrapers Of The World-Yemen (URL-5), (b)Harran Houses (URL-11)

As adobe is produced by naturally gathered clay soil and water, it is completely of local nature and depletion of reserves is not a matter of discussion at all. It poses no danger to the nature during production and does not require any plant for such processes. It is a completely ecological material with high thermal insulation value, low production energy and does not produce any waste and has no harm on human health.

2.3. Wood

Wood is an organic material with fibrous tissue derived from trees that are living organisms. It is one of the oldest building materials used by mankind from past to present. Early on, it was used depending on the skills and experiences of people, but in the following years, wood started to be applied in a scientific way in parallel with the advances in technology. It has a significant place among other building materials due to working securely against pushing, pulling, bending and cutting, its elasticity, easy processing and assembling (Sen and Yesilkaya, 2010). Wooden materials are used as load-bearing, coating, woodwork, panel insulation and mold elements in buildings. Moreover, it has a wide scope of application as a furniture element.

Looking at the Anatolian traditional buildings from past to present, we see wood in elements like windows, doors and roofs in building using **natural stone** and **adobe** as load-bearing material; and stone materials are used in the foundations of buildings utilizing **wood** as a load-bearing element. Thus, we can say that; different local architectures have come into being with a combination of **wood-stone** or **wood-adobe** materials (Kuban, 1995)



Figure 8. The Examples Of Traditional Architectural In Which Stone-Wood-Mudbrick Materials Used Together (Yaman, 2007)

Natural wooden materials are cut from trees that are renewable resources in forests and used after processing. A good balance should be provided between production and consumption and a proper forestry policy should be adopted to prevent the exhaustion of wood resources. Otherwise, we may face the risk of losing forests, and this in turn will bring natural environmental problems like erosion, air pollution and global warming.

Since wood undergoes very few processes during its processing, the required energy amount is low. But, the amount of wastes generated during its production is huge. Such wastes are utilized in the production of artificial woods like particle board and plywood, or it is used as a industrial fuel as chips and battens. The energy required by artificial woods produced out of natural wood wastes is high, besides such materials are not recyclable. Because of being produced by use of chemical substances, they contain matters injurious to human health.

Wooden material has no detrimental effect on human health in its natural form. Yet, it is weak against external forces (humidity, impacts, infestation etc.). Some additive materials are used

to eliminate this, and in this way wood becomes long-lasting and durable. But these additive materials are harmful to human health.

2.4. Brick

Mankind has shaped the soil in nature to use it in buildings and burned this clay soil and made it more durable. The first building material to be produced in this manner is brick. The difference between brick and adobe is that; brick is burned in fire, not sundried. Being an inevitable part of Seljuk and Ottoman architecture in Anatolia, brick is used both as a load-bearing element together with stone, and also as a facing with glazed tile. Sivas Gökmedrese and Konya İnce Minareli Medrese can be listed as the most distinct examples. But today, it is generally as the load-bearing element in buildings and the main component in dividing wall construction, and coating material in floors, walls and roofs.

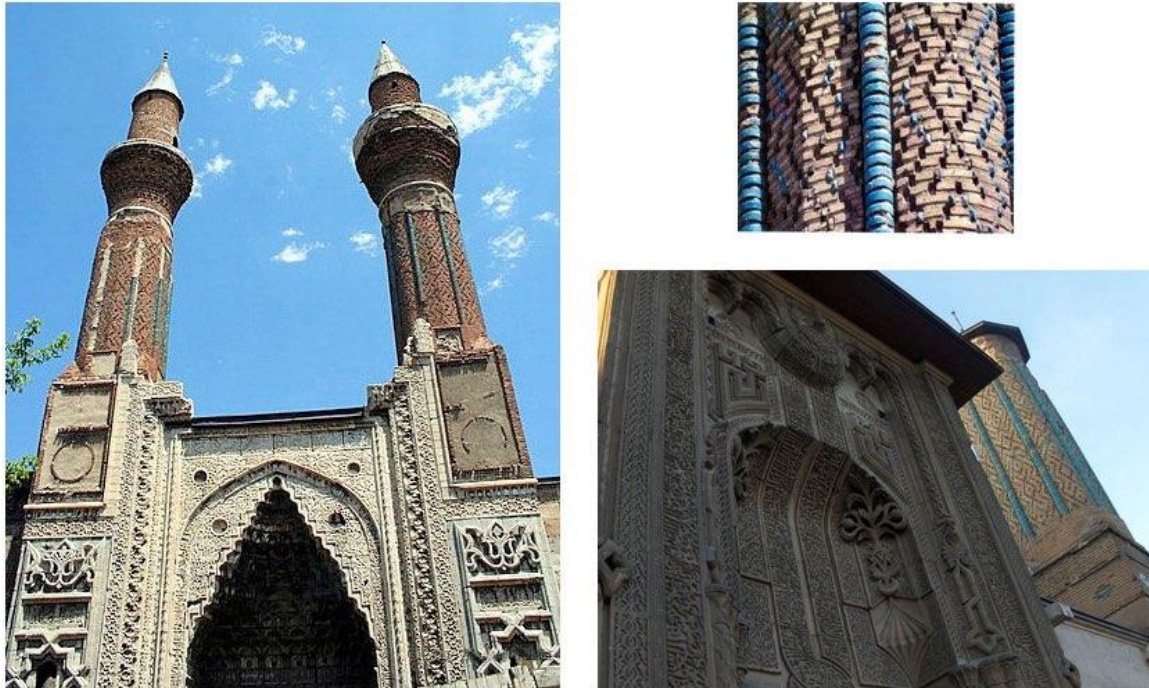


Figure 9. Sivas Gökmedrese and Konya İnce Minareli Medrese (URL-14)

As brick is made out of clay soil, derived from nature and has no chance of depletion, it could be described as a local material. Nevertheless, for it is produced by burning instead of sundrying, the energy amount required during production is higher compared to adobe materials. Because the wastes generated during the production and demolition of buildings can be reused for brick material production, it is recyclable material.

2.5. Concrete

Concrete is a hardening composite building material in plastic consistency at first, then becoming solid over time and taking the shape of molds that is obtained by homogeneously mixing cement, aggregate, water and additive materials if necessary at certain amounts. History of concrete goes a long way back like civilization history, and it is known to be used about 5000 years ago during the erection of Egyptian Pyramids in its most primitive and rough form. For Romans, concrete had a vital importance, and colosseums, monuments and road were built by using the primitive form of this material. Concrete in such buildings do not have tensile and impact strength. The building element formed as a result of strengthening concrete with reinforcement materials is known as **reinforced concrete**. Being one of the most important building materials of our century, concrete is one of the leading load-bearing structure

materials. It could be shaped relatively easier compared to other building materials. This ability is improved even more with additive material use and unique designs have seen the light of day.



(a) Restaurant Submarino - L' Oceanografic (b) Opera Hall of Valensia, Spain

Figure 10. The examples of individual designs of concrete buildings (a: URL-6),(b: URL-9)

One of the biggest problems during obtaining aggregate from the nature is disruption in topography. As a consequence, negative conditions like erosion, air and water pollution are formed. Environmental problems created during concrete production vary depending on the concrete production method. The rapidly increasing ready-mixed concrete production in the world and our country has superiorities in many aspects, but can create negative conditions in terms of environment unless required measures are taken. The most common problem in ready-mixed concrete production is water consumption and water pollution (Coskun and Esin, 2010).

One of the most significant factors of global warming that causes climatic changes is greenhouse gases. Harmful emissions generated as a result of fossil energy source consumption in particular are named as greenhouse gases. Since the energy requirements of concrete production are met by these resources, the resulting greenhouse gas emission level is considerably high. Especially during production of cement, one of the main component of cement, atmosphere-pollutant chemical substances are created as well as greenhouse gases. The negative influences of all these harmful substances disturb the natural balance and consequently human health.

High amounts of energy are consumed during concrete material production, raw material extraction, making them components, transporting, mixing and using them building sector. More energy requirement necessitates more fuel consumption and leads to environmental pollution. After the lifecycle of buildings, the resulting wastes are broken and used in various fields as filling materials (Tuglu, 2005).

2.6. Metal Materials

Metal materials can be divided into two parts as ferrous materials extracted from the nature as ores like steel, cast iron etc., and non-ferrous metals like copper, lead and aluminum. Alloys are produced by mixing two or more metals to attain several features. For example, steel is an alloy material composed of iron and carbon mixture.

Iron and **steel** are known as materials since ancient times. Early on, they were used only in weapon and utensil production since their production was limited. Later, their production broadly increased and they were first used as building material in bridges, and after increases in material quality, they started to be used in buildings. **Steel** is used in two forms as load-bearing system element and cladding element in buildings (URL-4) **Lead** is a soft and easily

malleable metal. It is used as a plate in buildings. Moreover, some paint materials contain high amounts of lead.

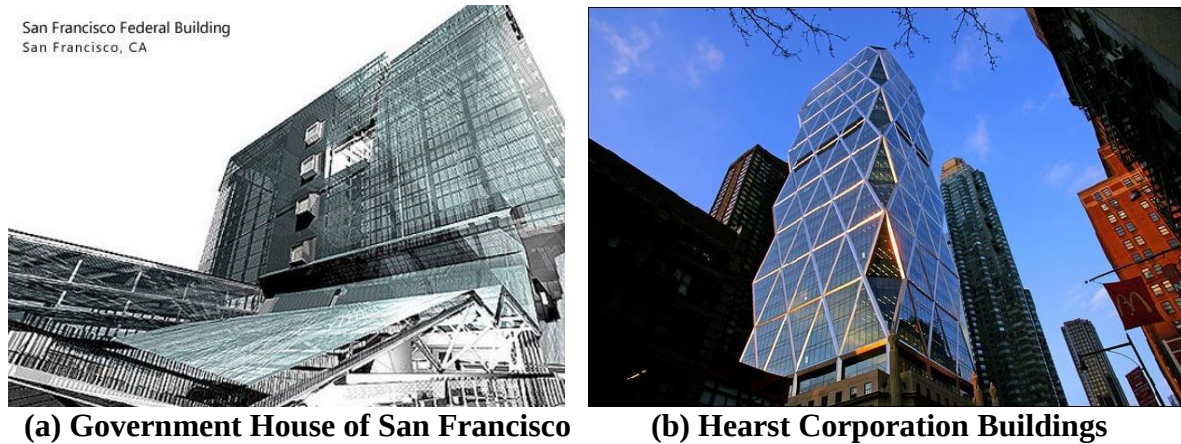


Figure 11. The Example Of Buildings Have Steel Structure (a: URL-7), (b: URL-7)

Metal ores are non-renewable resources. Turkey has various rich mine reserves thanks to its geological position. Therefore, it is one of the important countries in world mining in terms of underground resources. Negative conditions like loss of soil, air and water pollution happening while extracting mines from quarries disturb the natural balance. Similarly, carbon dioxide emission during mine processing and metal material production lead to an increase in air pollution, and increased water consumption brings with it unfavorable conditions like disturbance of ecological balance. Wastes produced after processing cause environmental and water pollution. Lead releases a toxic substance when exposed to high temperatures and this substance poses a threat to human health.

The energy amount used during mine extraction and metal material production is incredibly high. Moreover, steel is one of the highest energy containing materials. The most positive aspects of metal materials with respect to environment is their recyclability. For instance, 1/3 of the aluminum produced in the world is made out of recycled aluminum (Onat, 2004).

2.7. Glass

Glass is an inorganic based material mainly composed of silica (SiO_2) that becomes fluid in very high temperatures and solidifies when cooled. Since it is rapidly cooled during its production, it has an amorphous nature. This feature brings transparency and durability to glass (Unal, 2010). The first glass materials made by man were found in Egypt and Eastern Mesopotamia in about 3500 BC. After about 2000 years of the invention of glass, blow glass technique was invented and durable thin transparent plates could be produced for windows. With today's advancing technology, as a building material, glass offers an unlimited design freedom and authenticity to designers both technically and aesthetically.



**(a) 4UF A Cinema Center, Dresden, 1998
2010**



(b) Gimpo Art Center, South Korea,

Figure 12. Glass as a construction material providing individual design (a: URL-10),(b: URL-13)

Because the raw material used in glass production is derived from the nature, it could not be exhausted. From this aspect it is a local material. Like other nature-oriented materials, natural habitat is harmed during raw material extraction. Raw materials used for glass making are mixed and smelt at a high temperature. Then, the smelt glass is cooled to a certain temperature and shaped depending on the desired type of glass. The energy amount used in these processes is substantially high. Hence, it is unfavorable in terms of energy.

Glass material has no health damaging effect during its use. Depending on the type of glass systems used it may contribute to the energy saving ability of the building and serve as a sun-blind. After its lifecycle, it could be used again in glass making, i.e. it is recyclable, and this is positive aspect of glass (Onat, 2004).

3. CONCLUSION

According to sustainable architecture approach, people should get their needs to survive without harming the nature and in a way accommodating themselves to it. Therefore, in the production and use of buildings that satisfy the basic requirement of people, it is aimed to use scarce resources carefully, minimize their damages to the environment and reduce energy consumption. Environmental effects occurring during building constructions are attributable to building materials and production methods of these materials to a great extent.

In sustainable architecture approach, materials to be used in building design are expected to be local and renewable resource-based, low energy-consuming in their use, recyclable and not harming the nature and human health during their production and use. The duty of designers here is to pay attention to these features in material selection while taking public and environmental health into account.

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