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Tracing the Historical Development of Architecture in Cyprus and its Resilience to Seismic Hazards

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ABSTRACT

Cyprus is an island nation in the eastern Mediterranean Sea, with a rich and varied history of architecture. Located within a seismically active zone, Cyprus has experienced a number of earthquakes over the centuries, with some of them being particularly destructive. This initiative examines the evolution of architecture in Cyprus from 1489 to present, and how this evolution is related to seismic risk. Specifically, the work will register structural elements by time period, and analyze how these elements contribute to seismic response. Further it will explore the development of architecture in Cyprus, from the Venetians to the Ottoman Empire to the British Colonial period, the Greek-Cypriot period, and the modern era, and the structural elements of each time period. The paper describes how the structural elements of each time period affect seismic risk, and what modifications may be necessary in order to improve seismic risk in Cyprus. This paper will provide useful insight into the evolution of architecture in Cyprus and its effects on seismic risk.

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1. Introduction

Located in a seismically active region and situated on the boundary between the African and Eurasian tectonic plates, Cyprus has experienced several significant earthquakes throughout its history. The most notable seismic event occurred in 1953, registering a magnitude of 6.3 on the Richter scale, resulting in severe damage to buildings and infrastructure across the island. Additionally, several other earthquakes with magnitudes ranging from 4 to 5.5 on the Richter scale have transpired in the past. The susceptibility of Cyprus to seismic activity is further compounded by its high population density and a significant number of buildings constructed without adequate earthquake-resistant features. It is noteworthy that the architectural landscape in Cyprus has been influenced by numerous cultural, political, and economic factors spanning centuries, ranging from the Venetians, Ottoman period, British colonialism, and the contemporary era. One of the most significant periods in Cypriot history was the Venetian Empire's rule, which lasted from 1489 to 1570-71 [1]. The Venetians brought about a significant architectural legacy to the island, which can still be seen today. Following the Ottoman conquest of Cyprus in 1570-71 [2], the island's architecture underwent significant changes. Ottoman-style architecture became dominant, and the Ottomans introduced the use of brick, elaborate tile patterns, and the art of tile-making. Mosques, public baths, and other Ottoman buildings were built throughout the island during this period. During the British colonial period [3], which lasted from 1878 to 1960, the island's architecture once again underwent significant changes. The British introduced a new architectural style known as colonial architecture, characterized by large verandas, high ceilings, and the use of local stone. Many buildings constructed during this period, such as the St. John's Cathedral in Nicosia, reflect this style. In the post-independence period, starting from 1960 [4], there was a resurgence of interest in traditional Cypriot architecture, particularly in rural areas. Traditional stone-built houses with red-tiled roofs and wooden shutters became popular, and many historic buildings were restored and repurposed as museums, cultural centers, and restaurants. Following the Turkish invasion of Cyprus in 1974 [5], there was a large influx of refugees from the north to the southern part of the island, which led to the development of informal settlements to house the displaced population. These settlements were often made up of casual structures, which were constructed quickly and with limited resources. After the 1980, there was a construction boom on the island, with many modernist buildings constructed in cities and tourist areas. These buildings featured modern materials such as concrete and glass and were often characterized by their sharp angles and minimalist designs. In recent years, there has been a growing interest in preserving the traditional architecture of Cyprus. Many historic buildings have been restored, and traditional building methods and materials are being used once again. This has led to a renewed appreciation for the island's cultural heritage and a growing interest in sustainable and eco-friendly building practices. This study aims to explore and document the aforementioned styles and periods, highlighting the unique features of each and how they have contributed to the island's architectural diversity. Furthermore, this research will focus on the structural elements of the various architectural styles that have helped Cyprus's structures resist the destructive effects of earthquakes. The island is located in an area of high seismic activity, and as a result, its architectural heritage has faced numerous challenges from natural disasters. Through this research, we will examine the different techniques and materials used in constructing these monuments and how they have contributed to their durability and longevity.

The importance of this research lies not only in preserving and promoting the island's cultural heritage but also in providing valuable insights into the evolution of architecture in Cyprus and the broader Mediterranean region. By documenting the architectural styles and structural elements that have characterized Cyprus over the centuries, this research aims to contribute to a greater understanding of the island's past and its role in shaping the cultural landscape of the region. Additionally, the study aims to expand the limited literature available on this topic. It is hoped that this research will serve as a valuable resource for scholars, architects, and cultural heritage professionals interested in the architectural history of Cyprus.

2. History

Venetian architecture in Cyprus during the 15th and 16th centuries reflected the influence of the Venetians which controlled the island as a colony during this period [6]. The Venetians introduced new building techniques, materials, and architectural styles that blended Venetian and Gothic elements. One of the key structural elements in Venetian architecture in Cyprus was the use of limestone [7], which was readily available on the island.

Limestone was used to construct many buildings, including churches, forts, and palaces. The use of limestone provided a durable and weather-resistant material that could withstand the island's harsh climate and salty sea air. Venetian architecture in Cyprus also featured elements such as Gothic arches, columns, and ornate decorations. These elements reflected the influence of Venetian Gothic architecture, which was popular in Venice during the 15th and 16th centuries. Many buildings constructed during this period, such as the Church of St. Nicholas in Famagusta, reflect this blend of styles. The Venetians also introduced new building techniques, such as the use of timber trusses in roofing construction. Timber trusses allowed for wider spans and greater interior space in buildings, without the need for interior columns. This technique was used in many Venetian-style buildings in Cyprus, such as the Venetian Palace in Nicosia. Seismic codes were not a significant consideration in Venetian architecture in Cyprus during this period, as the technology and understanding of seismic activity were limited. However, the use of limestone and timber trusses in construction provided some degree of seismic resistance, as limestone is a relatively flexible material that can withstand ground movements, and timber trusses are able to flex and absorb some degree of seismic (kinetic) energy.

After the end of the Venetian Empire, the Ottomans followed. The Ottoman Empire had a significant influence on the architecture of Cyprus during their rule, which lasted from 1571 to 1878 [8]. Ottoman architecture is characterized by a blend of traditional Islamic, Byzantine, and Persian styles. Many of the structures built during this period were designed with safety considerations in mind, such as earthquakes, which are common in the region. Ottoman architecture in Cyprus typically features thick masonry walls, which are reinforced with wooden ring beams to increase stability and support heavy roofs. The use of arches and domes is also a common feature of Ottoman architecture in Cyprus, which helps to distribute weight and minimize stress on walls. Another characteristic of Ottoman architecture in Cyprus is the use of minarets, which are tall, slender towers typically found adjacent to mosques. The Ottomans were well aware of the earthquake-prone nature of the region and incorporated several features to mitigate the effects of seismic activity in their architectural designs. Ottoman architects in Cyprus often used wooden elements, such as roof structures and flooring that could absorb the impact of earthquakes and prevent buildings from collapsing. Another feature of Ottoman architecture in Cyprus that helped reducing the damage from earthquakes was the use of flexible joints, such as timber dowels, to connect walls and floors, allowing for movement without causing structural damage. Additionally, the Ottomans were known to use decorative features, such as stone carving and tile work, to strengthen walls and add extra support to buildings.

At the end of the 19th century the British rule the island. The British Empire architecture in Cyprus is characterized by a blend of architectural styles that reflect the influences of the British colonial period and the local Cypriot culture [9]. The architecture of this period can be divided into three main phases: The Early Colonial Period (1878-1914), the Interwar Period (1919-1939), and the Late Colonial Period (1940-1960). During the Early Colonial Period, the British built many public buildings. These buildings were designed in the neo-classical style, with grand entrances, columned porticos, and ornate cornices. Many of these buildings were constructed using local limestone and featured deep, shaded verandas to provide relief from the hot Mediterranean sun. In the Interwar Period, there was a shift towards a more functional and modernist style of architecture, which reflected the changing needs of the British administration in Cyprus. During the Late Colonial Period, there was a return to a more traditional style of architecture, which was influenced by the emerging nationalist movement in Cyprus. Buildings constructed during this period often featured elements of Cypriot vernacular architecture, such as the use of local stone and the incorporation of traditional arches and domes. The structural elements of the British Empire architecture in Cyprus were influenced by the prevailing building practices in Britain at the time, as well as by the local building traditions of Cyprus [10]. The buildings constructed during this period typically had load-bearing masonry structures, with brick or stone walls supporting the floors and roof. The walls of these buildings were typically thick and had deep window and door openings, which provided shade and ventilation. The thickness of the walls also helped to provide good thermal insulation. Roofs were typically flat and made of reinforced concrete or timber joists covered with tiles. In some cases, the roofs were supported by arches or vaults, which helped to distribute the weight of the roof evenly and reduce the load on the walls. The floors of these buildings were often constructed of timber or reinforced concrete, depending on the size and use of the building. The floors were typically supported by timber or steel beams, which were supported by the walls or columns.

The architecture in Cyprus from 1960 to 1974 reflects a period of rapid development and modernization following the country's independence from British colonial rule in 1960 [11]. During this period, Cyprus experienced a significant population growth, urbanization, and a boom in the construction industry. During this period, the main structural material used in Cyprus was reinforced concrete, which was popular due to its strength, durability, and ability to be easily molded into various shapes. Structural elements such as beams, columns, and slabs were commonly used in building construction, and their size and design were determined by the load-bearing capacity required for each building. In terms of seismic codes, Cyprus did not have a national seismic code during this period. However, building regulations required that structures be designed to withstand the potential effects of earthquakes, given the island's location in a seismically active region. Building codes were primarily based on European standards, with some local modifications to account for regional seismic hazards. In practice, however, it is worth noting that some buildings constructed during this period did not meet modern seismic standards and were vulnerable to earthquake damage. This was due, in part, to the fact that seismic design was not yet fully understood, and in part to a lack of enforcement of existing regulations. The class of concrete used during the period from 1960 to 1974 in Cyprus was predominantly C20/25 for the principal structural members as columns and beams while C12/16 was used for structural members as floor slabs and foundation footings. During the same period the most common class of steel used in construction in Cyprus was likely mild steel [12], also known as low carbon steel or plain carbon steel. This type of steel is commonly used in construction due to its affordability and ease of use. Mild steel has a low carbon content and contains other elements such as manganese, silicon, and sulfur. It is relatively soft and ductile, making it easy to form into different shapes and sizes for use in construction. Mild steel reinforcement has characteristic yield strength of 250 N/mm^2.

Following the Turkish invasion in 1974, there was a large population movement as refugees moved from the north to the southern part of the island which led to the development of low-quality settlements to house the displaced population. These settlements were often made up of casual structures, which were constructed quickly and with limited resources. These settlements varied in size and scope, from small encampments to large, sprawling communities. The construction of the casual structures in these settlements was often haphazard, with little attention paid to building codes or safety standards. Poor quality materials such as corrugated metal, plywood, and low classed of concrete were commonly used, while buildings were often constructed without proper foundations or structural support. This lack of oversight and quality control was particularly evident in buildings constructed in the rural and suburban areas of Cyprus, where construction standards were often lower than in the major urban centers. As a result, many buildings constructed during this period were vulnerable to structural problems such as cracking, settling, and collapse. This was particularly evident during earthquakes, which exposed the weaknesses in many buildings and resulted in significant damage and loss of life.

The period from 1994 until now has been marked by continued development and modernization in Cyprus, with a focus on improving the quality and safety of buildings and infrastructure. The first seismic code in Cyprus was introduced in 1994. This code was later updated in 2004 to further improve earthquake-resistant design and construction. Cyprus adopted the Eurocode 8 (EC8) seismic design standard in 2012. Eurocode 8 is a European standard that provides guidelines for the seismic design of structures and is recognized as one of the most comprehensive and advanced standards for seismic design worldwide. The adoption of Eurocode 8 in Cyprus further improved the seismic safety of buildings in the country and brought Cyprus in line with the seismic design practices used across the European Union. One commonly used concrete class after 1994 was C25/30, which has a compressive strength of 25 MPa or 30 MPa of a cylindrical or cubic test specimen at 28 days and a tensile strength of approximately 3 MPa. This class of concrete is stronger and more durable than the lower strength classes of concrete that were commonly used in construction prior to the introduction of the new seismic codes. Other higher strength classes of concrete, such as C30/37, C35/45, and C40/50, have also been used in construction projects in Cyprus after 1994, particularly in areas with a high risk of seismic activity. After the introduction of the new seismic codes in 1994, in Cyprus, rebars with higher yield strengths and greater ductility have become more common since 1994. The most commonly used steel class for rebars in Cyprus is Fe 500, which has a yield strength of 500 MPa. Fe 500 is considered to be a high strength rebar and is used in construction projects where the structures are designed to withstand significant seismic activity.

3. Architectural Features

Over the years, the architectural features of each nation or era changed and new ones were introduced. This phenomenon can be observed very clearly in Cyprus, where it was occupied by different nations and each of them left its influence. Each of these features was not only aesthetically pleasing, but also played an important role in the survival of the building over the years.

One of the most important periods in Cypriot history was the rule of the Venetian Empire, which lasted from 1489 to 1570-71 [13]. At that time, structural elements such as arches, columns and trusses were introduced as the main components of buildings. Arches are curved elements that are often used in construction to distribute forces. When a load is applied to an arch it is distributed along the axis of the arch and transferred to the supports at either end. The stresses are highest at the point where the arch meets the supports and gradually decrease towards the center of the arch. The shape of the arch also plays a role in the distribution of forces and stresses. Arches with a steeper curve provide a larger vertical component and therefore transmit greater compressive force on the supporting columns. Designing and analyzing the vertical supports is a complex task that requires careful consideration of the thrust lines. When dealing with simple symmetrical loads, the thrust line of the arch is typically located at the center of the arch. However, when the loads are non-symmetrical, the vertical supports must be able to withstand the horizontal shear force generated by the arch. One possible solution to this problem is to make the vertical supports massive enough to absorb the thrust and transmit it to the foundation, similar to the buttresses used in Roman triumphal arches. Another solution is to add additional vertical loads to generate compressive forces, e.g., the weight of pinnacles of a Gothic cathedral, to shift the trust vector downwards than sideways. In all cases, tension elements like tension rods are necessary to support the horizontal forces. In addition to distributing the weight, arches provide lateral support, resisting horizontal forces such as wind or earthquakes. This lateral support is mostly due to the massive vertical elements but also the arches which hold the columns in place and contribute to the collective response of the whole structure.

Trusses, another feature of Venetian architecture, typically consist of a series of triangles, which are able to distribute loads and stresses efficiently. The size and organization of the triangles depend on the span of the truss, as well as the load that the truss is required to support. The connections between truss members are typically designed as pins which do not allow moments to transfer through the joints and therefore the members do not experience any bending stresses. Instead, the loads applied to the truss are transmitted through the members, enabling the whole section, as axial forces, which produce tensile or compressive stresses in the members. Another way that horizontal forces are distributed through a truss is through the top and bottom chords. The chords are typically the longest members in the truss and can resist both tensile and compressive forces. When a horizontal force is applied to the truss, the top and bottom chords transfer the force to the supports.

Columns are important elements resisting seismic forces, as they provide vertical support and transfer forces from the roof or upper floors to the foundation. The design of columns for seismic resistance depends on a number of factors, including the seismic hazard of the site, the size and shape of the building, and the type of materials used.

After the Venetians the baton was passed to the Ottomans who remained on the island until the end of the 19th century [14]. Structural elements such as thick masonry walls, beams and domes were introduced into the local culture and architecture. Thick masonry walls can be effective at resisting horizontal forces, such as those caused by wind or seismic activity. One of the primary ways that thick masonry walls resist horizontal forces is through their weight and mass. The weight of the wall helps to resist the force of the wind or earthquake, while the mass of the wall helps to absorb and dissipate the energy of the force. Another way that masonry walls resist horizontal forces is through their stiffness. The stiffness of a wall can be increased by adding reinforcing elements, such as steel bars or wire mesh, or by using masonry units with higher compressive strengths. The reinforcing elements help to distribute the force more evenly throughout the wall, while the stronger masonry units are better able to resist the compressive forces. The connection of the wall to the foundation and surrounding structure is important for resisting horizontal forces. The wall should be properly anchored to the foundation and should be designed to transfer forces to the foundation and surrounding structure without causing damage.

One of the primary challenges in designing domes for seismic resistance is the distribution of forces. During an earthquake, the ground can move in multiple directions, causing horizontal and vertical forces to act on the dome. As a result, the dome must be designed to distribute these forces effectively throughout the structure. One approach to distributing seismic forces in dome structures is to use a system of tension and compression members. The dome can be designed as a series of interconnected arches, with the weight of the structure distributed through a system of cables, chains, or other tension members. This approach can help to evenly distribute the seismic forces throughout the structure, reducing the risk of localized failure. Another approach to designing domes for seismic resistance is to use reinforced concrete or other high-strength materials. These materials can be used to create a monolithic dome, which is a single, continuous structure that is able to resist seismic forces. The design of the dome [15] will need to take into account the seismic hazard of the site, as well as any additional requirements for insulation or waterproofing.

At the end of the 19th century Cyprus was ruled by the British and remained under their occupation until the middle of the 20th century. This period was differentiated by the creation of new materials such as concrete which was used as the main building material and in combination with steel created a combination of time and earthquake resistant structures [16]. Roofs, slabs, and beams provide diaphragmatic behavior maintaining a “box like” system. Diaphragms form a rigid plane or surface ensuring that the structural elements are connected together, transfer in-plane forces and distribute them evenly throughout the structure during a seismic event. The stiffness and strength of the diaphragm depends on a number of factors, including the size and spacing of the supporting beams, the thickness and strength of the slab or roof, and the connection details. The diaphragm must also be designed to transfer forces to the lateral force-resisting system, such as shear walls or moment frames, without causing damage to the structure.

Steel reinforcement is used in concrete columns to improve their resistance to seismic forces. Reinforcement is typically in the form of steel bars or wire mesh, which is embedded in the concrete to increase its tensile strength and ductility. Ductility refers to the ability of a material to deform without fracturing. Steel bars are typically designed to yield before the concrete in the column, allowing the column to deform and absorb energy during an earthquake. This helps to improve the overall seismic performance of the structure by reducing the risk of localized failure and improving the overall ductility of the column.

The use of steel structures in Cyprus can be traced back to 1980 after the country experienced significant economic growth, which resulted to the need for new infrastructure and buildings. Steel is highly ductile, which means it can undergo significant deformations before it fails. This kind of structure is typically lighter in weight than other materials, such as concrete. This means that seismic loads which are a function of mass, have less impact on steel structures, and the structures deform without collapsing. Steel structures can be designed with special connections that allow them to move and deform during a seismic event, without compromising the integrity of the structure. Structures of steel can be designed to meet the specific seismic hazard of a given location, using a variety of techniques such as bracing, moment-resisting frames, and base isolation.

4. Signature Buildings of Each Period

4.1. Venetian Walls of Nicosia

The Venetian Walls of Nicosia (Fig. **1**) are a series of defensive walls that surround the old city of Nicosia, the capital of Cyprus. The walls are considered to be one of the finest examples of Renaissance military architecture in the Eastern Mediterranean region. The Venetian Walls of Nicosia are characterized by their imposing size and strength. The walls are up to 20 meters high and are made of stone, with bastions and towers strategically placed along their length. The walls are almost 5 kilometers long and have three gates: the Paphos Gate in the west, the Famagusta Gate in the east, and the Kyrenia Gate in the north. The walls are built in a polygonal shape, following the contours of the ground. This means that the walls have a series of angles and bends, which makes it more difficult for attackers to approach them directly. The walls are also reinforced with various defensive features, such as moats, glacis, and ravelins, which further strengthen their defensive capabilities.

Figure 1: The Venetian Walls of Nicosia (source, A. Savin own work).

4.2. Larnaca Castle

Larnaca's Castle (Fig. **2**), also known as Larnaca Fort, is a medieval castle located on the southern coast of Cyprus [17]. The castle is characterized by its sturdy, rectangular structure, which is built from limestone blocks. The walls of the castle are up to 2.5 meters thick, and the entire structure is surrounded by a moat, which was once filled with sea water. The castle has two floors, with a central courtyard that is surrounded by various rooms and halls.

Figure 2: Larnaca Castle [17].

4.3. Church of St. Nicholas in Famagusta

The Church of St. Nicholas (Fig. **3**) is a medieval church located in Famagusta, a historic city on the eastern coast of Cyprus [18]. The church was built in the 14th century and is considered to be one of the finest examples of Gothic architecture on the island. The church is characterized by its tall, slender proportions and its intricate decorative features. The exterior of the church is built from local limestone blocks and is decorated with a variety of Gothic motifs, including pointed arches, tracery, and quatrefoil shapes. One of the most distinctive features of the Church of St. Nicholas is its bell tower, which is located at the front of the church. The bell tower is octagonal in shape and is topped with a pointed spire. The tower is decorated with a variety of ornate carvings and has several openings for the bells.

Figure 3: Church of St. Nicholas in Famagusta [18].

4.4. Hala Sultan Tekke, Larnaca

Hala Sultan Tekke (Fig. **4**) is a historic mosque located in the city of Larnaca, Cyprus [19]. The mosque is built on the west bank of Larnaca Salt Lake and is considered one of the most important holy places in the Islamic world. The mosque is built on a rectangular foundation made of local stone and its walls are made of thick stone blocks and have no windows. This is because Islamic tradition prohibits the depiction of living beings in religious buildings. The building has a central dome, which is larger than the four smaller domes located at each corner of the building. The domes are made of brick and covered with red tiles. The interior of the mosque is supported by columns made of stone. The columns are arranged in a square pattern around the central dome. The mosque has a large rectangular courtyard, which is surrounded by a low wall. The courtyard is paved with stones and is used for prayer and other religious activities.

Figure 4: The mosque has a large rectangular courtyard, which is surrounded by a low wall. The courtyard is paved with stones and is used for prayer and other religious activities [19].

4.5. Hamam Omerye, Nicosia

Hamam Omerye (Fig. **5**) is a historical public bathhouse located in the old city of Nicosia, Cyprus [20]. It was built during the Ottoman era in the 16th century and has since been renovated and restored multiple times. The hamam has many structural characteristics that are unique and distinctive. It is primarily constructed of stone masonry, which is a durable and sturdy building material. The Hamam Omerye has several barrel-vaulted ceilings, which are created by curving a series of arches. The barrel-vaulted ceilings provide structural support and help distribute the weight of the building. The roof is supported by timber roof trusses, which are triangular-shaped structures, made of wood. The timber roof trusses help distribute the weight of the roof and provide structural stability. The walls are reinforced with buttresses, which are projecting support structures that help distribute the weight of the walls and the roof. The Hamam Omerye has several stone columns that support the vaulted ceilings. The columns are constructed of stone blocks, which are stacked on top of one another and held together with mortar. It has several arched openings, which are created by curving a series of stones or bricks. The arched openings help distribute the weight of the walls and provide structural stability and inside it has an underground cistern that collects rainwater. The cistern is constructed of stone and is reinforced with arches and buttresses.

Figure 5: Hamam Omerye, Nicosia (source, A. Savin own work).

4.6. Kamares Aqueduct, Larnaka

The Kamares Aqueduct, also known as the Bekir Pasha Aqueduct (Fig. **6**), is a historic structure in Larnaca, Cyprus that was built in the 18th century [21]. It was designed to bring water to the city from a nearby spring and is considered a remarkable engineering feat of the time. The aqueduct is constructed of a series of arches, which are curved structures that support the weight of the aqueduct and distribute the water flow evenly. The arches are constructed of brick and are arranged in a linear pattern. The arches are supported by cut-stone piers, which are vertical columns of stone that provide structural support and stability. The piers are spaced evenly along the length of the aqueduct and are constructed of the same type of stone as the arches. The arches and piers are held together with mortar, which is a type of cement that is used to bond the bricks and stones together. The aqueduct features a stone channel that runs along the top of the arches. This channel was designed to carry the water from the spring to the city and is wide enough to allow for easy maintenance and repair. The aqueduct has a stone parapet, which is a low wall that runs along the top of the arches. The parapet is designed to provide additional stability to the aqueduct and to prevent people from falling off the structure. At the end of the aqueduct, there is a water basin that was used to collect the water from the spring. The basin is constructed of stone and is designed to hold a large volume of water.

Figure 6: Kamares Aqueduct, Larnaka (source, A. Savin own work).

4.7. St. Paul's Anglican Cathedral, Nicosia

The cathedral was designed by the British architect William Henry Woodrow and built between 1882 and 1893, during the period of British colonial rule in Cyprus [22]. The design of the church reflects the neo-Gothic style that was popular in Britain at the time, with pointed arches, stained glass windows, and a vaulted ceiling. St. Paul's Anglican Cathedral (Fig. **7**) in Nicosia was built using a combination of traditional and modern construction techniques. The walls of the cathedral are constructed using load-bearing masonry, which provides stability and support for the roof and other structural elements. The walls are made of local limestone and are several feet thick in some places. The roof of the cathedral is supported by a timber structure, consisting of large timber trusses and purlins. The roof structure is designed to provide strength and stability to the roof, while also allowing for some flexibility to accommodate movement during earthquakes. The interior of the cathedral features a high vaulted ceiling, which is supported by stone arches and ribbed vaults. The vaulted ceiling provides additional strength and stability to the roof structure, while also creating a sense of grandeur and space within the interior. The cathedral's foundation is constructed using reinforced concrete, which provides additional strength and stability to the building. The foundation is designed to resist the forces of earthquakes and other natural disasters.

Figure 7: St. Paul's Anglican Cathedral, Nicosia [22].

4.8. Municipal Art Gallery and Museum of Paleontology, Larnaca

The Municipal Art Gallery and Museum of Paleontology (Fig. **8**) is a historic building located in the city of Larnaca, Cyprus. The building was constructed around 1881 during the period of British colonial rule and was originally used as a government building [23]. The aforementioned, it is a masonry building, which means its structural elements are made primarily of stone and brick. The load-bearing masonry walls are the most significant structural element of the building, providing support and stability to the floors and roof. The exterior walls are constructed of local limestone, which is a durable and commonly used material in Cyprus. The walls are several feet thick in some places and are designed to resist lateral loads and provide structural stability. The roof of the building is a traditional pitched roof, covered with terracotta tiles laid in a herringbone pattern which is supported by timber trusses, which span between the load-bearing walls. Inside the building, the most significant structural element is the central staircase, which is made of marble and features decorative detailing. The staircase is supported by load-bearing walls and reinforced with steel elements to provide additional stability.

Figure 8: Municipal Art Gallery and Museum of Paleontology, Larnaca [23].

4.9. The District Administration Offices, Limassol

The District Administration Offices in Limassol (Fig. **9**) is a mid-century modernist building constructed in the 1960s [24]. The building's structural elements are primarily made of reinforced concrete, which was a popular construction material during the period of its construction. The building's structural design features a series of concrete columns and beams that support the floors and roof. The columns are arranged in a regular grid, creating a rhythm that is consistent throughout the building. The building's floor slabs are made of precast concrete panels that are supported by the concrete beams. The roof of the building is flat and is supported by a series of concrete beams, which span between the columns. The roof is covered with a waterproof membrane, which helps to protect the building from the elements. The District Administration Offices in Limassol are a prime example of mid-century modernist architecture, with a focus on functionality, efficiency, and simplicity. The building's use of reinforced concrete and precast concrete panels allowed for fast and efficient construction.

4.10. Residential Refugee Houses

The residential refugee houses in Cyprus (Fig. **10**) in 1974 were characterized by their makeshift nature and lack of amenities. They were typically organized into small rooms or cubicles that were partitioned off using plywood or other materials. This type of building was usually constructed with walls that supported the weight of the roof and upper floors and rarely from columns and beams of low-strength concrete.

Figure 9: Administration Offices, Limassol [24].

Figure 10: Typical residential refugee house (source, G. Xekalakis own work).

4.11. One, Limassol

The "One" is a high-rise building in Limassol (Fig. **11**), Cyprus that was completed in 2021. It has a height of around 170 meters, which makes one of the tallest buildings in Cyprus and one of the tallest buildings in the eastern Mediterranean region. The One has a reinforced concrete structure, with a combination of concrete columns, beams, slabs, and a raft foundation with piles because of its position close to the Limassol's coast providing support and stability.

4.12. The Oval, Limassol

The Limassol Oval is a high-rise building in Limassol (Fig. **12**), Cyprus, which was completed in 2013 [26]. It has a height of around 80 meters and 16 floors. The Limassol Oval is notable for its distinctive elliptical shape, which gives the building a sleek and modern appearance.

Figure 11: One, Limassol [25].

Figure 12: The Oval, Limassol [26].

4.13. 360 Nicosia

The 360 Nicosia Tower (Fig. **13**) is located in Nicosia [27]. With a height of 135 meters and 34 floors, it is one of the tallest buildings in Cyprus. All the above three structures have been constructed using reinforced concrete and they have been designed to meet the relevant building codes and standards, including the seismic design requirements of Eurocode 8.

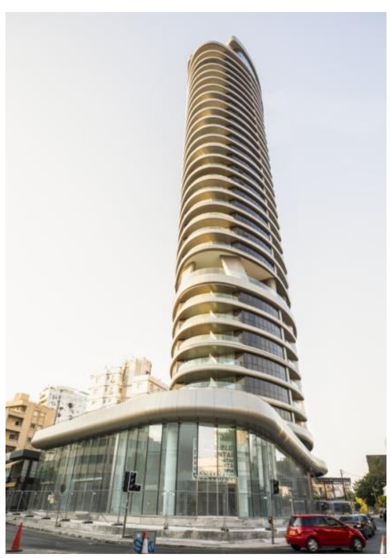

Figure 13: 360 Nicosia [28].

5. Conclusion

The history of architecture in Cyprus is a testament to the island's rich cultural heritage and the various influences that have shaped its built environment over the centuries. From traditional Venetian and local architectural styles to modern construction techniques, Cyprus has undergone significant changes in its architecture, reflecting the island's historical, social, and cultural development. However, seismic design considerations have not always been a significant factor in the construction of buildings, and many structures have been lost to earthquakes over the years. The devastating earthquakes from which the island has suffered brought attention to the need for seismic-resistant construction and introduced new building codes and regulations to improve the safety of buildings on the island. Today, modern structures in Cyprus are designed to withstand earthquakes, and efforts are being made to preserve historic buildings and incorporate seismic-resistant features into older structures. The history of architecture in Cyprus is an ongoing story that reflects the island's past, present, and future aspirations.

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