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Table of Contents

In memoriam - Prof. Dr Dzafer Kudumovic

It is with great sorrow that we remember **Prof. Dr. Dzafer Kudumovic,** who left us recently.

His life and achievements were great, but through it all he maintained a sense of simplicity.

He was born in 1949 in Banovici. Growing up on the banks of the Krivaja river, he dreamed about his future. Starting from his student days with his homework written on the board and some notebooks in his hands, he became a respected professor in the field of mechanical engineering, with particularly mastery in the field of welding techniques.

He studied in Croatia at the universities of Rijeka and Zagreb, earning his MSci degree at University of Zagreb in 1989 and doctorate in 1993 at the University of Rijeka. Before the outbreak of the war (1992-95) in Bosnia he was a manager of one of the preeminent structural engineering firms in ex-Yugoslavia and oversaw the construction of a number of key bridges in Bosnia connecting the main roads of the country from north to south. Under his management, the company worked internationally as well, overseeing the framing system for several big projects abroad (Austria, Czech Republic, Russia).

During this period, he gained rich practical knowledge and experience and also served as a Mayor of Banovici municipality in 1989-91.

In 1990, he started his academic career at the University of Tuzla, becoming a full professor in 2005. He was also a professor in the Faculty of Transport and Communication at University of Sarajevo, and a guest professor at the universities of Mostar, Bihac, Zenica, Novi Pazar (Serbia) and Ljubljana (Slovenia).

He was author of many books, including Science of Strength of materials, Materials I and II, Welding, Basics on technology of railway transport etc., and many scientific papers. His vision enhanced the academic life of the Balkan region. In 2001, he was awarded for innovation in Brussels and Nurnberg for the self-acting water pump Klipna pumpa RC-2000 (Piston Pump). In 2006, he established the TTEM journal, which he managed during his lifetime. In 2007, he was awarded by the special recognition in Republic of Slovenia for multilateral work dedicated to welding techniques and for his contribution to economic progress.

He was a beekeeper and he also loved sport. He played football during his student years and this helped him make strong friendships and overcome the challenges of being a student far from home.

In 1984, he received special recognition for his contribution in organisation of the Winter Olympic Games in Sarajevo.

Once, a professor told him:

"Kudumovic, I am sure you will become something important in your life, but never change, keep your spirit and never cause others to suffer by your decisions".

He mentioned these words several times, it was important to him, and thus anyone who knew him informed his attitudes and his approach to life and work. Also, this is why so many of his ex-students became his friends.

He lived a simple life, enjoyed being with people of every nation and religion, and had a great circle of family and friends. No matter how much life made him busy, he took joy in his family, as a great husband and father to his two daughters.

His passing is a great loss for all of us,

We will always miss him

May God have mercy on him.

Editorial

The contribution of three medieval monuments to contemporary urban fabric in Istanbul and their current problems of conservation

Mine Esmer

Fatih Sultan Mehmet Vakif University, Istanbul, Turkey.

Abstract

In Middle Ages, Constantinople had been through changes in its social structure and public construction was limited to small-scale churches, and defense structures. A new plan type in church architecture initiated with two examples that were built for Byzantine Emperor Basil I at the Great Palace and could not survive till today. In this article, Kilise Camii, Atik Mustafa Pasa Camii, and Fethiye Camii, constructed between 843-1204, with variations of the newly emerged plan type, were handled with their physical and social environments. These monuments enable us to comprehend the construction techniques, aesthetic values, architecture, and social milieu of the Middle Ages in the Byzantine capital.

Key words: *Byzantine architecture, Istanbul, medieval structures, heritage preservation, urban landscape*.

1. Introduction

The social structure of the society in Constantinople changed from Late Antique Period to the Medieval Era. In the 4th-6th centuries, in Constantinople private activities within the society replaced the public events held in urban open-spaces. Therefore, by the 7th century, the construction of public buildings was limited to small churches, and defense structures. A new plan type emerged in religious architecture during this period that according to scholars initiated with two churches built by Emperor Basil I within the Great Palace [1]. However, none of the two structures (Nea and Theotokos Churches) could survive to the present day. Within the scope of this article, three structures representative of Middle Byzantine churches, namely Vefa Kilise, Atik Mustafa Pasa, and Fethiye (Pammakaristos Monastery Church) will be examined together with their physical environments and social milieu. These structures built initially between 843-1204 present various variations of the above-mentioned plan type in Constantinople, the center of all economic, social, and architectural developments as the capital. These three monuments have survived to the present after numerous repairs that culminated in various changes to their original structures.

From the initial names of these three buildings, only one, the Pammakaristos Monastery Church (Fethiye Camii) is known. The arguments on the names of the other two have not yet been clearly identified. After the conquest of the city by the Ottomans, the decrease in population caused Sultan Mehmed II (1451-1481) to initiate forced migration from Anatolia and the Balkans to revive his new capital [2]. Although the Greek population of the city increased with this practice of Mehmed II, the previous residents, as well as the names of the streets and monuments, changed along with the newcomers [3]. As a result, a serious fracture occurred in the continuation of the traditions, and customs inherited from father to son. Accordingly, the original names of monuments that did not bear an inscription, mosaic, fresco which identifies them, could not survive.

2. Kilise Camii at Vefa

The Kilise Camii is in the Fatih District of Istanbul, at the Vefa Neighborhood within the Suleymaniye Urban Area, on the western slope of the third hill of the historical peninsula. Its location was in the Xth region of the Byzantine arrangement of Constantinople. The existing parts of the Kilise Camii date to four different building phases. The three naved naos and narthex date to the 11th century. The northern and southern annexes should be additions after the Latin occupation [4]. The exonarthex was built around 1320 [5]. Mango claimed that the Kilise Camii was the *katholikon*

(main church) of one of the three monasteries established in the 14th and 15th centuries at the Vefa neighborhood [6]. The four cisterns near the building also support this view of being part of a former monastery (Figure 1). It is certain that the cistern 30 meters west of the Kilise Camii, is certainly related to Kilise Camii and the monastery it was part of. An illegal building, which today hosts Bilim Sanat Foundation, was built in the 1960s on this cistern and partially destroyed the western wall of the cistern. One can arrive at another cistern by passing through a barrel-vaulted tunnel from a work-shop located on Muskule Sokak, southwest of the Kilise Camii. Another cistern to the south of the Kilise Camii that still collects water on rainy days is present in the courtyard of the Faculty of Foreign Languages of Istanbul University. The fourth cistern on Muller-Wiener's map to the north of the Kilise Camii could not be found. Whether its entrance was not visible or Muller-Wiener was mistaken for its location.

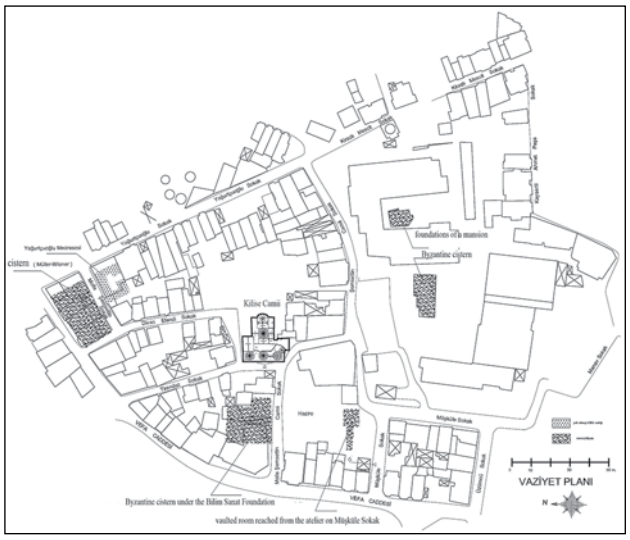

Figure 1. The presence of four cisterns near the Kilise Camii supports the view that the structure was the main church of one of the three monasteries established in the 14th and 15th centuries at Vefa (Esmer, 2012).

Kilise Camii was converted into a mosque in 1484 by Molla Gurani, one of the mentors and educators of Mehmed II (1451-1481). As a result of this change of function, one of the windows in the main apse was closed to place a mihrab niche and a minaret was added to the southwest corner, and its *iconostasis* (templon) was removed. Probably, the spoliated pieces used in its minaret may belong to the removed *iconostasis*. The building is rich in spoliated building materials. Particularly the outer narthex that dates back approximately 1320, has spoliated columns, capitals, bases, and marble balustrade plates taken from Late Antique structures. The letters "θε" is visible on a column base of the south *tribelo* (τρίβηλο) of the west facade of the exonarthex. (Figure 2). This inscription, which is the quarry number left by the mason and corresponds to 805, should have remained in a hidden spot where it was used initially, but here as a spoliated element it is visible on the western facade and sheds light on the construction techniques of the Late Byzantine period (1261-1453).

Figure 2. The letters "θε" are read on a column base belonging to the south tribelo (τρίβηλο) on the western facade of the exonarthex (Esmer, 17.02.2014).

In 1937, Miltiadis Nomidis, a Turkish citizen of Greek origin, worked with Hidayet Fuat Tagay in the building for 10 months. The most essential discoveries of this work are the tomb chambers in the basement and the mosaics of the exonarthex domes. The mosaics were cleared off the whitewash layers covering them [7]. Upon the death of Nomidis, his daughter donated his archives, which comprise notable information about work at Kilise Camii, to the Academy of Athens.

After the conquest of the city, the scholars of Mehmed II and his son Bayezid, namely Molla Husrev, Molla Gurani, and Seyh Vefa Efendi, established neighborhoods and built monuments at Vefa [8]. Vefa neighborhood preserved its importance until the mid-20th century. As a selected

neighborhood, one could observe at Vefa the mansions lined up on the ridges, with gardens arranged with trees and flowers. At that time, Vefa was an attractive district where worthy statesmen resided [9]. The neighborhood changed slightly with great fires and earthquakes since the reign of Roman Emperor Constantine (306-337 CE) but has not undergone an extensive change until mid 20th century. Until the second half of the twentieth century, the urban fabric of the neighborhood presented an organic development following the topography [10]. The urban fabric experienced a notable change with the construction of Ataturk Boulevard which opened on February 26, 1943. This town planning activity destroyed many structures such as Kirkcesme Fountain and Sekbanbasi Mescid, a converted Byzantine period church, to obtain a broad boulevard on the north side of the Valens Aqueduct with green urban spaces on both sides (Figure 3). Kirkcesme Fountain, located to the east of Gazanfer Ağa Medrese, was a part of the old and broad water network of Istanbul, on which a spoliated Byzantine relief plate with double peacock was visible [11].


Gazi Bulvarı tamamlanıyor

Figure 3. The town planning activities for the Ataturk Boulevard destroyed many cultural assets (Cumhuriyet Newspaper, 22.06.1942).

The problems of preservation for Kilise Camii are the negligence of the building, past repairs carried without restoration projects, material deterioration, and problems caused by the users (congregation) who make illegal changes such as changing wooden joinery with PVC, adding a restroom in the north annex and covering some spoliated slabs on the western facade and at the balcony parapets of its minaret with cement mortar. Today, the Suleymaniye region and Vefa District are inhabited by people with limited socio-economic level and education, as stated in the ITYYP (Istanbul Historic Peninsula Management Plan), which was approved in 2011, categorizing these people in the lowest income group and dealing with common labor [12]. According to the management plan, Suleymaniye is the first district for migrants from mostly Eastern Turkey to settle in Istanbul due to the low rents. Usually, the families stay here for an approximate period of six years and leave the neighborhood for living in a more luxurious flat at Bağcilar or Esenler Neighborhoods of Istanbul which are also known as "*ghettos*" of the megacity. High buildings surrounding Kilise Camii prevent the structure from being perceived by the environment. Besides, some buildings are hastily demolished at Vefa which creates an environment without identity, and piles of rubble and debris that is health-threatening.

Kilise Camii has been the subject of many interventions throughout its long life durée starting in Byzantine Era after fire, earthquake, war, occupation, etc. damages. After the Ottoman conquest, the transformation of the church into a mosque resulted in the loss of the interior elements belonging to the Christian liturgy such as ambon and iconostasis. On the eastern facade, the lower part of the diaconicon cell and the entire facade protrusion of the prothesis have disappeared. The south *parekklesion* adjacent to the south facade was not reconstructed after fire damage in 1833. Also, four marble columns supporting the main dome of the naos were replaced due to the same fire damage. Original Ottoman additions such as the minbar and sultan's lodge have not survived until today. It should also be noted that the name of the neighborhood in which the structure is present has not survived from the Mehmed II period (1451-1481) to the present day.

The Kilise Camii underwent its last comprehensive repair in 1937 in the 20th century. This repair, which endured only ten months, was stopped by Vakiflar (The Pious Foundations) suddenly for an unknown reason [13]. After this date, Vakiflar only implemented superficial and without-project repairs. In 1972, essential traces were lost on the exterior facade due to a restoration by Vakiflar

without a proper project. The roof of the northern annex was also altered in the scope of this repair. In 2018, the most recent restoration work started in Kilise Camii. Until then, the leakage from the roof which was not well assembled gave damage to the vaults, domes, and walls of the building. The salts in the cement-based mortar of the previous repairs caused efflorescence visible in many parts of the structure.

The motifs of engravings from the last Ottoman Era repair and mosaics found in 1937 at the outer narthex domes were covered with whitewash by the imam in 1979. The Nomidis' restoration which was run by Miltiadis Nomidis together with Hidayet Fuat Tagay was very meticulous work. Unfortunately, this repair could not be fulfilled completely. After this repair, the internal appearance of Ottoman engravings together with Byzantine mosaics, containing different cultural layers was altered. The current users have scraped and/or plastered the reliefs on the western facade of the monument with cement mortar. New interventions constantly continued especially after 1995, the year in which the congregation transformed the northern annex of the structure to a WC. In 2009, the wooden joinery on the east facade of the building was replaced with PVC-based joinery without a project. Regarding this, the complaint made to the Istanbul Regional Directorate of Pious Foundations was inconclusive. The parapet slabs of its minaret balcony, which are spoliated elements were visible until 1995. After that year, the congregation covered them.

The Kilise Camii has survived from the Medieval Era to the present day. It is an important element of Istanbul's multi-layered cultural heritage. The scholars have good reasons due to the fragments of structures around the building to believe that it was part of a monastery complex. Another subject of importance is the location of the Kilise Camii in the World Heritage Site of Suleymaniye with an outstanding universal value. To this end being within a World Heritage Site and archaeological fragments near the monument make it necessary to handle not just the edifice but also the surroundings of Kilise Camii meticulously. The Kilise Camii is being restored by Vakiflar since 2018 and the work is about to finish very soon. Most probably it will be reopened to worship in February-March 2021. The results of the latest restoration, during which the balcony parapets and apse of the north *parekklesion* was found in-situ, is awaited with great interest especially by scholars of Byzantine art and architecture.

3. Atik Mustafa Pasa Camii at Ayvansaray

Atik Mustafa Pasa Camii is a notable Byzantine Era structure at Ayvansaray; built as a church, the structure functions as a mosque since the end of the 15th-beginning of the 16th century. Ayvansaray is at the northwest of the Historic Peninsula and lies on the southwestern shores of the Golden Horn, at the junction of the Land Walls and the Golden Horn Walls. Atik Mustafa Pasa Camii was present in the neighborhood bearing its name "Atik Mustafa Pasa" [14], however, as the result of urban planning which took place in 1934, it was misplaced out of the borders of the neighborhood bearing its name [15]. Thus, Atik Mustafa Pasa was in the borders of the Balat-Karabas neighborhood between 1934-2008. In 2008 as a result of another urban planning activity Kasim Gurani, Molla Aski, Balat-Karabas, Atik Mustafa Pasa neighborhoods were unified and named as Ayvansaray neighborhood.

In the Ayvansaray neighborhood the traditional ship and boat construction continued until the 1980s at the Kalafat Square on the Golden Horn shores. Near to the square, there is Ayvansaray ferry pier. The terrain rises very steeply to the west towards Tekfur Palace, which is on the 6th hill of the City, at the highest point of Ayvansaray. According to the "Notes on the city of Istanbul" (Notitia Urbis Constantinopolitanae) written in 425 during the reign of Theodosius II (408-450 CE), Ayvansaray was a town called Blachernae surrounded by its city walls [16]. With the construction of the land walls by Theodosius II, the town was comprised within the city as the Blachernae neighborhood in the 14th region.

Ayvansaray displays a multi-layered cultural heritage with its archaeological and architectural elements. The rich cultural heritage at Ayvansaray with the land walls and terrace walls belonging to different periods, infrastructures of the Blachernae Palace, Byzantine and Ottoman period monuments, and houses from the Late Ottoman-Early Republican periods is worthy of mention.

The gates of the Golden Horn walls between Sarayburnu and Ayvansaray and notable piers have come to this day by taking Turkish names during the Ottoman period. Among these gates, those near Ayvansaray are Ayia Anastasia Gate (Atik Mustafa Pasa Gate) and Kiliomene Gate (Ayvansaray Gate) [17].

Fragments of walls from the town of Late Antique Blachernae, presenting the characteristics of the Roman Period (3rd-4th centuries), are visible in the Anemas dungeons, Tekfur Palace, Pteron walls, and near the Hagios Demetrios Xyloportas Church [18]. A wall fragment from the Blachernae walls still stands on the north-east of the Hagios Demetrios Church, which lies 100-150 m south of the Atik Mustafa Pasa Camii (Figure 4). This piece of wall is a notable component of the rich archaeological, architectural, and urban cultural assets in and around Ayvansaray.

Ayvansaray became distinguished with the Blachernae Palace in the Middle Byzantine Period and earned a privilege in the city [19]. Some of the remains of the vaulted infrastructure of the Blachernae palace complex have reached to twentieth century. Dirimtekin published the archaeological excavations carried out in this region in 1958 [20]. Some vaulted spatial units, especially near Ebuzer Gifari Mosque and Emir Buhari Tekke, are still visible as part of the infrastructure of this palace [21].

Figure 4. The wall fragment from the Blachernae walls is still visible to the north-east of the Hagios Demetrios Church, situated 100-150 meters south of the Atik Mustafa Pasa Camii (Esmer, 10.12.2013).

Today, as one continues walking on the Kuyu Street towards the city after passing through where the Ayvansaray (Kiliomene) gate used to be, on the left corner is the Panayia (Koimesis) Vlaherna Church and its Holy Spring, which was built by the Furriers' Society of Orthodox Christians in 1869. In the Byzantine Period, on the same spot, there was the Theotokos ton Blahernon Church built by Emperor Markianos (450-457 CE) and his wife Pulcheria. The emperor came to visit the church and the holy spring by boat to the pier facing the Ayvansaray Gate [22]. Inside the Ayvansaray Gate, to the east of Ayvansaray Kuyu Street, which provides access to the church and the holy spring, there was another building with external dimensions of 29 x 18.3 m, perpendicular to the Golden Horn Walls [23]. The building was called Portico of Carianna (Embolos Cariana) [24]. The building should be included in the building group (consisting of a church, a nursing home for the aged, and an embolos) built by Emperor Maurikios (582-602 CE). It was destroyed before 1950 and was in use as a coal storage house before demolition [25].

Toklu Dede Mescidi was another Byzantine Era structure located on the corner of Kafesci Yumni and Ayvansaray Kuyu Streets, in the eastern-western direction parallel to the Golden Horn shores. The name of the mosque is missing in the Istanbul Pious Foundations Registration Book dated 1546. However, in Hadikatu'l-Cevami, it is stated that this *mescid*, transformed from a church is the *mescid* of the neighborhood where Ebu Seybetu'l Hudri's tomb is located and it is named after a veteran named Seyh Toklu Ibrahim Dede [26]. In 1929, its north and west walls including half of its apse were demolished by its owner. After the demolition, frescoes that were unearthed from the plaster became visible on its south wall [27]. Eyice states that the construction of new structures in the 1980s resulted in the complete disappearance of the building from Istanbul's historic topography [28].

According to one of the Bostancibasi (Chief Gardener) Registers written in 1230 (1814-15), there were boathouses, houses, and mansions on the shores of Ayvansaray [29]. The management, defense, trade, multicultural settlement including as well mansions, kiosks, pavilions for hunting surrounded by large royal gardens around the Golden Horn were gradually replaced by the industry (which developed primarily in the coastal regions where access is easy) in the 19th century. In the 19th century, Ottoman State was in charge

of numerous reforms to catch up with the technology of the west. In the 20th century, industrialization continued to be the dominant function in the region with the state's urban planning decisions [30]. The factories built on the shores of the Golden Horn have affected the social fabric over time, the summer pavilions on the Bosphorus gained importance, so the ones around the Golden Horn gradually lost their importance; ethnic groups left the Golden Horn neighborhoods (with the force of the obligatory population exchange in 1923, the Wealth Tax in the 40s, the 6-7 September events in 1955, and 1964 deportations). Migrants and lower-income groups settled around the Golden Horn; small ateliers have been turned into factories and finally, the urban texture of the Golden Horn has been severely damaged.

By 1984, the Golden Horn became extremely polluted where industrial, sewage water, and slaughterhouse wastes (the Sutluce Slaughterhouse, which continued its function between 1923-1990) were poured for long years, the water depth fell below half a meter at some locations, and the boats could hardly move. In 1984 the mayor of Istanbul, Bedrettin Dalan made major demolitions to solve this situation. But the demolitions which were carried out unplanned resulted in the loss of industrial heritage along the South bank of Golden Horn; as well as cutting sharply the liaison of the urban fabric of historical districts such as Fener, Balat, and Ayvansaray with the sea.

In the 21st century, the Ayvansaray Turkish Neighborhood Renewal Project, which started in 2013 at Ayvansaray, was run with the force of law no 5366. Law no. 5366 on "Conservation by Renovation and Use by Revitalization of the Deteriorated Historical and Cultural Immovable Property", shortly called the "Renewal Law" came into effect in 2005, causes irreversible damages and losses through the renewal of the qualified urban sites as seen at Ayvansaray. The project area was in the hands of users with low socio-economic levels and education; therefore, the inhabitants were easily deported with the force of the law. And the project was implemented by accepting the area as involving "no archaeological or architectural heritage", although the contrary was valid. As a result of the project carried out on the building blocks 2867, 2868, 2869, 2872, surrounded by Toklu Ibrahim Dede, Kuyu, Kafesci Yumni Streets of Ayvansaray Neighborhood, the notable archaeological and architectural heritage in this area has been irreversibly destroyed (Figure 5) [31].

Figure 5. The building blocks 2867, 2868, 2869, 2872 surrounded by Toklu Ibrahim Dede, Well, Kafesci Yumni Streets of Atik Mustafa Pasa Neighborhood were the subject of The Ayvansaray Turkish Neighborhood Renewal Project, carried out by the Fatih Municipality.

Atik Mustafa Pasa Camii was classified by Eyice as the "corner walled type" of "cross-in-square" planned structures in Byzantine church architecture [32]. It was built in the second half of the 9th century. The entrance of the building is from the street where the Ayia Anastasia door was opened during the Byzantine period, now called Çember Street (this street is called Haci Zade Street in the Pervititch map, section 29 prepared in 1929). The building, which is thought to be one of the first examples of the cross-in-square plan type in Istanbul [33], stands out among the other Middle Byzantine Period buildings in Istanbul. The dome, narthex, and minaret of the building are Ottoman period additions (Figure 6). Its dome should have been renewed as a result of the damage of the 1509 earthquake together with the eave-cornices. The outer prayer hall or the western portico which must have replaced a narthex at an earlier phase, has largely lost its original architectural character with various repairs. The upper part of its minaret and its stone cone present Late Otto-

man characteristics. These stone cones are usually constructed after the 1894 earthquake [34].

Huseyin Ayvansarayî, who is an 18th-century scholar who was born and buried at Ayvansaray, wrote in his book about the mosques and mescids in Istanbul that is called *Hadikat'ul Cevami*: "*That the Atik Mustafa Pasa Camii transformed from a church was adjacent to the city walls inside the Ayvansaray Gate*" [35]. The founder of the mosque was the grand vizier of Bayezid II (1481-1512) Koca Mustafa Pasa [36]. The structure is also known as Cabir Camii according to the belief that the tomb of a companion of Prophet Muhammed, namely Cabir, is under the diaconicon cell of the former church.

Figure 6. The dome, outer portico, and minaret of the Atik Mustafa Pasa Camii are the Ottoman period additions to the structure (Esmer, 15.12.2009).

The initial document of registration as a cultural asset for Atik Mustafa Pasa is in the Archives of the Committee for Preservation of Antiquities affiliated with the Istanbul Archaeology Museums (Encumen Arsivi in Turkish). The registration document has the signature of Mehmet Ziya Bey, who had filled it on May 21, 1334 (1918). On the template for registration is written: "*Facing this mosque, in front of the wooden house belonging to a lady called Turbedar, the baptism basin of the ancient church still stands. It is possible to descend down to the floor of the basin with 3 steps*". There are three steps on the fourth side of the three-leaf clover-shaped vessel [37]. Ali Saim Ülgen, who made additions by revising the template in 1936, stated that the baptism basin in front of the Atik Mustafa Pasa Camii had been removed to the Archaeology Museums in 1921 with the inventory number 3898.

The name of the Atik Mustafa Pasa Camii in the Byzantine Period is unknown as in the case of the Vefa Kilise Camii. Yet, there are various opinions on the issue. According to one of these views, the building was dedicated to the doctor saints Cosmas and Damianos, also known as the "Anargyroi" [38]. Anargyros means that the person does not expect in return for his work to receive money from the patient he treated [39]. This claim stems from the frescoes discovered by coincidence in 1956 by the workers. The frescoes in the middle part of the south facade, on the tympana of the lower row of arches, are dated to the last period of Byzantine art in Constantinople, the first half of the 15th century (Mathews and Hawkins, 1985: 133). After the discovery of the frescoes, Ernest Hawkins, together with Saban Kolat, a master builder working with Hawkins at the time, had nailed a wooden curtain on the wall to protect the frescoes. Hawkins photographed the frescoes both in color and black-white formats for archives of the Byzantine Institute of America [40]. Janin claims that there are six churches in Istanbul that are dedicated to Cosmas and Damianos [41]. However, none of these six churches overlap with Atik Mustafa Pasa. The fact that the frescoes belong to the first half of the 15th century suggests that a *parekklesion* was added to the first construction at that time, and consequently, production of them may be independent of the dedication of the building. Hawkins waited for years, for the Vakiflar to take a precaution and build a simple protective system to preserve the frescoes in-situ on the wall. However, in 1985, he observed that they were covered with whitewash like the exonarthex mosaics at Vefa Kilise Camii [42]. According to

the imam of Atik Mustafa Pasa the frescoes, which have remained whitewashed under the wooden curtain built by Saban Kolat and Hawkins until the 1992 repair, were closed during 1992 repair by the congregation (Figure 7).

The Atik Mustafa Pasa Camii requires a repair following a project of scientific standards, which should be prepared by results of an analytical examination by a multi-disciplinary group of experts i.e. conservation architects, art historians, civil engineers, etc. While preparing the survey, with preliminary research permission to be obtained from the Regional Board for Preservation, a detailed examination work should be carried on surfaces covered with any sort of inappropriate additions. The structure has static problems which can be deduced from the cracks that occurred at the 1999 earthquake. Besides, due to its location on the Golden Horn shores, the building has sunk approximately 1-1,5 m from the level at the date of its initial construction. By a research excavation, it may be possible to shed light on the history of the building by determining the information about the first design and the original height of its facades. The frescoes on the south facade should be opened if they are still intact and can be preserved. Otherwise, after the necessary documentation, they should be covered with a suitable protective layer to be passed on to future generations.

Figure 7. The frescoes in the middle part of the south facade, on the tympana of the lower row of arches, are dated to the last period of Byzantine art in Constantinople, the first half of the 15th century (Esmer, 30.03.2009).

4. Fethiye Camii and Museum (Pammakaristos Monastery Church) at Carsamba

Fethiye Camii, overlooking the Golden Horn from a broad artificial terrace on the 5th hill of the Historic Peninsula, was within Constantinople's XIV. region in Byzantine Era. It was the church of the *Theotokos tis Pammakaristou* Monastery [43]. (Figure 8). Apart from the churches and five cisterns (one below the school to the west of the church, one in the northeast, another to the east of the church, one to the south of the church, and the last one under the naos of the church), no building has survived from the monastery, which was established in the name of the Virgin Mary. Fethiye Camii consists of two adjacent churches; the main church*/katholikon* of the Pammakaristos Monastery on the north was dedicated to Virgin Mary, and the tomb chapel on the south was dedicated to John the Baptist [44].

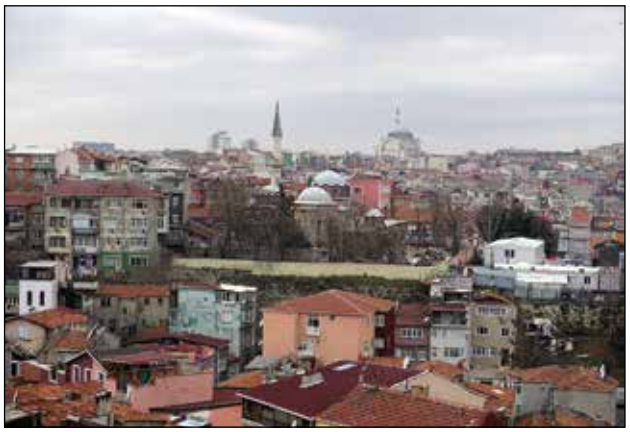

Figure 8. The Fethiye Camii complex is visible together with the terrace on which it is standing and surrounding urban fabric (Esmer, 10.02.2017).

Currently, Fethiye Camii is located at Fatih District, in Çarsamba quarter, in Balat Neighborhood. In Ottoman Period the mosque was in its neighborhood bearing the same name as the mosque [45]. In the Pious Foundations Registers (Vakiflar Tahrir Defteri), it is stated that Katip Musluhittin Neighborhood was to the west of the mosque and the mosque was located in its neighborhood called Fethiye Neighborhood [46]. As a result of the municipal regulations made in the 20th century, Fethiye Neighborhood was included

in Katip Musluhittin Neighborhood; and with a final arrangement made in 2008, the neighborhoods of Yavuz Sultan Selim, Katip Musluhiddin, Tevkii Cafer, Hizir Çavus, Tahta Minare, and Hatip Musluhittin were combined as Balat Neighborhood.

The name of the district is probably called after those who migrated here from the Çarsamba District in Samsun. In the period of Mehmed II, the neighborhoods were named by migrants from different parts of the Ottoman State or immigrants, usually with the name where they came from [47].

In the Byzantine Period, Çarsamba District was in the XIVth region of the city. There were many churches and monasteries in the area where Aspar (Sultan Selim Çukur Bostani) and Aetios (Karagumruk Stadium) open cisterns are located nearby. Odalar Camii, Kefeli Camii, Boğdan Saray, Hirami Ahmet Pasa Camii, Kasim Ağa Camii, and Ipek Bodrumu are Byzantine structures in the vicinity that survived to present in different states of preservation.

After the conquest, Pammakaristos was left to the Greek community as a women's monastery [48]. After a short while, with the consent of Mehmed II, Patriarch Gennadios relocated the Greek Patriarchate into the Pammakaristos monastery [49]. In the Patriarchate registers, there is no record of the building within 130 years after the conquest while it was in use as the patriarchate. Yet, one can read some details about the appearance of the building from the diaries of three German travelers [50]. In 1573, the theologian Stephan Gerlach came to Constantinople as an ambassador and his diary, which is about his five years in Constantinople, was first published in 1674 [51]. After Gerlach, Salomon Schweigger, who came also as an ambassador to Istanbul in 1578, and stayed for three years. In his diary, published in Nuremberg in 1608, he described his visit to Pammakaristos Monastery with Gerlach [52]. On the engravings on wood drawn according to the narration of Gerlach and Schweigger, the monastery structures are seen on a broad plain surrounded by a wall (Figure 9). One year after Gerlach and Schweigger, in 1579, Hans Jakob Breuning visited the Patriarchate in Constantinople during his journey to the East [53].

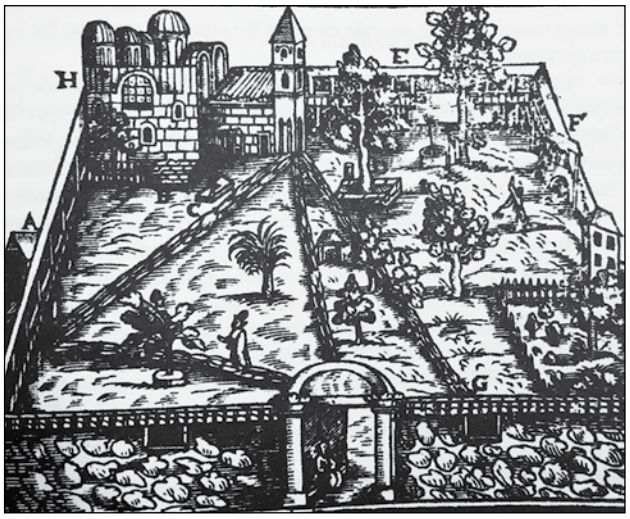

Figure 9. The engraving according to the narration of Schweigger presents the monastery on a broad plain surrounded by a wall [54].

Fethiye Camii complex comprises, on the ground, the north church, the north annex, the Ottoman annex to the east of the north church (which replaced the destroyed main apse and the pastophoria cells), the south church (tomb chapel), the outer narthex (corridor) surrounding the building from the west and south, and a minaret rising at the southwest corner. Under the ground, there is a cistern (under the naos of the north church) and a burial chamber (under the north wing of the west corridor of the exonarthex). The northern church is classified by Eyice as the "corridor type" of the Byzantine church structures [55]. In this plan type, also classified as ambulatory type, the square space under the main dome is surrounded by vaulted corridors from three sides (north, south, and west). The main dome rises like a tower above the roof level of the surrounding corridors; the middle space is illuminated by windows on the tympana of the arches supporting the dome. The south church has a cross-in-square plan that is a typical Byzantine church plan type.

Fethiye Camii buildings show various construction phases [56]. The domed central space, which forms the core of the northern church, and the corridors around it and the cistern underneath them belong to the first phase of the structure (Comnenoi Period). After 1261, the building was repaired and the northern annex was built. Around 1315, the *parekklesion* was added. The exonarthex surrounding the building from the north, west, and south

was built between 1326-41. Later, Pammakaristos Monastery was taken from the Greeks during the reign of Sultan Murad III (1574-95) and it was converted into a mosque with the name of Fethiye in memory of the conquest of Azerbaijan and Georgia [57]. The major spatial interventions created by this functional change occurred in the north church. The main apse and pastophoria apses were replaced with a domed annex with a mihrab towards the qibla. Also, a minaret was built on the southwest corner of the building. The *tribela* (τρίβηλα) with 2 columns and 3 arches to north, west, and south of the domed central space were removed and replaced with wide-span single arches.

No information or document of importance about Fethiye belonging to the 17th century has been found so far. The only source, Evliya Çelebi, states that: "*The building has a minaret and a large courtyard, it is a home for the poor, and a well-illuminated mosque*" [58]. Comparing to today, during the Ottoman period, sixteen extra rectangular jamb windows at ground level illuminating the interior should be considered for this interpretation (They were closed in 1937 Vakiflar repair).

From the 18th century, two comprehensive repair registers and an expense record found in the Ottoman Archives of the Turkish Presidency were examined by Mazlum [59]. Based on these documents, Mazlum stated that the monument underwent repairs in 1729, 1759, and 1766-67 consecutively, but most of the traces of these repairs were erased or covered during the restoration work of Sultan Abdulmecid in 1845 [60].

In the 20th century, the General Directorate of Pious Foundations (Vakiflar) repaired the building in 1937, 1955, and 1959. In the 1937 campaign, carried out by architect Sureyya Yucel, the most extensive changes were the removal of the wooden sultan's lodge and the uncovering of the mosaics on the soffit of the main dome in the South Church. Due to the Byzantine Congress, which was to be held in Istanbul in 1955, the Pious Foundations aimed to show Byzantine monuments in Istanbul in a good state of preservation. To this end, some edifices including Fethiye were repaired [61]. For Fethiye, under the supervision of architect Cahide Tamer from Vakiflar, the repairs can be summoned as covering the gynaikeion domes and Ottoman annex' dome with lead imitating concrete, replacing the broken window panes, cleaning the vegetation on the walls, re-pointing and replacing the ruined stones of the minaret pedestal [62].

Fethiye Camii underwent another repair in 1959 [63]. The chief architect of this repair, during which more extensive changes were implemented, was also Cahide Tamer [64]. A bulky percentage of the original marble cornice carved with acanthus leaves of the domed central space was renewed. After this restoration, the building was divided into two with wooden panels to be used with two functions as a mosque and a museum [65]. Stone renovations especially on the north facade are remarkably excessive. After this restoration, the northern church was opened to worship as a mosque.

For the south church, restoration work was carried out by the Byzantine Institute of America between 1960 and 1963. The mosaics and frescoes were cleaned, and some additions of the Ottoman Period were removed. The Byzantine Institute desired the building to regain its appearance in the Byzantine Period. Therefore some extensive interventions were implemented. Among the most extensive interventions by the Byzantine Institute can be spelled: to construct a semi-circular arch on the north wall of the naos to hide an Ottoman-era pointed arch, placing imitation columns cast from concrete on the existing bases of the original ones, to reconstruct the apse of the prothesis, which was transformed into a rectangular window with jambs, to build up the rectangular windows with jambs on the south wall of the naos and narthex.

For the repairs carried out by both the Pious Foundations and the Byzantine Institute in the 20th century, it is remarkable that the historical value of the original or earlier states of the structure of the building was not respected and cement-based materials were used in abundance. Moreover, for the campaigns of the Pious Foundations, no proper restoration projects were prepared and none of the activities were documented and kept as part of the history of the structure. The changes can be detected only by the sake of some photographs. The justification for the removal of the original acanthus leaf cornice or the wooden sultan's lodge cannot be made since there is no report or project decision on these implementations. On the other hand, meticulous documentation was made by the Byzantine Institute repairs. However, a selective restoration

practice is seen, the Ottoman phases of the structure were not respected and an excessive intervention with reinforced concrete was implemented.

In the meantime, new interventions and repairs, especially in the past 15-20 years in the north church which were carried out by the congregation of the mosque were very excessive and harmful. The entrances to the burial chamber and the cisterns under the naos were muffled with cement mortar. The whole building needs an urgent repair with scientific standards. From the photographs taken by the Byzantine Institute in 1957, presenting the inner space without plaster, it is clear that the building has complex problems of architectural history. The restoration of such a structure should be carried out by a multi-disciplinary team of conservation experts with sufficient experience and knowledge.

Finally, due to the problems of preservation, the museum section of Fethiye is being restored by the Pious Foundations since 2018. The restoration work is expected to be compatible with the international principles and guidelines suggested by ICOMOS charters.

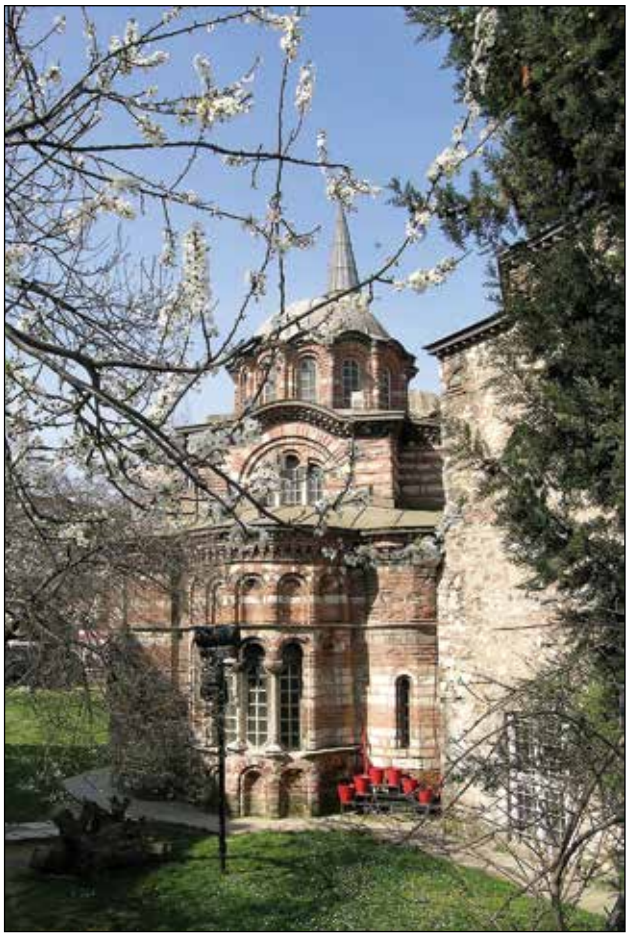

Figure 10. The Fethiye Museum (South Church) eastern facade with the apse (Esmer, 20.03.2010).

5. Conclusion

These three monuments, founded in Mid-Byzantine Era (9th-13th centuries) and had some later interventions/additions in the Late Byzantine Era (13th-15th centuries), Ottoman Era (1453-1923), and Republican Era (1923-present) have survived to the present day with various functional and physical changes to their original structures. These structures are unique historical documents with their architectural styles, construction techniques, spatial designs, dimensions, material usage, opus sectile, mosaic, fresco decoration elements, and various phases of masonry from medieval Istanbul to today. They convey the aesthetic values, architecture, and social environment of the initial design period as well as present the evolution of architecture and urban texture through centuries with their multi-phased masonry (Figure 10).

They constitute an indispensable layer both in the horizontal and vertical stratigraphic texture of the city, and they should be transferred to future generations without any further changes, together with all archaeological and architectural remains surrounding them. A buffer area as a protection zone should be considered around such notable medieval buildings, and repairs/interventions without proper analysis and projects should be avoided both for these structures and their surroundings. These monuments should be presented in the best way in the urban texture as well their surroundings which are internationally accepted as inseparable parts of all historic monuments.

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The place and importance of the Ottoman period sabilhanes in the Crete aqua architecture

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Abstract

Since Crete Island has a strategic importance on the Eastern Mediterranean border, it has been dominated by many civilizations such as Minoan, Doric, Ancient Greek, Roman, Damascus Umayyad, Andalusian Umayyad, Byzantine and Venetian states. The first contact of the Crete Island with the Turks began with Aydin and Menteseogullari principalities from the 1330s. and during the reign of Sultan Ibrahim, 1645 Captain-Derya Yusuf Pasha conquered Chania Castle, then Rethymno, Kisamo, Granbosa and Apokorano castles were taken by the raids of Deli Huseyin Pasha. Finally, in 1669, with a military operation under the supervision of Grand Vizier Koprulu Fazil Ahmet Pasha, Heraklion Castle was conquered and the entire island was included in the Ottoman administration. The island exited Ottoman rule in 1913 and after the Treaty of Lausanne (1923) within the scope of the exchange on the island, the Muslim population emigrated to Turkey.

The aim of this article is to evaluate the original contribution of the Ottomans to the water architecture in Crete over a period of nearly 300 years, through the sabilhanes. Waterways were built on the island during the Venetian period. During the Ottoman period, these waterways were used effectively and maintained. Besides, sabilhanes built for charitable purposes are among the most elegant works of Ottoman-Turkish architecture. Having a unique position between sculpture and structure in the city, the physical structure of the sabilhanes can be regarded as an indicator of the architectural style, aesthetic taste, technology and also cultural and economic development of the city. The scope of this study is to examine the architectural features of eight sabilhanes built in the cities of Heraklion, Chania and Ierapetra in Crete. In this context, the issue of sabilhanes has been handled with examples in Istanbul and Cairo and a typology suitable for sabilhanes in Crete has been presented. The first sabilhane in Crete was built by (Queen Mother) Valide Hatice Turhan Sultan in 1672 in Heraklion. The last sabilhane was built in Yeraptra in 1872 by Ali Makaronake. In addition, two sultan fountains were built. Six of these eight sabilhanes in Crete were demolished, three of which were architecturally described from archive photographs. The facade and plan drawings of the two sabilhanes that have reached today were prepared by measuring, their inscriptions were read and dated and archive documents were obtained.

Key word: *Crete, Heritage, Sabilhane*

1. Introduction

Crete Island, one of the largest islands in the Mediterranean, surrounds the Sea of Islands on the eastern Mediterranean border like a belt from the south. In addition to its natural harbors, it has been an important settlement in history with its high mountains, wide and fertile plains. Although the first traces of settlement on the island dates back to 3000s BC; in the 2000s BC, a strong state centered in Knossos was established under the leadership of King Minos. The island, which stands out as a wide junction point in the middle of the sea far from the land in a region surrounded by the land parts of the Balkans, Anatolia and North Africa, developed as a strong sea state with the influence of Egypt and became an important cultural center that is accepted as the cradle of European civilization [1]. The Doric and Ionian raids that started in the 1400s B.C. ended this high civilization with a great disaster [2]. Although the island preserved its strategic importance after this, it could not have its former pioneering and crucial role [3]. The island which was captured by Rome in 69 BC, remained in the hands of Eastern Rome after the Roman Empire split into two [4]. Established in the east of the Mediterranean, the Islamic State conquered Syria and North Africa in a short time and took Anatolia and Crete under its influence. The

first Muslim raids to Crete Island started in the period of Muawiyah I (661-680), different parts of the island were captured at various dates and finally the whole island was taken under control during the period of Caliph Me'mun (813/833) [5]. In 961, the Byzantines ended the Muslim rule of 150 years on the island and forced the island people, the majority of whom were Muslims, to convert or leave the island [6]. After this date, the island, which would occupy the Byzantine Empire with various rebellions until the Crusade IV, was captured by the Venetians in 1204 [7]. The first relations with the island administration under the Venetians were established by a number of commercial agreements between Aydinogullari and Menteseogullari Principality in 1337 [8]. Despite the turbulent situation with Venice, the relations with Crete continued this way until the middle of the 17th century, through the Cretan Greek merchants in Istanbul [9]. The Ottomans, who wanted to strengthen their dominance in the Mediterranean the 16th century onwards, started to prepare for Crete after conquering Rhodes in 1522 and Cyprus in 1571 [10]. The Ottoman State finally declared war on the Venetian Republic for the conquest of Crete in 1645, and the entire island was conquered in 1669, after 24 years of great struggles on many fronts [11].

After Chania was conquered by Yusuf Pasha in 1645, Deli Huseyin Pasha also conquered Rethymno Castle in 1646. In this way, with the partial support of the people of the island, different places within the island were conquered and preparations were made for the conquest of Heraklion [12]. The end of the 30-year wars in Europe, and the fact that Sultan Mustafa became the sultan at the age of seven after Sultan Ibrahim drove the Ottoman Empire into some internal conflicts and the conquest of Heraklion was not given enough importance [13]. Besieged twice after 1645, Heraklion was finally taken by Koprulu Fazil Ahmet Pasha in [14]. After the conquest, a large military group was settled in the city with their families. The administrative structure of Crete was in the form of a state consisting Heraklion, Chania, Rethymno and Istiye (Stia) sanjaks [15] The Greek Revolt that broke out in 1821 also affected Crete and turned into an international problem especially after 1896 and was off the Turks hands after the 1913 Balkan War [16]. The complete withdrawal of the Turkish population on the island happened with the Lausanne Treaty.

Crete, which has had a unique social and cultural structure throughout history, has many charitable foundation works built by people, who shaped Ottoman politics such as sultan, queen mother and grand vizier, during the Ottoman period. One of the most comprehensive sources about Crete is Huseyin Kami Hanyevi's two-volume book named "*Crete History*" (1864). In addition to this, W. Miller's "*The Latins in the Levant (1908)*" which is mostly about political history, and C. Hawes, and B. Harriet's "*Crete The Forerunnes of Greece (1911)*" works are among the important works made in the last century. After these extensive studies, researches on more specific issues related to Crete were conducted. In this context, the multi-authored "*The Eastern mediterranean under Ottoman Rule: Crete, 1645-1840*" book is about the social and cultural structure of the island in the Ottoman period. Ersin Gulsoy's "*Conquest of Crete and the Establishment of the Ottoman Administration (1645-1670)*" doctoral thesis, examined the establishment of the Ottoman administration on the island. In this respect, the charitable foundation works established in cities are also included in the study. Nukhet Adiyeke's doctoral thesis named "*The Ottoman Empire and the Crisis of Crete (1896-1908)*" is a comprehensive study in which the events taking place on the island are handled with legal, political and economic dimensions. A. Anastasopoulos, E. Kolovos, M. Sarigiannis's work named "Οι πρώτοι δύο αιώνες οθωμανικής κυριαρχίας στην Κρήτη *(1645-1821):* νέες πσις και εαι ερμσις" (2017) and E. G. Chalkiadakis "*The Water Supply to Heraklion, Crete, Greece From the Ottoman Period (1669) to the Present; the Modern Aqueduct and the Ancient Springs*" (2019) are the most current research subject that was conducted in the light of the new documentations found on Crete. There is no compiler resource that directly examines the structures in Crete. In Heleni Porfyriou's work, "*The Cartography of Crete in the First Half of the 17th Century: a Collective Work of Generation of Engineers*" (2004), which is about the development of Crete in a general sense, construction traces about the periods were investigated through old

maps. Although it is not a compilation work that covers all works, there are many studies conducted by Nikólaos Stavrinídis, Elisábet Zachariádou and Vasílis Dimitriádis on Ottoman documents about the island at different times and on different themes. These researches are on the historical background of the Ottoman period works rather than the architectural aspect. In addition, in the database Digital Crete which was established under FORTH regarding all the artifacts found in Crete Island, that has been hosting countless works since the Minoan Civilization, the bibliography of the previous researches related to that structure and its names are included.

Apart from the above-mentioned studies, there is no comprehensive study about the sabilhanes on Crete Island. In this research, the facade and plan drawings of the sabilhanes located in different cities of the island were prepared by measuring them and their architectural features were explained. The uncertainty about dating the structures has been removed from the documents by analyzing documents like foundations certificate-charters and inscriptions.

1.1. Purpose and Scope

The fountains, which are among the most important charities for Muslims, show the value given to water and charity. Turks, too, have equipped every corner with fountains of various sizes in the cities they founded with the motto "*Cleanliness is from faith*" and their only expectation from those who drink the water was a prayer (Fatiha) for the builders [17]. In this sense, the Turks used the fountains as an image that strengthens the belief in the afterlife in the urban space. In Islamic art, fountain architecture has different architectural diversity such as selsebils used as garden ornaments, sadirvans used as ablution places, sabilhanes where other drinks are served besides water, and fountains that meet the water needs of the neighborhoods [18]. Among these, the sabilhanes, which can also include the subject, differ from others as a structural program. It has a unique position between sculpture and structure in the city. The physical structure of the sabilhanes can also be regarded as an indicator of the architectural style, aesthetic taste, technology and cultural and economic development of the city. The researches on the sabilhanes are mostly based in Istanbul, among them Izzet Kumbaracilar's "*Istanbul Fountains*" (1938) is the most fundamental source. In addition, Semavi Eyice (1968), Behcet Ünsal (1986), Celal Esad Arseven (1983), Ayla Ödekan (1997), Nur Urfalioglu (2009) mentioned the issue of sabilhanes in various encyclopedias [19], [20], [21], [22].

The purpose of this study is to document these buildings, which are silent witnesses of the urban history in different cities of Crete Island, and to create a resource for researchers from architecture discipline and different disciplines by analyzing them architecturally. Eight sabilhanes within the scope of the study were documented from written sources and examined in terms of location and architectural formation. In addition, similar examples in nearby geographies are included in the evaluation part.

1.2. Method

The word sabil, which means "*path*", has become widespread in daily language, meaning charity related to water. Even today, electrical appliances like water coolers are called fountains (sebil). However, sabilhanes, which are an important building type in the city in architecture, are built according to an architectural program in which the water tank, snow tank, beverage tank and the subject who performs the catering work. Therefore, its use with the suffix "hane", which was also common in the past and defines interior and exterior spaces, rather than a generalist definition like "*sebil*", meets the architectural description more accurately. (Sabilhane meaning kind of sabilhane) Although most of the researches on the sabilhanes are based in Istanbul, Cairo and Jerusalem, there are studies covering different periods, too. Among them, Ayhan Aytore's "*Water Architecture in the Turks*" (1959) and Ünsal's "*Style Research on Turkish Fountain Monuments*" (1981), Ödekan's "*Typological Analysis in Urban Fountain Design*" (1992), Önge's "*Fountain, Fountain and Fountains of Anatolian Principalities Period*" (1997) were based on a reclassification that has been made in accordance with the sabilhanes in Crete. The most important part of the sabilhanes is considered as the area where the catering will be carried out. Other storage areas are

shaped on-site according to the suitability of the place where the sabilhane is built.

This situation has been taken into account in the typological analysis and classified according to the window plans instead of the general structural plan.

The sabilhanes subject to the study are listed according to cities and dates in terms of subject integrity. According to this, firstly, the sabilhanes in Heraklion were mentioned and respectively in Chania and Yarepetra. The architectural features and shaping of each sabilhane were mentioned. Its typological analysis is presented in the form of a table in the conclusion for an easy presentation. At the same time, among those with an inscription, the builder and its dating were revealed, and for those without an inscription, dating was made according to the records in the archive documents. In the evaluation part, the architectural features of the fountains built in Istanbul and Cairo recently in accordance with the sabilhane house typology in Crete are mentioned. In the conclusion part, the analysis of the typological table and the similarities and differences of the sabilhanes in Crete with respect to their contemporaries are presented.

2. Sabilhanes

Unlike fountains, sabilhane houses are generally built on or near the water source in the city. The sabilhanes located near the water source have water reservoirs, while the sabilhanes built right above the water source do not have a water reservoir. Besides, in the 18th century, the water architecture in the city was shaped according to a more holistic design approach. Square fountains were built together with sabilhanes [22]. There are many terms for these details as many details about water architecture were produced during the Ottoman period [23]. Some of the terms derived from the sabilhanes are shown in the figure below.

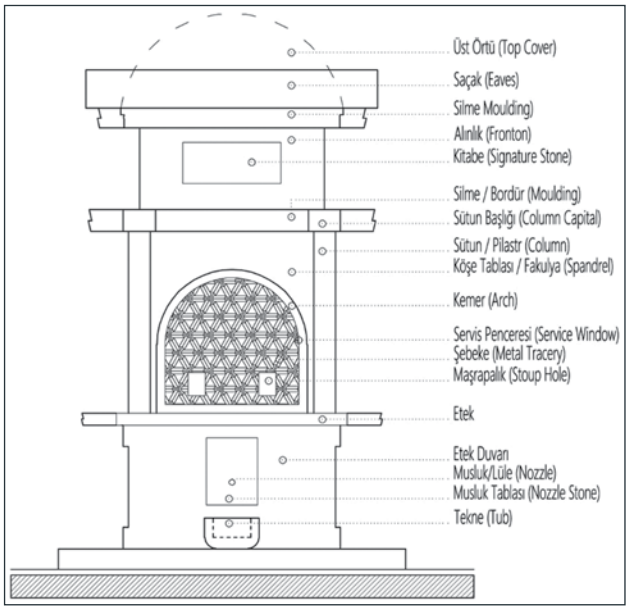

Figure 1. Terms related to the Ottoman fountain structure

Table 1. Sabilhane typology according to location, physical form and facade type

A. By Their Location		**C. By FacadeType**	
1. Detached		1. Structure	a. Column
			b. Foot
2. Integrated		2. Arch Type	a. Pointed
			b. Cusped
B. By Physical Formation			c. Half Circle
1. Door / Window Facades	a. Every Front		d. Lento/Flat
	b. Certain Fronts	3. Eteklik (Continuous-projecting base)	a. Flat
2. Plan Type	a. Regular Polygon		b. Round
	b. Wavy		c. Without eteklik
	c. Concave Partitioned	4. Column Capital	a. Baroque
3. Top Cover	a. Dome		b. Imperial
	b. Roof	5. Fringe Type	a. No fringe
			b. Wider
			c. Flat / Terrace

Image 1. Turhan Sultan Sabilhanesi script

2.1. Heraklion (*Kandiye*), Valide Hatice Turhan Sultan Sabilhane House (1672)

There has been a lot of confusion about the builder of this sabilhane, which is a magnificent structure in the city square. Different builders, definitions and locations are described for the same structure. For this sabilhane, the names and charities of Ahmet Pasha, Melek Ibrahim Pasha, Haci Ibrahim Aga and Turhan Sultan mixed together. The structure that is not named by E.H. Ayverdi, was named Ahmet Pasha Sabilhane in Nusret Cam's "*Yunanistan'daki Turk Mimari Eserleri*" book.

Evliya Celebi, one of the eyewitnesses of the conquest of Heraklion (1669), mentioned a sabilhane next to the mosque in Heraklion and built by Ayan Mehmet Efendi and Kethuda Ibrahim Pasha in the name of Turhan Sultan (d. 1683) [24]. Besides, among the foundations in Heraklion, H. 1190 In the foundation certificate-charter dated M.1776, it is mentioned that the sabilhane was repaired by Haci Ibrahim Aga bin Ebubekir from the notables of Heraklion.[1] According to the foundation certificate-charter, Turhan Sultan Mosque (St. Salvator Church), in order to repair the sabilhane and waterways next to it and to cover the fees of its staff, he donated many of his real estates, lands, vineyards and gardens in and around the city center. The summary of his foundation certificate-charter is as follows:

"Of the said foundation revenues, first of all, foundation real estates, sabilhanes and waterways were to be repaired, the remaining 110 coins would be paid to the sebilci (the dispenser) who was appointed to the fountain, 30 per month to the suyolcu (person who is in charge of water ways), and 4 loads of snow per day in the summer months would be purchased and served at the sabilhane. In addition, a house in a suitable place will be purchased from the foundation revenues for the residence of the dispenser and will be allocated to his residence" [25]

Haci Ibrahim Aga, the second builder of the sabilhane, who is often confused with Melek Ibrahim Pasha in the sources, is from the rich notables of Heraklion and we learn from his *vakfiye* in 1776 that he repaired many fountains, sabilhanes and waterways in Crete Island. The same name is mentioned in the inscription written of the sabilhane house in six columns, two lines and twelve cartridges in total. In today's Turkish writing of the inscription is as follows:

"Haci Aga kim odur hem-nam Ibrahim Halil /
Sa'i edub yapti sefa ile bina beyt-i seyid /
Sukkam-i mermere kazdirdi bu hayri cemil-i /
Tasindan su cikarib tasiyla ve azimussanda /
Dil? atar su luleden dirayet? esnasinda? /
Gelsun icsun su ve hem kilsin salavat-i selam
Cennet-i a'lada kevser icse de? delil? /
Bu zula-i abide iden teskane? Mah-i sebil /
Nukdu her yeni hayrin ahir? fa'izi? .... /
Ya ab-i selsebil ide ustaniz? Gider bi-sebil?/
Nutkudur tarih tamir ihlasla kildi .... /
Isterim mihrab-i? pak ic .... kildi sebil
Ketebe Mustafa Sukru"

Subject to confusion, Melek Ibrahim Pasha (d. 1685) was appointed as the guardian of Heraklion in 1673 in Crete. The epitaph of a charity building he had built during this period is now exhibited in the Heraklion History Museum. The inscription

1 VGMA, Book No: 988, Page No: 122, Date: H. 1190 / M.1776

Image 2. Turhan Sultan Sabilhanesi numbering script and enterance script

made of marble consists of two lines and the current Turkish writing of the inscription is as follows:

"*Sahibu'l-hayrat / Melek Ibrahim Pasha / Year 1095*" (M.1683).

There are two more inscriptions on the walls of the fountain. One of them is on the entrance door. "*Ve mine'l-mai kulli sey'in hay'*"[2] verse and on a square marble slab in one of the side walls. there are numbers in different digits are written in boxes of rows and five columns. The meaning of this inscription consisting of numbers is not fully understood.

Valide Hatice Turhan Sultan, the real builder of the sabilhane, is a strong political character, who was the regent of the sultanate during her life. In 1656, she transferred her powers to Koprulu Mehmed Pasha, whom she appointed as the grand vizier, and devoted her time mostly to charity [26]. In researches about her, her devotion to religion, generosity, philanthropy and not being ambitious has been mentioned. Through her foundations, she built castles for the needs of the state as well as charity work. After the seizing of Heraklion Castle in 1669, the repair of the castle and the buildings inside was made in the name of Turhan Sultan, and at the same time, St. Salvator Church was converted into a mosque in her name [27]. This building was demolished in 1973. Today it is called Kornarou Square. In an engraving from the 1890s, The Valide Turhan Sultan Mosque, converted from St. Salvatore Church, and its sabilhane and (Bembo) fountain are clearly visible.

Image 3. (A) Turhan Sultan Sabilhane square view and (B) drawing from 1890s (Stavridis, 1970)

The fountain was built using stone and marble columns. Its vertical facade consists of three parts. There is the first section up to the eteklik and the second section where the door window opening measure are close to each other, and a third section

2 Surah Anbiya, Verse 30; Verse meaning: "And We made every living thing out of water"

on which the pulley is located. While the first and second sections attract attention with their marble column capitals and less cascading moldings, the third section has a multi-layered molding.

A large water reservoir was built behind the fountain. The section where the water reservoir is located on its six sides is blank, the others are permeable. Accordingly, the plan scheme is in the form of a hexagon based on the water reservoir. The three facades facing the square are smaller compared to the two facing sides. There is a door on one of the side facades. The top of the building is covered with a wide-eaved sectional roof. At the center of the roof is a cylindrical lighthouse, which has lost its function today.

The windows of the fountain room are semi-circular arches made of stone. Its door is double-centered tangential arches surrounded by marble lintels. Each facade with a window also has a marble fountain and basin. The *eteklik* of the fountain has a very short and angular form.

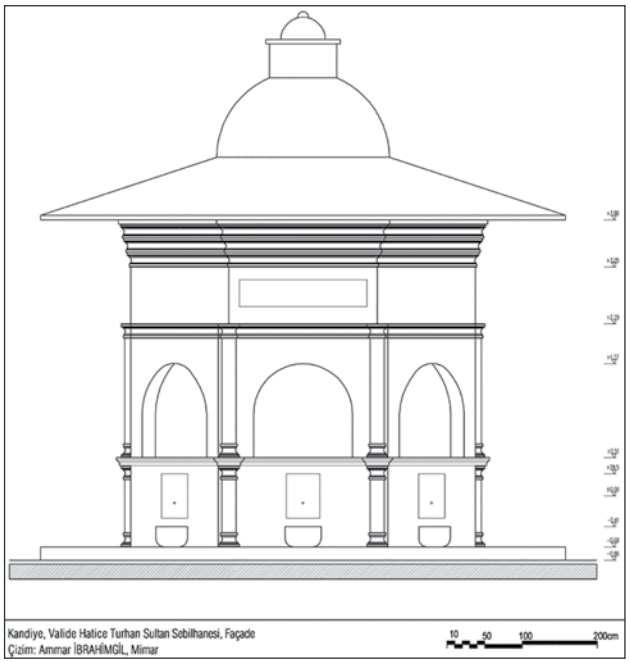

Figure 2. Turhan Sultan Sebilhanesi front facade

Image 4. Turhan Sultan Sabilhane front and rear facade facing the square

Image 5. Detail examples of Turhan Sultan Sabilhane's

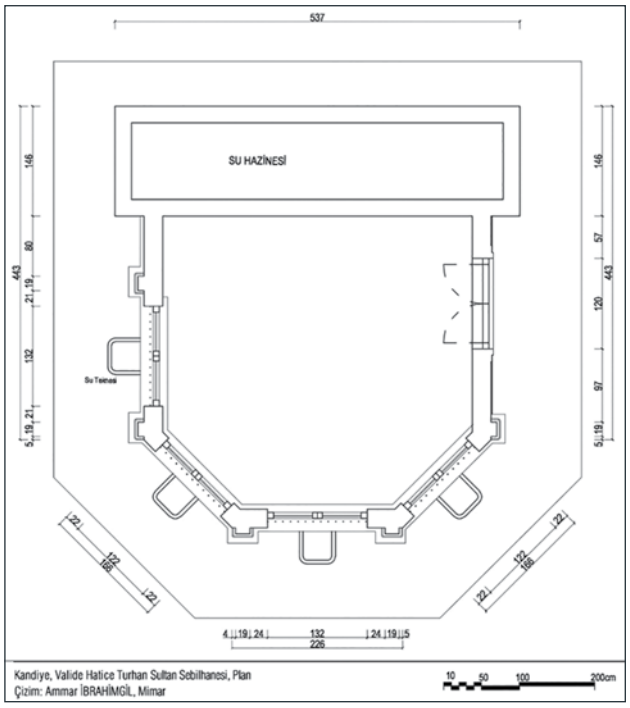

Figure 3. Turhan Sultan Sebilhanesi plan

2.2. Heraklion (Kandiye), Numan Pasha Sabilhane (1744)

The crisis of the state in the 17th century was overcome by the appointment of Koprulu Hafiz Mehmed Pasha as the grand vizier in 1657. Thus, it started the Koprululer period under the Ottoman administration, which would continue until Merzifonlu Kara Mustafa Pasha [28]. His son Koprulu Fazil Ahmet Pasha (d. 1676) conquered Heraklion and started Koprululer's relations with Crete. Fazil Numan Pasha (d. 1719, Heraklion), the eldest son of Fazil Ahmed Pasha's younger brother, Grand Vizier Mustafa Pasha, also served on the island three times as Heraklion guard. According to Orhan F. Koprulu, who published the inscriptions of the building, which has not survived to the present day, the possibility of having the fountain house built by the trustee of Fazil Ahmed Pasha foundations has been emphasized since the fountain was built 3 years before Fazil Numan Pasha started his duty [29]. In the article of Orhan Koprulu (1976), the current Turkish version of the inscription transferred from Mehmed Yunus (1920) is as follows (In related sources, it is stated that it cannot be read in places due to the destruction in the inscription):

"... / Cesme-i omri zaman havz-i hayat du-cehar (caresiz) / Lule-i ... acip ... kan akit / Gorke ... tesne-i dil oldu revan / Ta ki zulal-i nev ... atsan ede ol tesne-i dil / Ruhuna bu cesme-i sari vakf edub oldu ayan / Her kim icerse bugun ruhuna kilsin dua / Ola ki yarin bula rahmet Hak'ta mekan / Haif gaybi gelub soyledi tarihini / 'Cesme-i ab-i hayat oldu zehi [cuyu] revan' / 1115" (M. 1703-04)

Within foundations of Heraklion VGMA, in the document of Haci Huseyin School, in Notebook 994 page 36, the area between the Fazil Ahmet Pasha Mosque and the old provincial building is mentioned as Numan Pasha District [30]. According to Nikolaos Stavrinidis, the sabilhane, located on the right side of the old provincial building in today's Kallergon Square, was demolished in 1915 [31]. Numan Pasa Neighborhood described by the sources describes the apse side of Agios Titos Church, its current name. It is possible that a sabilhane structure under protection in the area used as a park between the Agios Titos Church and the old provincial building is related to the Numan Pasha Sabilhane.

Image 6. Protected fountain structure in the park between Agios Titos and the former provincial building

2.3. Heraklion (Kandiye), Yakasiz-zade Haci Mustafa Aga Sabilhane (1764)

Stavridis stated about the sabilhane that the building was built by Haci Mustafa Aga bin Mehmed Yakisiz-zade in 1764, near the Zekeriya Bey Mansion, on the north side of L. Kalokairinou Street, in the direction of the Old Chania Harbor. However, this building was demolished during the road construction works in 1915 [31]. In the foundation records regarding the Sabilhane, it is stated that Heraklion was built in the Bey District by the inhabitants of the Aga Mahallesi Mosque and by the merchant Yakasiz-zade Haci Mustafa Aga Bin Mehmet Aga. The summary of the endowment is as follows [32]:

"Yakasiz-zade Haci Mustafa Aga Bin Mehmet Aga, from the community of Aga District Mosque of Heraklion and merchant tradesmen, had built a sabilhane house in the Sivri Cesme Bazaar of Heraklion with a length of 14 zira (a scale about 70 cm), a width of 7 zira and a fountain nect to it. In order to cover the costs of the said sabilhane and the mosque built in Iskupla Village of Pezbe Sub-province of Heraklion, the Foundation donated the properties, features and numbers of which will be given below. According to the terms of the foundation, 25 kurush of the annual income of the real estates endowed would be given to the trustee of the foundation, 100 kurush for the expenses of bringing snow to the sabilhane in the summer, 15 kurush for the repair of the sabilhane and fountain waterways, 6 kurush for the suyolcu (repairman of fountain waterways). In addition, the foundation house adjacent to the Karagoz bakery in Heraklion was used for the settlement of the sabilhane worker (sebilci) and a salary of 30 kurush would be paid every year."

According to this, it is understood that the building is a large rectangular building measuring approximately 4x8m. A fountain was built right next to the building.

2.4. Heraklion (Kandiye), Koprulu Hafiz al-Hajj Ahmet Pasha Sabilhane (1768)

Orhan Koprulu, in his article published in 1976, based on the Heraklion sharia registry, narrates that Ebu'l jayr Hafiz el-Hajj Ahmed Pasha who was from Koprulu family and worked in Crete, worked as the Guardian of Heraklion in H. 1157 / AD. 1744 and H. 1170/ AD. 1756 [29]. In addition, based on the article of Mehmed Yunus (1920), it is stated that the sabilhane had three sides and inscriptions on each side. Accordingly, the first 6 lines of the inscription are on the facade facing Vezir Street, lines 7-10 on the facade facing the Harbor Gate Square and lines 11-15 are on the third facade. The current Turkish writing of the inscription is as follows [29]:

"1. Bismillahirramanirrahim

2. "Ve ce'alna mine'l-ma'i kulli sey'in hay"	(Kuran, Enbiya Suresi, 30. Ayet)
3. Cenab-i Asaf-i ali nesradin	Ulu himmeti fevka'l-aladir
4. Kopruluzade Makbul Salattin	Ebu'l-Hayr-i tekniye hakka sezadir
5. Vezir Ibnu'l-vezir Ibnu'l-vezirdir	Muselsel muttasil fermani revadir
6. Kerem-i mevrus bil zati cebbetli	Mahalliyle eder sahibu itadir
7. …	…
8. Yekun haci Ahmet Pasa zisan	Bab-i hayri ruhnumadir
9. Muyeser oldu Fethi kale-i nis	Olup ser-askeri yevmu'l gadir
10. Hele sad eyledi ecdadi	Denilmez mi bu hayra hos ceradir
11. Hususan ruh-i Numan musiri	Ogul yay sarabiyla sakadir
12. Yakin bildim bu hayr ettin hudusu	Kadumu yemin Sultan Mustafa'dir
13. Lebiben gel yeter hatm-i kelam et	Garaz tarihi bilinmek muntehadir
14. Sebil-i Hazret desturu kerem kem	Beyan tarihi guya nuvadir

15. Agiz bir eyleyib ikvan dirler / Safayi can veren atsana mader (sene 1182) /
Ketebe el-fakir Ahmet el-mazhar es-suhuri Hafiz kutbu El-Hac Ahmet / El-vezir el-Kopruluzade"

Stavrinidis also stated that this three-sided sabilhane was located between the Agios Titos Church and the harbor on the present-day 25 August Street and was destroyed in 1915 [31]. From the notes of a Kandiyeli scholar named Mehmed Yunus, it was stated that there were about 150 tombstones in the cemetery of Fazil Ahmet Pasha Mosque (Agios Titos Church) and up to ten people from the Koprulu family, one being the grand vizier, was enamoured. [29]. Thanks to the strong charitable foundations of Koprulu family in Heraklion, it is understood that a charity was made every period.

2.5. Heraklion (Kandiye)**,** Kalipsiz Ismail Aga Sebilhanesi (1792),

It was built on L. Kalokairinou Street in Heraklion, on the port side of Chania Harbor in H. 1207 / AD 1792 by Kalipsiz Ismail Aga bin Ali Aga. Built as a foundation property, the fountain was sold to the National Bank of Greece in 1926 and then demolished [31]. Although the inscription of the fountain house does not survive today, the inscription text of this sabilhane is located on the divan of Salacioglu Mustafa Celveti, one of the sheikhs of the Celveti order, who lived in Crete. The tomb of Salacioglu Mustafa Celveti, who lived between 1750 and 1850, is in Crete. The current Turkish writing of the inscription is as follows [33]:

"Rahmet olsun ruhuna kim etdi bu hayra kiyam /
Selsebilinden na'imin cani reyyan ola tam
Sohreti el-Hac Ismail Kalipsiz-zadedir /
Eylemisdi sa'yini takvaya cari subh u sam
Lucce-i tevfikina kildi ani mazhar Huda /
Akidip cud u sehaya oldu makbul-i enam
Bu mahalede tesnegana yog idi ma'dan eser /
Eyledi ihya ahalisinin sulandi has u'am
Nuh felek devriyle cikdim eyledim tarihini /
Al Husey'in 'askina nus eyle ani ey humam
Sene 1207" (M. 1792)

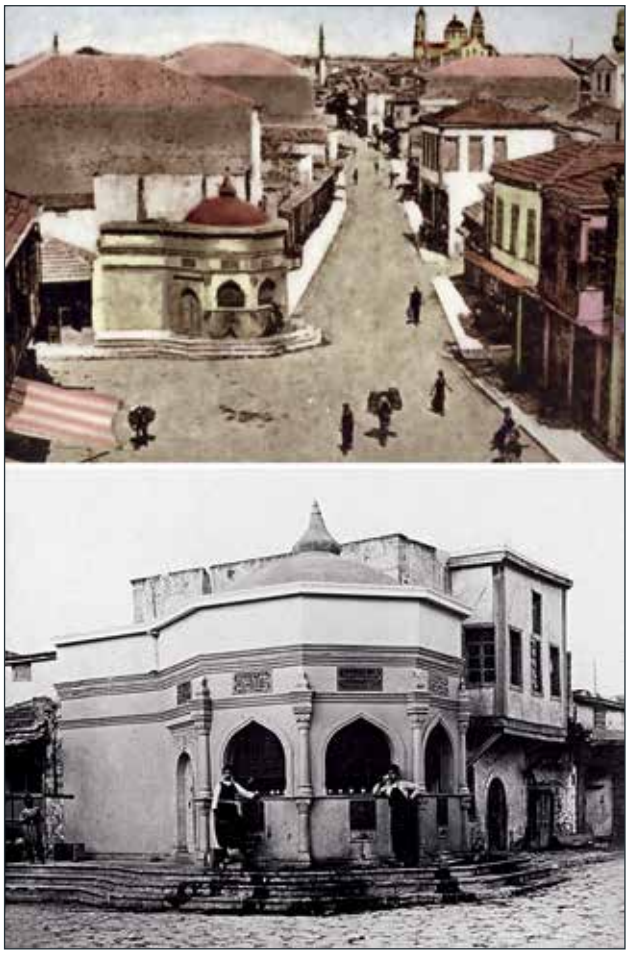

Image 7. Kalipsiz Ismail Aga Sabilhane in the 1900s (a-Stavrinídis, 1981, b-URL-1: T. Tzouliadakis)

2.6. Heraklion (Kandiye)**,** Sultan Abdulmecid Sebilhanesi (1847)

As the Ottoman Empire's influence in the Mediterranean increased, it started to put pressure on Crete. In this context, the defense and infrastructures of the cities were strengthened during the Venetian period. Major repair of the waterways of the city of Heraklion began in the Venetian period in 1625 with the Morosini aqueducts that brought the water of the Youktas mountain. This waterway, which fills the eastern cistern entering through the Jesus Gate in the city, extends to the Morosini Fountain [34]. In addition, a line has been built to reach the palace, bazaar and cathedral. However, when Heraklion was besieged and the Morosini waterway was destroyed, the water need of the city was met by the waterway built from the Bethlehem Bastion cistern on the west side of the city to the Priuli Fountain on the port side [34].

With the conquest of Heraklion, the area where the Morosini Fountain is located was transformed into the Pool Square with Evliya Celebi's description. Finally, before Sultan Abdulmecid's visit to Heraklion in 1850, the Cretan Guard Mustafa Nail Pasha added marble columns on the basement of the pool side of the Morosini Fountain and transformed the structure into a sabilhane in the name of Sultan Abdulmecid [34]. The fountain was discovered on the pool wall built in the Venetian period. The fountain has a flat cover. In addition, its inscription, which is wrapped around all facades, is gilded on marble. This sabilhane was disbanded after the withdrawal of Turkish soldiers from the island in 1898 [34]. The studies of Gerola (1905), who studied the island's waterways, and Stavrinidis (1969), who investigated the water structures on the island, are the most original studies on the island's waterways [35].

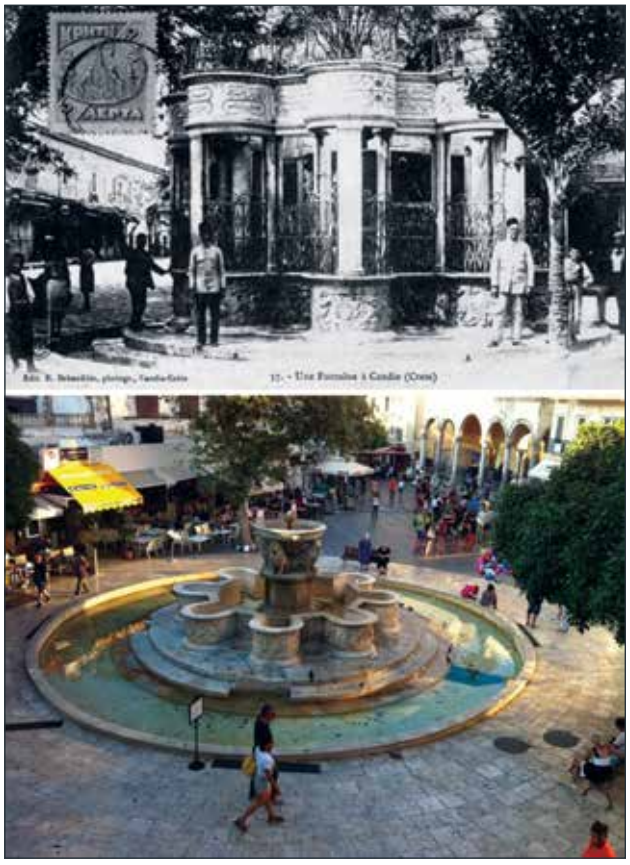

Image 8. Conversion of Morosini Fountain (1625) to Sultan Abdulmecid Sabilhane (1847) and current status (a- E. G. Chalkiadakis, b- URL2: Tripadvisor)

2.7. Chania, (Hanya), Sultan Ibrahim (Hunkar) Mosque (Cukur Cesme) Sabilhane (19th century)

Immediately after the conquest of Chania in 1645, St. Nikola Cathedral was converted into a mosque with the name of Sultan Ibrahim. The Public Mountain House was built in the courtyard of this mosque on the Cukur Cesme located in the 1821 Square. In R. 1299 / H. 1893, the list of foundations belonging to Muslims and their villages and other income was announced on the island. In this table, the revenues donated by the Sultan Ibrahim Foundation to charities built in Chania, Rethymno and Heraklion are mentioned [16]. The fact that there are charities belonging to the foundation in Heraklion, which was conquered 30 years after the death of Sultan Ibrahim, shows that the foundation grew and continued its investments. The sabilhane built opposite the Sultan Ibrahim (Hunkar) Mosque in Chania also strengthens the opinion that this fountain was built by this foundation. Although Chania was conquered in 1645, in the endowment of Sultan Ibrahim which was on the page 44 of the book dated 1753 and numbered 988, which was examined about Chania, the sabilhane was not mentioned, but Cukur Cesme that was under sabilhane and provided the water for the fountain was mentioned [36]. According to this, the sabilhane was built from Sultan Ibrahim's foundation on the eve of an important event, as in the Sultan Abdulmecid Publif Fountain House. The sabilhane at the entrance of Cukur Cesme, which resembles a small cistern, surrounded by stairs, was destroyed in the 1920s. Today, there are only columns and iron railings surrounding Cukur Cesme in the square.

When the archive photographs are examined, the sabilhane, which is seen to be made of stone, is an octagonal structure with oval edges. It consists of four sections separated from each other by moldings on the vertical. The corners of the first section up to the *eteklik* resemble an oval shaped square. The second section where the windows are located, the beam section where the inscription is placed and the last section with triangular pediment constitute the general form of the sabilhane. The top cover of the fountain is covered with a cone shaped roof made of ridges and streams ob-

tained by leaning on triangular pediments. With this top cover feature, it is the only example of a sabilhane that has reached today.

The semicircular arched window spaces of the sabilhane, which has no eaves, are divided into two by thin columns. The inscriptions on each surface of the plates in the form of circles or ellipses on the pediments of these windows with pointed arches indicate that the sabilhane belongs to an important person.

Image 9. Chania, Sultan Ibrahim (Hunkar) Mosque (Cukur Cesme) Sabilhane, 1905 (Archeological Museum)

2.8. Ierapetra (Yerapetra), Ali Makaronake Sabilhane (1872)

Yerapetra is a settlement located in the south of the region where the land is knuckled in the east of the island. It developed with the construction of fortresses and other defense structures with the conquest of the Ottoman Empire. According to the administrative division in 1868, Iarepetra is a center consisting of 16 villages in the Lasid Sanjak.

In order to improve the political situation and restore peace in Crete Island, which become an international problem as of the last quarter of the 19th century; Aleppa Agreement (1878) and the Crete Nevahi Regulations (1878) made, ensured the public to directly participate in the government. During this period, the successful political management of Sakir Pasha, Cevad Pasha and Mahmud Celaleddin Pasha, who served as governor in Crete, restored Ottoman authority on the island [37]. In the town, which is also called Prepetra in Ottoman sources, according to VGMA, 989th notebook, 99th page, in 1891, with the help of Cevat Pasha, Mahmud Celaleddin Pasha, the gendarmerie and the people of the island Hamidiye Mosque was built in the name of Sultan Abdulhamid Han II [38]. The fountain is located on the left side of this mosque. When the present size of the city and the dates of Ottoman works are examined, Yerapetra appears as a city where the Muslims in the south of the island, whose peace was disturbed at the end of the period due to the Greek revolts, came together. Two mosques in the city, a large school and two fountains, and the sabilhane house built by li Makaronake in 1289 / AD 1872 are the main works that have survived from the Ottoman period.

The outer walls of the fountain room are carved in an oval shape and semicircular niches are formed, and inside it is octagonal. The fountain room, which has an outer edge length of 120 cm, is made of smooth cut stone. There are column heads with plant motifs on the three-segmented columns that extend outward on the facade. It has a dome on a wide and protruding molding. The windows of the sabilhane, where different styles are used together, are made in an orientalist style with two levels and are finished with a pointy arch. However, the lack of skirting and door of the sabilhane is against the characteristic construction of these structures. On the other hand, there are also architectural features that are not seen in the typical fountain or sabilhane house structure. According to Stavridis, the building was repaired in the 1950s [24]. No data could be found to compare before and after repair. However, it was accepted as a sabilhane house due to the definition of a space that will contain a subject in the building.

The inscription made of marble in the form of a circle is on the south side of the sabilhane house. It is decorated with a dragon head motif emerg-

ing from moldings on both sides of the inscription. The Turkish writing of the epitaph of Sabilhane is as follows:

"Sahibu'l-hayrat ve talibu'l-hasenat / Makaronaki Ali En'amellahu / Bi-lutfehu'l-Celi / Sene 1289"

Image 10. Yarepetra, general view and epitaph of Ali Makaronake Sabilhane

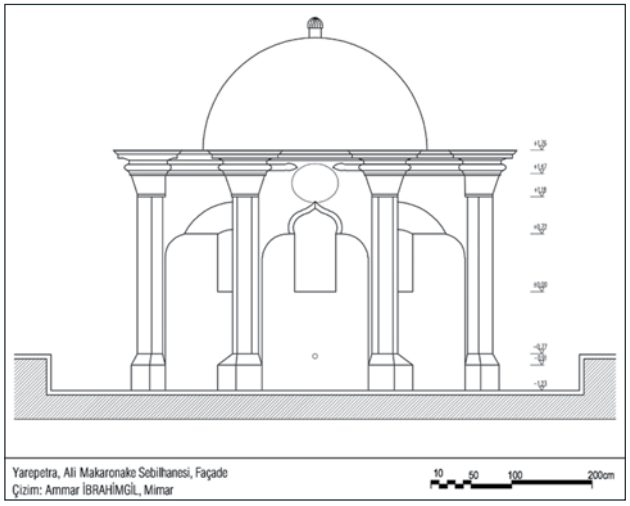

Figure 4. Yarepetra, general view and epitaph of Ali Makaronake Sabilhane

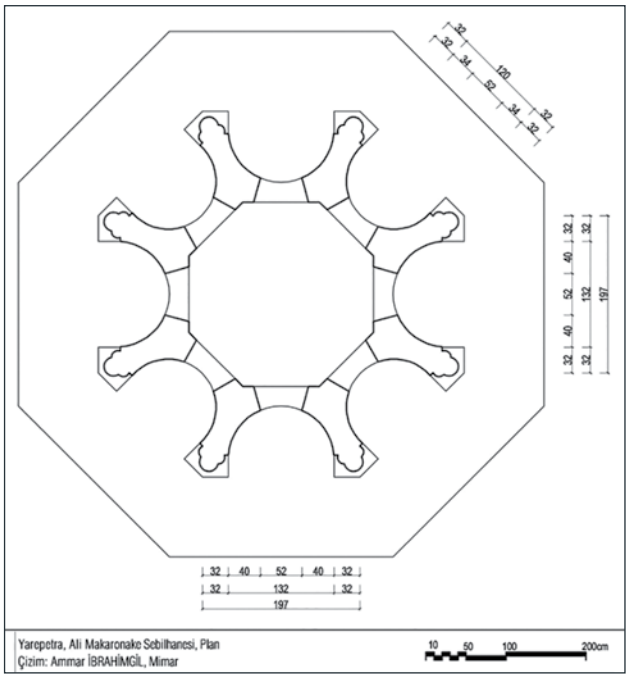

Figure 5. Yarepetra, general view and epitaph of Ali Makaronake Sabilhane House

3. Evaluation

There is no comprehensive source that examines the architecture of the sabilhane houses in a holistic manner. The reason for this is the abundance of these structures, which were built by the Seljuks, Mamluks and Ottomans, so by Turks who had seen this structure as a work of art itself, in different political boundaries, and the demolition of some of them over time and the changes made on the structure could not be traced. While evaluating the sabilhanes, this situation was taken into consideration and in order to preserve the integrity of the subject, the sabilhanes in Cairo and Istanbul, where the largest number of sabilhanes have reached today, were mentioned.

Sabilhanes in Cairo have developed differently in terms of architecture. Since the water was distributed on the ground floor and the upper floor was used as a Quran school, these buildings were called "sebil-kuttab". In Cairo, eight sabilhanes/Quran schools (sebil-kuttab) built by Mahmut I in 1750, Mustafa III in 1758, Rukiye Dudu in 1761, Ibrahim Bey el-Kebir in 1768, Nefise Beyza in 1796, Sergeant Ali Kethuda in 1797, Silahtar Suleyman Aga in 1837 and by Umm Abbas in 1867, coincide with the fountains in Crete [39]. The common feature of these structures is that they do not have a square-de-

fining feature and that their location is built inside, adjacent to, between, or beyond a larger building or courtyard wall. In this respect, except for Erzincanli Hasan (1830) and Ahmet Rifat Pasa (1864) sebil-kuttabs, all of them have an oval shape. On the other hand, in addition to the decoration of the facade with verses, under the influence of Westernization, floral motif ornaments and the use of tiles are also widely used.

The sabilhanes built in Istanbul reflect the common architectural style of their time. Major researches on this subject are made by Izzet Kumbaracilar. *Istanbul Fountains*" (1938) and Nur Urfalioglu's master thesis "*Istanbul Dispensers, Especially Uskudar Dispensers, Problems and Protection*i" (1989) [40] [41]. In addition to these two studies, numerous researches about ornamentation and other details have been carried out on 67 sabilhanes that have survived from nearly 130 fountains built in Istanbul. In the evaluation of the sabilhanes in Crete, the fountains built in recent times by the sultan, palace women and pashas were examined.

Among these, one was built by Hatice Turhan Sultan in 1663 within the program of Yeni Cami Kulliye, with Classical Ottoman style features. It was built as a large rectangular structure adjacent to the darulkurra structure, which is not standing today. On the left side of the building, the windowed part where the food is served is carried to the road. The fountain is in a large niche right next to this part. The large reinforced eaves with buttresses are the most striking feature of the building. This sabilhane house was damaged in a fire in 1906 and it was decided by the Ministry of Foundations to be renovated in accordance with the original. The inscription that has survived to the present day was rewritten in style of (*jali thuluth*) as signed by Calligrapher Sami Efendi in 1907 [42]. The 30th verse of Surah Anbiya is inscribed on the wall of the sabilhane house, which was used as a fountain, as in the sabilhane house in Crete [43]. After the Tulip Period, the influence of the Baroque-Rococo style began to be seen. This style difference is most quickly seen in the sabilhane house and fountain architecture. The forehead, which was kept quite wide in the Tulip Period, is not wider than the *eteklik* in this period [44].

The Hagia Sophia Sabilhane, built in the reign of Mahmut I (1730-1754) in 1740, has a rectangular plan adjacent to the Hagia Sophia Mosque wall. It is differentiated from other sabilhanes with its porch with columns. However, Mehmet Emin Aga Sabilhane, built in 1741 opposite the Dolmabahce Mosque, is regarded as the first sabilhane built in baroque style [45]. In Laleli, built on the street level by Sultan Mustafa III in 1762, the sabilhane draws attention with its thin columns separating the high windows, wide sliced eave and dense decoration [46]. The sabilhane, built by Mihrisah Valide Sultan in 1794, is the most popular structure example of the Baroque-Rococo style. There are fountains made of monolithic marble blocks on the sides of the sabilhane house, which comes out in the form of a semicircle. During this period, the plan setup of the sabilhanes was moved from the corner to the symmetrical center of the structure. Concave and convex curved lines in the plan plane are the decoration tools that stand out. Mahmut II period (1808-1839) was a period during which radical political and social changes were experienced in the Ottoman Empire. This also had reflections on the architecture. In 1840, the sabilhane, built next to the tomb in the name of Mahmut the II, is considered an important Tanzimat period monument showing French influence in architecture [45]. It is in the form of a circle in empire style and stands out with its high and thick columns. The sabilhane, which has no eaves, is roofed with a dome.

4. Conclusion

In terms of architectural style, one of the fountains built in Crete corresponds to the Classical Ottoman period, four to the baroque-rococo period and the other three to the empire period. In this respect, it cannot be said that the sabilhanes in Crete directly reflect the architectural styles in Cairo and Istanbul. It is mostly aimed at meeting the water needs of the neighborhood where they are located in a fixed layout scheme. Accordingly, the priority of meeting the water requirement and receiving blessings rather than the architectural design and patronage effect in the sabilhanes has been preserved.

The fact that most of the fountains built during the Ottoman period are in Heraklion and that the waterways are constantly repaired and maintained,

was because Heraklion had always been a crowded city. On the other hand, the construction of a sabilhane, even in a late date, when political unrest was high, such as 1872, and at an extreme point of the island, can be regarded as a reflection of the feelings of social solidarity, national solidarity and compassion of the Muslim population in Crete.

The sabilhanes spread throughout the city in Heraklion display a homogeneous distribution in the settlement texture. The dates of construction and location of the fountains are not in a region of the settlement area, the Yaksizzade Haci Mustafa Aga Sabilhane (1764) and the Koprulu Hafiz El-Hac Ahmet Pasa Sabilhane (1768) are far from each other and are fed from different water sources. The most striking situation in the location of the fountains is the effect of the Morosini waterway extended from the east side of the city to the harbor. Valide Hatice Turhan Sultan (1672), Koprulu Numan Pasha (1744), Ismail Aga without Pattern (1792), Koprulu Hafiz El-Hac Ahmet Pasha (1768) are the fountains built on this line. Finally, in 1847, Morosini Fountain was transformed into a sabilhane in the name of Sultan Abdulmecit. Among the sabilhane structures, only the Yakisizzade Haci Mustafa Aga Sabilhane House (Sabilhanesi) (1764) is fed by the water coming from the city's western cistern.

In the typological analysis of the fountains, Valide Turhan Hatice Sultan Sabilhanesi (1672) reflects the classical period with its regular polygonal plan, wide eaves, ornaments on the plates, while the column capitals and arch form reflect the traces of the baroque period. In the Kalipsiz Ismail Aga Sabilhanesi (1792), the column heads with plant motifs are the most important architectural elements that reflect the period characteristic. The arches are still in the classical period form. Sultan Abdulmecid Sabilhanesi (1847), on the other hand, reflects the traces of the empire period with its simple but heavy formation. The height of the columns and the simplicity of the head decoration are the most typical features of the fountain. Sultan Ibrahim Mosque Sabilhane (1847) has an eclectic style. The unadorned legs of the fountain are tied with arches bent outward. Between the arches, double belts in long, thin and pointed form resembling the gothic style, were made. In the middle of this double arch, plates in the form of a circle are placed. The plain column heads of the fountain house reach the thin flat pediment where the inscription is located. A second triangular pediment was built on the thin flat pediment, on which the roof rests. In the light of all this information, it cannot be said that the sabilhanes in Crete fully reflect the characteristic period features seen in the

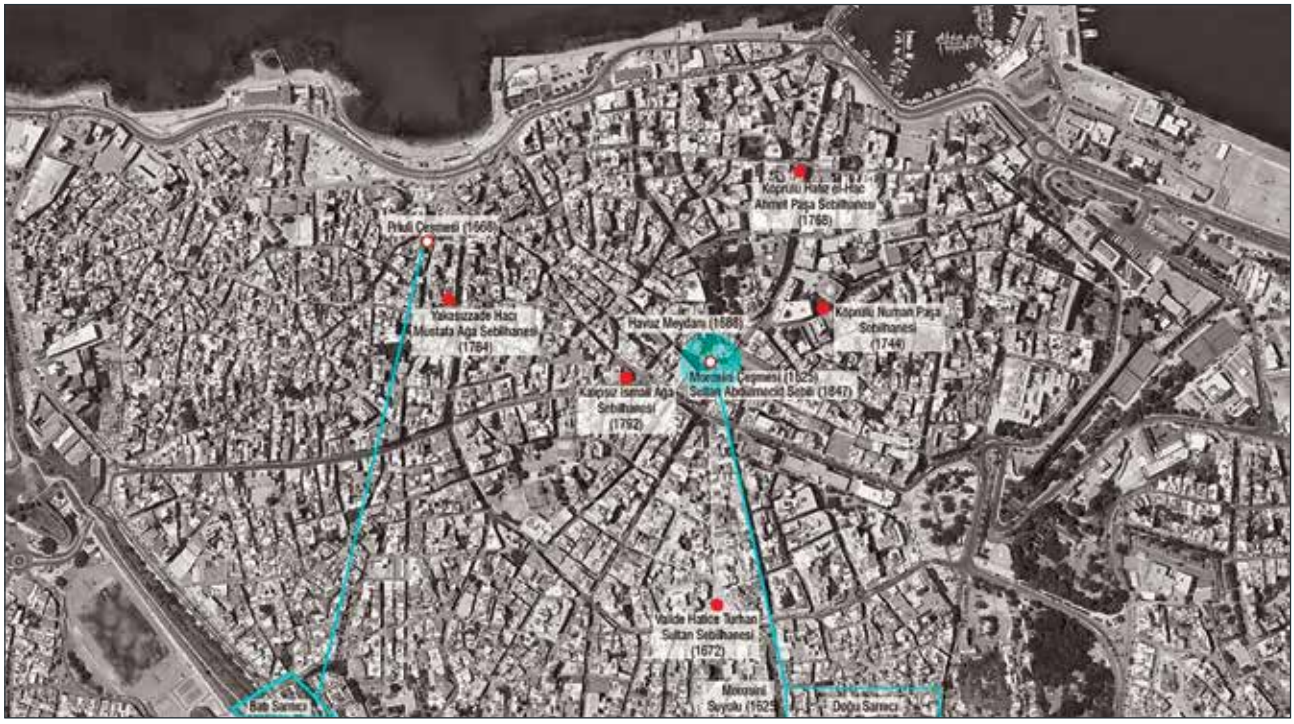

Figure 6. Distribution between waterways and water structures of Heraklion

sabilhanes in Istanbul or Cairo. It is understood that periodic interventions were made on generally known forms on a structural element scale.

Another feature of the fountains is related to their positioning on their location. While most of the sabilhanes are programmed in one structure group integrated to another building, there are also those that define a square in a separate way. Valide Turhan Hatice Sultan Sabilhane (1672), Sultan Abdulmecid Sabilhane (1847), Sultan Ibrahim Mosque Sabilhane (1847), Ali Makaronake Sabilhane (1872) are examples of sabilhanes built separately. Numan Pasha Sabilhane (1744), Ahmed Pasha Sabilhane (1759), Haci Mustafa Aga Sabilhane (1764), Kalipsiz Ismail Aga Sabilhane (1792) were built adjacent to various buildings.

The physical formation of the fountains has been examined under three headings. The most important spatial feature for the sabilhane, the number of facades, which are the windows that provide permeability between the interior and the exterior, the window plan shape and the top cover of the building were examined. While Sultan Abdulmecid Sabilhanesi (1847) and Ali Makaronake Sabilhane (1872) have doors / windows on each facade, this permeability is provided in the corners or on one surface in other sabilhanes. While the window plans for the catering function are Valide Turhan Hatice Sultan Sabilhane (1672), Kalipsiz Ismail Aga Sabilhane (1792) and Sultan Ibrahim Mosque (1847) without a pattern, the Sultan Abdulmecid Sabilhane (1847) has an undulating plan. Ali Makaronake Sabilhanesi (1872) has a concave partition plan. The fact that the Numan Pasha Sabilhanesi (1744), which does not have any traces of image, is described adjacent to the province building in written sources, and the fact that the Ahmed Pasha Sabilhanesi (1759) has three facades in documents indicates that these structures are also in regular polygonal plan. On the other hand, it is stated in the documents for the Yaksizzade Haci Mustafa Aga Sabilhanesi (1764)that it is a structure of 7 x 14 zira in the bazaar, and the fact that there is a fountain next to it, shows that this structure can be a rectangular like Hagia Sophia Fountain (1740) or it can be formed like Damat Ibrahim Pasha Sabilhanesi as well (1719), because of this, the window was excluded from the plan typology.

The top covers of the sabilhanes in Crete are of three different types: dome, hipped roof and flat / terrace. While the top cover of the Valide Turhan Hatice Sultan Sabilhane (1672), the Kalipsiz Ismail Aga Sabilhane (1792) and the Ali Makaronake Sabilhane (1872) is a dome, the Sultan Ibrahim Mosque (1847) has a segmented hipped roof which is unique. Sultan Abdulmecid Fountain (1847) was built as a flat / terrace roof, as it was built using the walls of the Morosini pool. The carriers of the window parts on the facades where they reflect the most characteristic features of the sabilhanes were examined under five headings: arch type, skirt type, column capital and eaves type. According to this, for Valide Turhan Hatice Sultan Sabilhane (1672), Kalipsiz Ismail Aga Sabilhane (1792) and Sultan Abdulmecid Sabilhane (1847) columns stand out. Sultan Ibrahim Mosque Sabilhane (1847) and Ali Makaronake Sabilhane (1872) have foot carriers made with masonry system.

There are several types of window shaping of sabilhanes. Kalipsiz Ismail Aga Sabilhane (1792) and Sultan Ibrahim Mosque (1847) has pointed arches, Ali Makaronake Sabilhane (1872) with sliced arches, Valide Turhan Hatice Sultan Sabilhanesi (1672) with semicircular arches and finally, Sultan Abdulmecid Sabilhane (1847) with flat lintels. The *eteklik* part, which is an important structure element in the construction of the sabilhanes, varies according to the periods. Most of the fountains built in Crete do not have a wide and oval skirt typical of the baroque period. Valide Turhan Hatice Sultan Sabilhane (1672), Kalipsiz Ismail Aga Sabilhane (1792) and Sultan Ibrahim Mosque Sabilhane (1847) are flat-sided, although they were built in different periods. Sultan Abdulmecid Fountain (1847), on the other hand, has a round form as it uses the pool walls of the Morosini Fountain as a skirt. There is no clear information about the original condition of Ali Makaronake Sabilhanesi (1872). However, it was accepted as an unskirted sabilhane.

Column capitals are one of the most easily reflected elements in architecture. According to this, while Valide Turhan Hatice Sultan Sabilhanesi (1672), Kalipsiz Ismail Aga Sabilhane (1792) and Ali Makaronake Sabilhane (1872) reflects the baroque period with floral motifs, Sultan Abdulmecid Sabilhane (1847) and Sultan Ibrahim Mosque Sabilhanesi (1847) reflect empire style with their simple capital. One of the most obvious features in Ottoman architectural styles is observed in the

Table 2. Typological Analysis Table of Crete Sabilhanes

A. By Their Location		
1. Detached	Valide Turhan Hatice Sultan Sebilhanesi (1672), Sultan Abdulmecid Sebilhanesi (1847), Sultan Ibrahim Cami Sebilhanesi (1847), Ali Makaronake Sebilhanesi (1872)	
2. Integrated	Numan Pasa Sebilhanesi (1744), Ahmed Pasa Sebilhanesi (1759), Haci Mustafa Aga Sebilhanesi (1764), Kalipsiz Ismail Aga Sebilhanesi (1792)	
B. By Physical Formation		
1. Door / Window Facades	a. Every Front	Sultan Abdulmecid Sebilhanesi (1847), Ali Makaronake Sebilhanesi (1872)
	b. Certain Fronts	Valide Turhan Hatice Sultan Sebilhanesi (1672), Ahmed Pasa Sebilhanesi (1759), Kalipsiz Ismail Aga Sebilhanesi (1792), Sultan Ibrahim Cami Sebilhanesi (1847)
2. Plan Type	a. Regular Polygon	Valide Turhan Hatice Sultan Sebilhanesi (1672), Ahmed Pasa Sebilhanesi (1759), Haci Mustafa Aga Sebilhanesi (1764), Kalipsiz Ismail Aga Sebilhanesi (1792), Sultan Abdulmecid Sebilhanesi (1847),
	b. Wavy	Sultan Ibrahim Cami Sebilhanesi (1847),
	c. Concave Partitioned	Ali Makaronake Sebilhanesi (1872)
3. Top Cover	a. Dome	Valide Turhan Hatice Sultan Sebilhanesi (1672), Kalipsiz Ismail Aga Sebilhanesi (1792), Ali Makaronake Sebilhanesi (1872)
	b. Roof	Ahmed Pasa Sebilhanesi (1759), Sultan Ibrahim Cami Sebilhanesi (1847)
	c. Every Front	Sultan Abdulmecid Sebilhanesi (1847)
C. By FacadeType		
1. Structure	a. Column	Valide Turhan Hatice Sultan Sebilhanesi (1672), Kalipsiz Ismail Aga Sebilhanesi (1792), Sultan Abdulmecid Sebilhanesi (1847),
	b. Foot	Sultan Ibrahim Cami Sebilhanesi (1847), Ali Makaronake Sebilhanesi (1872)
2. Arch Type	a. Pointed	Kalipsiz Ismail Aga Sebilhanesi (1792), Sultan Ibrahim Cami Sebilhanesi (1847)
	b. Cusped	Ali Makaronake Sebilhanesi (1872)
	c. Half Circle	Valide Turhan Hatice Sultan Sebilhanesi (1672),
	d. Lento/Flat	Sultan Abdulmecid Sebilhanesi (1847),
3. Eteklik	a. Flat	Valide Turhan Hatice Sultan Sebilhanesi (1672), Kalipsiz Ismail Aga Sebilhanesi (1792), Sultan Ibrahim Cami Sebilhanesi (1847)
	b. Round	Sultan Abdulmecid Sebilhanesi (1847)
	c. Without Eteklik	Ali Makaronake Sebilhanesi (1872)
4. Column capital	a. Baroque	Valide Turhan Hatice Sultan Sebilhanesi (1672), Kalipsiz Ismail Aga Sebilhanesi (1792), Ali Makaronake Sebilhanesi (1872)
	b. Imperial	Sultan Abdulmecid Sebilhanesi (1847), Sultan Ibrahim Cami Sebilhanesi (1847)
5. Fringe Type	a. No fringe	Sultan Abdulmecid Sebilhanesi (1847), Sultan Ibrahim Cami Sebilhanesi (1847), Ali Makaronake Sebilhanesi (1872), Kalipsiz Ismail Aga Sebilhanesi (1792),
	b. Wider	Valide Turhan Hatice Sultan Sebilhanesi (1672),

formation of eaves elements. The size and shape of the eaves changed according to the periods. The wide eaves and oval or segmented eaves that were common in the Baroque period were not observed in Crete. Sultan Abdulmecid Sabilhane (1847), Sultan Ibrahim Mosque Sabilhane (1847), Ali Makaronake Sabilhane (1872) and Kalipsiz Ismail Aga Public School (1792) was built without fringes. In Valide Turhan Hatice Sultan Sabilhanesi (1672), which is built with wide fringes, the simple formation of the classical period wide eaves is seen rather than the baroque style.

The article examined eight sabilhanes on Crete Island, six in Heraklion, one in Chania and one in Yarepetra. Among these eight sabilhanes, Valide Hatice Turhan Sultan Sabilhanesi, built in 1672, has the closest date. The latest one is Ali Makaronake Sabilhanesi, built in 1872 in Yarepetra. Six other sabilhanes except these two, was demolished after 1915 for various excuses. Construction dates and builders of eight sabilhanes in Crete have been determined precisely. According to this, the builder of the two sabilhanes is the sultan, one is the governor sultan, two are the pasha from the Koprulu family, and the other three are from the Cretan notables. The disappearance of the foundations of the post-Ottoman sabilhanes caused their functions to be lost to a great extent.

It is very striking that this number of sabilhanes were built on Crete Island, which was an important stop in the middle of the Mediterranean in Ottoman geography. It shows that Crete has a unique character with its social and cultural structure.

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High-rise building construction technology

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Abstract

High-rise building construction requires new approach so as to enable performances needed in buildings of this type. The new approach calls for enhancements in construction technology and the logistical arrangements. Besides this, ecology may shed a new light to the design, construction process, and the satisfaction of the future users of high-rise facilities. The sustainability is another important issue in the world of high-rise buildings. Worldwide, there are technological innovations and achievements reached on daily bases, thus sustainable concepts and applicable technologies for decreasing energy consumption and the emission of CO^2 have to be utilised. This paper is to present structural and architectural technological solutions applied in the high- rise building construction and the technological development prospects opened in this field. High-rise construction has always relied on technological innovations in engineering. Technological innovations used in high-rise building construction manifest in various aspects: geometric shape, foundation, construction pit protection, vertical and horizontal construction, materials, vibration damping systems and energy efficiency. In the design of different architectural forms, determining the relationship between the building shape and the quality of its construction is an important aspect. A high-rise building, due to its shape, can be very prominent and recognisable feature in the urbanity layout. Complex shapes and requirements arising from the height of buildings cause an increase in the structural elements load. The building responds to earthquakes with sinusoidal vibrations. In order to counteract both these forces and the wind-load, in addition to the rigidity of the construction, very advanced vibration damping devices technologies are used.

Key words: *high-rise buildings, development, clients, differences between continents, innovations, ecology*

1. Construction pits – Construction and the Protection

A construction pit is a space where a foundation is constructed, as well as horizontal and vertical elements of the building subterrain stories. The construction pit space must provide for the accessibility for the machinery and workers, but primarily it must ensure safety of the workers and the material means used in the construction process. The choice of the construction pit depends on the building to be constructed, the building site and the soil features, presence of groundwater, and different other factors. Construction pit design and construction must ensure its stability and waterproof performance, meaning preventing water penetration. Preventing water penetration is the key feature in the construction pit protection design, because deep construction pits can be irreversibly affected by groundwater in sense of compromising stability of the pit walls and the safety of the workers. The construction pit becomes a geotechnical structure in cases where there are more unfavorable circumstances faced, in whic case it is necessary to develop its own special project design. In the paper we shall present and explain several solutions for the construction pits' building and protection will be presented and explained, namely soultions of: reinforced concrete diaphragms, reinforced concrete piles and top-down method, jet pour. [1]

Permanent protection implies that the constructed structure remains in the ground as a separate structure, but also often as a load-bearing part of the structure of the future building in the form of a kind of permanent wall. The choice of construction pit protection method depends on the geological characteristics of the soil, the depth of the pit excavation and the level of groundwater.

1.1. Reinforced Concrete Diaphragm

The diaphragm is reinforced-concrete continuous wall constructed in soil and is applied as a

protective element in construction pits, as a construction structure element, as a land slide remedy structure, as a separating structure between main subterrain facilities, as a anti-filtration screen etc. The construction includes the excavation of a trench under the protection of a bentonite support suspension, installation of designed reinforcement basket, and Preplaced Aggregate Technology placing of concrete to form the wall.

The designed or constructed reinforced concrete diaphragm must withstand the active load of the surrounding soil and the hydrostatic pressure. Horizontal loads are taken and distributed on anchor-shaped turnbuckles anchored in the surrounding ground. The walls are made of successive elements of 2.5 to 5 m in length, thus even sides are constructed first and then the odd ones. Diaphragms/ the slurry walls are made as waterproofing element and are designed to reach very great depth -greater than 30 meters.

In sense of diaphragm construction, we differentiate several phases and typical sequence of work includes:

- Construct the guide wall
- Excavation to form the diaphragm wall trench
- Inserting reinforcement
- Placing concrete filler /Concreting
- Finishing the wall top. [2]

Guide wall construction is done before the excavations. Two parallel lightly reinforced-concrete walls of up to 100 cm high are constructed so that their top is levelled with the surface. The size of the future diaphragm dictates the space between these walls. [1]

Trench excavation – In normal soil condition excavation is done using a clamshell or grab, or by use of trenching drum cutter excavator if the soil contains soft boulders and rocks. The latter, called the spoil is than mixed into the slurry. [2]

Inserting reinforcement means placement of prefabricated reinforcement cage that cosists of horisontal reinforcement grid to which main reinforcement grid is welded. Main reinforcement is installed on both sides of the cage. The distancers are necesarry to be installed to so as to secure the protective layer of concrete; reccomended layer is aproximately 10cm. [1]

Concreting – placing of concrete is done using tremie pipes. The pipe initially touches only the bottom of the excavation to avoid the segregation of concrete. As concrete being poured down, bentonite from slurry gets displaced due to its lower density than concrete. Concreting step must be executed in line with the technical prescript and as an uninterrupted step. [1]

Finishing - Finishing involves removing the top of the concreted diaphragm because a 0.5 to 0.8 m bad layer appears at the top of the diaphragm, which needs to be removed. Sometimes parts of the diaphragm are connected by a capping reinforced concrete beam [1]

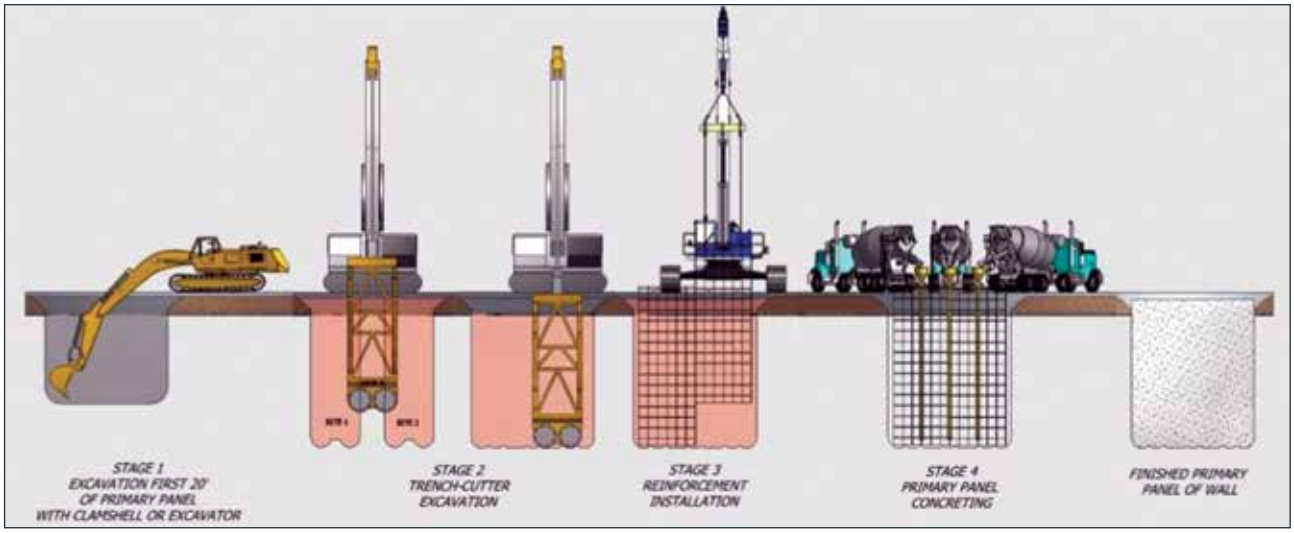

Figure 1. The Diaphragm Construction Technology [3]

1.2. Reinforced Concrete Piles

Loads and supports execution involve the construction of reinforced (tangent pile and /or bored pile) and non-reinforced piles (pylons) that may or may not be intersecting to form a protective wall. This wall can be additionally supported by ground anchors or internal supports. The process begins with the construction of a guide that sets the patterns for the pylons. This is followed by the construction of non-reinforced piles with a space between them for the later construction of a reinforced pile. The reinforced column is drilled between two non-reinforced piles, which creates an interlocking pile wall of piles with and without the reinforcement. The secant wall is most suitable for the soil profile where the water level is high or if there are additional loads on the active sides.

Another system of wall piles for support are adjacent piles that represent a reinforced piles wall where the piles are closely spaced but do not overlap (Tangent Pile Wall). Adjacent piles are suitable for soil where the water level is not high or it is regulated/ lowered down by proper drainage.

Both systems are additionally reinforced with a capping or the head beam construction that, as a single monolithic reinforced concrete beam, connects all the piles. The safety and continuous walls of the piles have both anchors and supports /bracing that provide them with lateral support.

1.3. Geotechnical anchoring

Geotechnical or ground anchors are a special element within geotechnical structures used to enhance and strengthen the natural terrain behind the soil profile or the protective structures set for the protection of the construction pit with reinforced concrete diaphragms or piles. The anchors transfer the tensile force from the structure to the surrounding soil. [5]

To elect a proper anchor, it is necessary to define basic anchoring elements which are:

- Part of rock or the soil that enables secure transfer of force from the anchor to the ground,
- Value of the force that the anchor takes on,
- Type and durability and the dimensions/size of the anchor chosen,
- Anchor Execution approach/method,
- The anchor prestressing programme, and
- Handover and testing of the executed anchors.

Executing complete geotechnical anchor/ground anchor can be divided into four main operations:

- Drilling,
- Manufacturing, transporting, storage, assembly and installation of anchors,
- Consolidation grouting, and
- Prestressing.

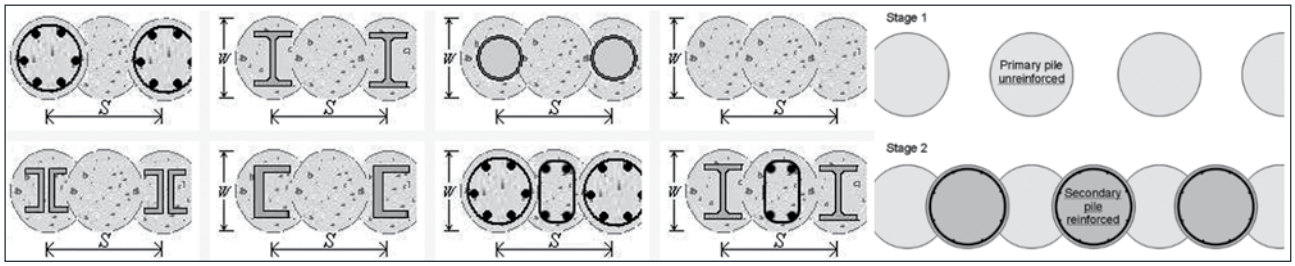

Figure 2. Overview of order and methods of reinforced piles execution [4]

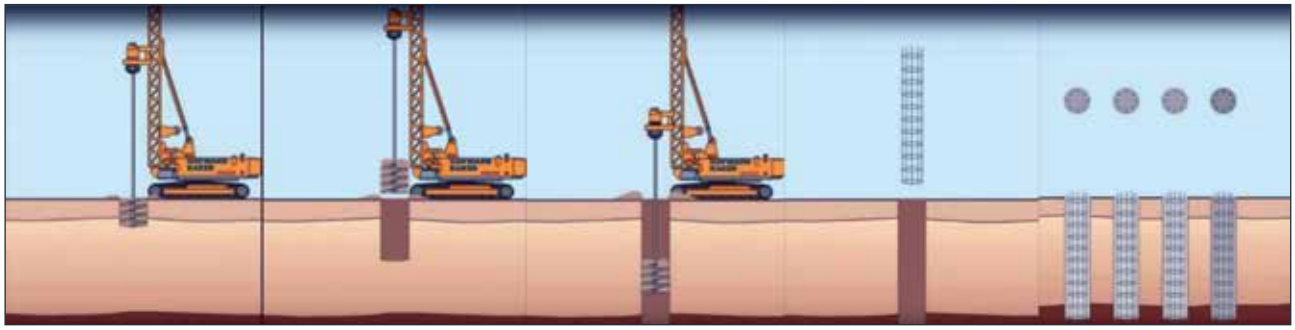

Figure 3. The technology of reinforced concrete piles used in excavation and protection of construction pits [4]

1.4. Top–down method

The top-down method of excavation and protection of a construction pit is a newer technological method used in special cases. This method, instead of geotechnical anchors, uses using ceiling panels propping approach. Some advantages of this method are:

- Safety, in sense of elimination of the impact of neighbouring buildings,
- Saving time, due to the elimination of time required for the anchors' execution,
- The diaphragm constructed is also utilized as the perimeter walls of the subterrain part of the building and
- Cost and time savings on execution of monolithic support plates at levels with propping

It has to be noted that this method requires high precision of the construction of steel rods that are installed in the piles, as well as the precise design of the diaphragm and the installation of permanent connecting elements containing sealing strips. The great advantage of the method is prospect of performing works on the underground and aboveground part of the building at the same time. [1]

After diaphragm works are finished, the pit gets excavated. The difference of this method is in the fact that after the pit excavation next step is drilling for piles and pillars and the installation of these elements. The piles take on the load until the panel is finished, upon which they act synergistically. After the installation is done, a ceiling slab concreting formwork is added, and if need be with an opening for evacuation of the excavated materials. The piles teak on whole of the load until the foundation slab is built, after which the elements act in synergy. In the subterrain section of the building there are openings left so as to assist evacuation of the excavated materials out but also used to transport building materials in. These openings also serve as airing during the construction. Upon first ceiling slab concreting, the works move a storey down, which is done by machines through the opening in the slab constructed.

The excavation of the next underground level/ storey starts below that ceiling slab. After excavation work under the ceiling slab is done to the required depth and the excavated material transported out of the construction pit, the construction of the next ceiling slab commences. This can be done in two ways, one way is that the slab formwork be placed on the ground itself, and the other way is that the ceiling slab formwork is performed by means of suspensions attached to the ceiling slab of the upper storey. [1]

2. Technology and formworks for execution of reinforced concrete structure

Formwork is usually a temporary structure; constructed for a targeted purpose it is used for a limited time. To claim that the formwork is of an optimum design and construction, it must be able to take on and withhold the load of fresh concrete slurry, vibrations, and its own deadweight. Under the load pressure it has to remain unchanged in its designed shape and form - meaning without deformations such as bulges or deflections, because high-rise building construction may be very challenging, and in some cases of twist-towers, the construction is not the same on any of the stories.

2.1. Formwork election criteria

In order for the formwork system to be rational and economical, it is necessary to make a formwork design to guarantee a safe, efficient and rational solution that guarantees a shortened technological cycle and fast construction of the facility. When choosing a formwork system, one should take into

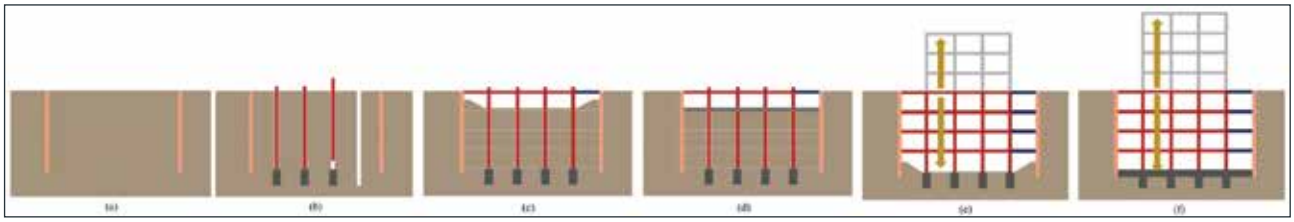

Figure 4. Top-down method in steps [6]

account the flexibility and modularity of the system due to the savings in the work-hours fund (construction deadline agreed) and its adaptability to changes in the geometry of the building structure.

2.2. Formwork classification

Formwork can be classified according to several criteria, but the basic division is usually according to the construction type, construction technology and material from which the formwork is made.

The basic division of formwork is:

- Formwork for vertical structures, and
- Formwork for horizontal and slightly inclined slabs.

2.2.1. Formwork for vertical structures

Formwork for vertical load-bearing structure construction is technologically advanced demanding equipment in terms of criteria that must be met by both the formwork and the load-bearing structure. There are several technological solutions for formwork used in executing vertical structures – from small portable formwork used for construction of column and walls, to large deck /slip forming sliding formwork.

2.2.1.1. Technologies with large portable form work systems

This technology is characteristic for the fact that large portable formwork gets prefabricated in a central plant and is then transported to the construction site where it, by use of cranes, gets mounted at the exact point of use. The formwork is up to 50 m^2 in size and occupies a large storage space on the construction site, and it requires cranes of certain capacities due to the heavy weight. The number of uses (re-use quota) is from 100 to 300 applications, depending on the maintenance quality. The formwork consists of a cladding and a load-bearing structure that does not disassemble during use unless repair or regular maintenance is required. The structure is usually made of metal, composed of lattice girders or "U" profiles, and the cladding is made of engineered wood boards.

2.2.1.2. Technology with small portable formwork systems

This technology is characterized by prefabricated formwork panels with load-bearing frames made of metal, aluminium, synthetic or steel, and the cladding made of prefabricated engineered wood or synthetic materials. The panels have standard heights of one storey, and different widths in order to adapt to the floor plan of load-bearing and the partition walls. This formwork, with its flexibility, enables "formwork" and the production of walls of different lengths and thicknesses. The number of uses is up to 300 times, providing regular maintenance is done. Super-lightweight formwork is also patented; made from innovative polymer-based composite materials. The formwork is easy to manipulate and transfer, easy to assemble and solved all the details of the connections and profile pieces.

2.2.1.3. Climbing, sliding and lifting formwork

More efficient and easier construction of high-rise buildings have been enabled by inventions such as sliding and lifting formwork, concrete pumping, and the use of high-capacity cranes. Sliding formwork enables faster construction of slender buildings, and shortens technological breaks in construction cycles. This type of formwork enables "sliding" over the built-in concrete, while keeping the thickness of the concrete along the entire circumference the same, which means - it is possible to work continuously on the building, especially on those of the correct basis, with a pronounced height dimension.

Climbing formwork means large dimensions formwork for walls that depends on the capacity of tower cranes, so they are transferred from one work front to another. This type of formwork is applied in the form of products adjusted for being transferred from position to position by means of cranes or hydraulic presses. The biggest advantage is its flexibility and stability at heights, due to the working ties/clips. [7]

Climbing formwork is a prefabricated formwork that can be assembled and disassembled used for the construction of walls of high-rise buildings where the walls must be executed in a continuous form along the entire height. The formwork is mounted and dismounted in the height section of

the wall. The climbing formwork system consists of a climbing console that is anchored to the lower already concreted part of the wall. A work platform can be hung on the console for possible repair and subsequent finishing of the walls. The transfer of the climbing console and other formwork elements, together with the hanging working platform and the scaffolding on top of the formwork element, is done by means of a crane or some other source for elevating it. This system enabled that both sides of the wall are executed simultaneously. The work is usually divided into 3 phases: first a certain height section of the wall is made, then the upper part of the formwork is separated from the wall for cleaning and inspection, and finally the whole system is raised to the next section.

2.2.2. Formwork for horizontal structures

Formwork structures used for horizontal reinforced concrete slabs construction are made as pre-prepared modular sets in the dimensions of the grid of vertical load-bearing elements. They can be made as light and smaller dimensions or as heavy assemblies of formwork tables.

2.2.2.1. Formwork system of small panel form work elements

Formwork structure is built by elements of small dimensions which are set in pre-prepared casings arranged as per designed layout. The casings are commonly adjustable and made in metal, and rely on especially designed vertical supports that enable early removal of the formwork claddings at the same time acting as a support to the finished horizontal structure.

Formwork made of small portable panels with especially designed system of horizontal casings made in wood or metal, and metal support elements which enable for early removal of the formwork at the same time acting as a support to the finished ceiling structure.

2.2.2.2. Table Formwork System

A table form/flying form is a large pre-assembled formwork for reinforced concrete slabs, often in predefined size matching the distance between load-bearing vertical structures (pillars or walls) forming a complete bay of floor slab. When de-

Figure 5. Self-climbing Formwork Platforms [8]

fining size/dimensions of the table formwork it is necessary to take into account manoeuvring and vertical transport, lifting to the higher storey by use of lifting platforms and/or taking into consideration the load capacity of the tower crane at the construction site. Load-bearing structure is executed in metal, and its height is adjustable so as to enable easier evacuation from one site and the transfer to another. This type of formwork requires that the load-bearing walls are transverse and with the open facades in order to dismantle and evacuate the formwork of the ceiling structure and lift it to the next storey.

2.3 Vibration-damping Elements

In high-rise vibration dumping devices usually exploited elements are those of viscous friction (viscosity) capacity. The devices are usually executed as cylinders containing fluids, with perforated or loosely adhering pistons moving inside the space. When some movement gets transferred to the piston of the oil tank, a viscous frictional force proportional to the speed of the piston is created in the cylinder bumper. At the same time, the stability of viscosity properties of oils or other liquids used in vibration dampers have to be ensured. Thus, each swinging of the mass dissipates part of the vibration energy of the structure and reduces the amplitude and acceleration of its vibrations.

3. Conclusion

Given all the peculiarities of the high-rise buildings, achieving low-energy consumption is challenging task. High energy consumption in the high-rise buildings influenced researching for innovative solutions to enhance energy efficiency in this field. This paper displayed and overview of prime technological advancements through presenting selected high-rise buildings constructed in the last decade with focus on their geometry, construction and structure system, sophisticated vibration-damping elements and systems, sustainability, and similar related features. The high-rise buildings construction technology is highly demanding and is rather specific in certain of its technological procedures, while the technical approach applied itself depends on the use of building materials in the construction process.

The profitability of the entire project is strongly influenced by the time needed for the construction

Figure 6. Table Formwork [8]

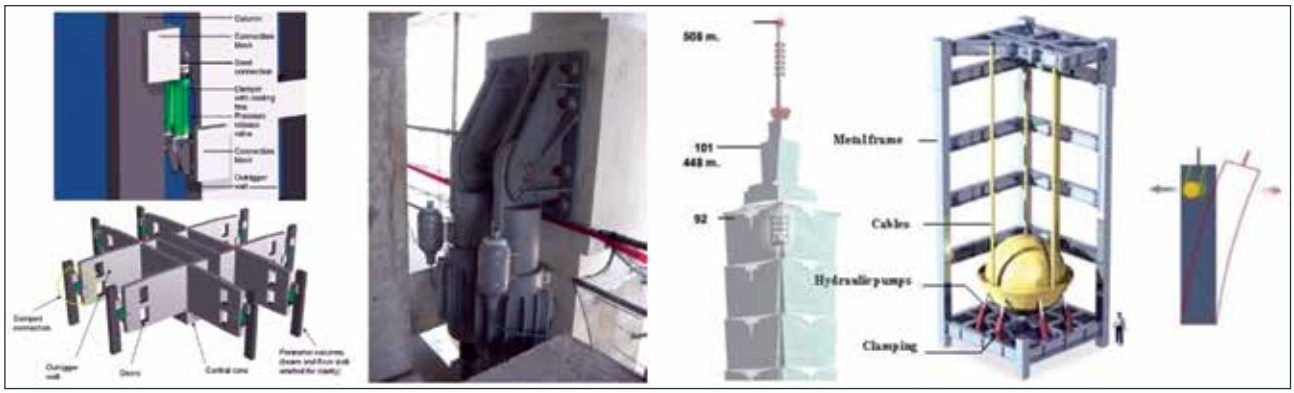

Figure 7. Vibration dumpers installed in towers of Francis Shangi-La (Filipini) and Taipei 101(Taiwan) [9]

so it is very important to carefully design and plan the construction site - especially if the facility is being erased in a densely urban and developed area, with difficult access to the site, and by the choice of optimal technologies for different construction works. One of the high-rise building construction advantages is common repetition of larger number of storeys, enabling for utilisation of standardised and modular elements installed with the use of routine procedures. Greater progress in the construction of facilities has been achieved through the equipment development and improvement, as well as the technological procedures in the construction method.

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The Effectiveness of Cognitive Trips Across The Web "Web Quest" Regarding The Development of Academic Achievement Among Middle School Students in Teaching Computer Subject

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Abstract

This research aimed to identifying the effectiveness of using the Cognitive Trips across the Web strategy "Web Quest" regarding the development of academic achievement among middle school students in computer subject. In order to achieve this, the two computer units "Web Sites" and "Java Introduction" of the second–grade of middle school were reformulated, using the Web Quest; a teacher's guide, activities book for students and an achievement test were prepared in the two units. The achievement test in the two units was applied on basis of "pre and post application" to the research sample, which consists of two groups experimental group and control group, each of them consists of 30 students. The two units were taught using the "Web Quest" for the experimental group and the usual way for the control group. The results showed that there were statistically significant differences between the mean scores of the control groups and experimental group on the achievement test in favor of the experimental group, the results also showed the effectiveness of using the Web Quest strategy regarding the development of academic achievement among middle school students in computer subject.

Key words: *Cognitive Trips across the Web "Web Quest", Academic achievement.*

1. Introduction

In order to achieve better results of the educational process, this requires getting out of the old educational methods that based on indoctrination, memorization and the inability to retrieve information again, and start to orientation towards the new educational methods based on research, exploration and analysis; in order to achieve this, we have to develop the learning resources, take advantage of technological developments and applying them in the educational process, such as the international information network the "Internet" and benefit from its positive impact on the learner [1].

Accordingly, the modern educational strategies and methods needed to be developed in a way that can help and enable the advancement of the student and make him/her the main focus of educational process and direct the student to the information via the Internet in order to obtain it with the least time and effort possible and within an active educational environment that increases his/her achievement [2]. One of these strategies was the Cognitive Trips across the Web strategy "Web Quest" that combined the adequate educational planning with the adequate use of the international information network the "Internet" to organize the navigation and research process [3]. The Web Quest is one of the e-learning methods that combine the adequate educational planning and the use of the Internet [4] Most of the results of previous studies emphasized the importance of diversifying teaching strategies in developing academic achievement, integrating technology and applying it in teaching as well as the importance of making the student learn by doing the research by himself, and providing modern methods that provide students with the possibility of self-learning to achieve the desired aim. An achievement test was applied as an exploratory study on middle school students, and the test showed their low achievement. Therefore, the research problem was identified in the low academic achievement of middle school students in the computer subject, the current research tries to answer the following

main questions: What is the effectiveness of the Cognitive Trips across the Web "Web Quest" in developing academic achievement in the computer subject for middle school students? And What is the effect of teaching the two units "Web Sites" and "Java Introduction" using Cognitive Trips across the Web on the academic achievement of middle school students? Research Aim to Identify the effectiveness of the Cognitive Trips across the Web strategy in developing academic achievement in the computer, information and communication technology subject among middle school students. Helps educational supervisors by presenting an electronic strategy to teach the "Computer, Information and Communication Technology" subject, which helps in training teachers, and providing them with the skills of applying e-learning. Designing an educational website for the two units "Web Sites" and "Java Introduction", which includes an electronic test. Research participants A group of second-grade middle school students at Daqahlia Middle School consists of (60) students. They were divided into two groups, the first was experimental group consists of 30 students and the second was control group consists of (30) students. The second semester of the academic year (2019/2020). Research Tools Designed an educational website for the two units "Web Sites" and "Java Introduction" , Academic achievement test, A teacher's guide using Cognitive Trips across the Web "Web Quest "and Student Activities Book in the two units using Cognitive Trips across the Web "Web Quest". The results also showed the effectiveness of using the Web Quest strategy regarding the development of academic achievement among middle school students in computer subject.

2. Literature review and background

E- Learning

E-learning is one of the best ways to apply the technological innovations, multimedia and the Internet to raise the quality of education at the present time[5]. Whereas, it provide students with the skills of modern knowledge that based on learning and searching for information in a way that matches with the learning demands of the Twenty-First century, changing the concept of the education that based on memorization and indoctrination to active education which focusing on the student and changing the student's role from being a recipient to be an active participant in the educational process, thus, the teacher's role will changing as well from being a source of information to be a facilitator and trainer [6]. This learning shall be at an environment full of information resources and information technology and communication [7].

Defines e-learning as: "Students learn by electronic means such as the Internet, local networks, CDs and a data projector" [8]. Academic Achievement "It was defined procedurally as the amount of information obtained by students of the second grade of middle school during their study of one of the units of the computer, information technology and communication subject using the Cognitive Trips across the Web strategy "Web Quest". It is measured by the score obtained by the student in the achievement test prepared for that.

Cognitive trips across the web.

Added that cognitive trips across the web are organized and flexible educational activities that help to invest the student's time, to obtain information from the sources available to him on the international information network (the Internet) [9].

Types of Cognitive trips across the web

1- Short Term Cognitive Trip:

It has duration of one to four lessons, and the educational goal is often to access, understand and retrieve information sources. Usually, this cognitive trip is limited to one subject [10].

2- Long Term Cognitive Trip

In contrast to the short-term cognitive trip across the web, the long-term cognitive trip ranges from a week to a month, and it focuses on questions that require advanced mental processes such as analysis, synthesis, evaluation. Results of the long-term cognitive trip submitted in the form of oral presentations or in the form of research, worksheets, for online presentation [11]. These presentations may require, in addition to answering the major questions of the task, the control of advanced computer tools such as presentation programs like PowerPoint, image processing programs, HTML [12]

The components of the cognitive trip across the web

Introduction: This stage relies heavily on the experiences, knowledge and skills previously

available to the learners, in which the introduction to the lesson is made and a clear idea of the topic and its elements [13].

Tasks: After arousing the interest of the learner and suspending him, he is given an accurate description of what he is expected to accomplish at the end of the cognitive trip, and it includes main tasks, sub-tasks related to real-life situations, and it is required to be short, concise and builds on the learner's previous knowledge.

Resources: there are many sources, including: web pages, experts who can be made available via e-mail, searchable databases via the Internet and electronic books.

Processes: Steps of the work on the cognitive trip are described in a detailed step-by-step, and the nature of the work (individually or collectively) is determined. If the work is (collective), learners are divided into groups, and works is distributed among them, and draw clear specific steps that each student will take to reach the achievement of the task after determining the time required to complete this task [14].

Evaluation: As the evaluation in these trips is the main criterion for measuring the skills that the learner will master through the activities, and therefore modern evaluation methods should be followed in light of e-learning environments.

Conclusion: This stage includes a summary of all the previous steps in the form of reportable statements about the task, what has been accomplished in it, the information associated with it, and the possibility of making an extension to the questions asked, and researching them again in another cognitive trip.

Teacher Page: It is a separate page that is inserted after the cognitive trip is carried out; to guide other teachers towards employing the cognitive trip across the web [15].

Advantages of cognitive trips cross the web:

The presence and availability of motivational elements, such as giving a specific role to the learner, or presenting a specific situation and scenario, increases the motivation of the learner [16].

It provides the opportunity for the person creating the cognitive trip across the web (the teacher) to act as the observer for the websites being visited [17].

Cognitive trip across the web are suitable for all specializations, all educational topics, and for all levels of students due to the diversity of their activities [18].

The study aimed to demonstrate the effect of the different patterns of designing cognitive trip across the web to develop programming skills among students of the professional diploma specializing in educational technology at the College of Education, and the research found a statistically significant difference between the mean scores of the two experimental groups in each aspect The cognitive and performance aspects of the dimensional programming skills for the benefit of the first experimental group that studied the long-term web cognitive trip strategy[19].

This aimed to study the effect of using the Web Quest strategy in teaching mathematics on the development of achievement and motivation for achievement. The results of the study confirmed that achievement motivation was met with great interest by psychologists, until research in this field became one of the distinctive features of contemporary psychological thought [20].

The study aimed to find out the effect of an educational program based on the Web Quest on the level of achievement of first-grade secondary students in computer research in Jordan. The results of the study revealed statistically significant differences at the level of ($\alpha = 0.05$) in the level of achievement. Where the arithmetic mean of the experimental group reached (19.90) and the control group (11.88), and the difference appears in favor of the experimental group [21].

The research aims to identify the effect of using the Web Quest strategy on the tenth grade students' achievement of the basic and scientific enlightenment of the tenth grade students and the development of their cognitive motivation. The results showed that the use of Web Quest technology has a positive effect on the achievement of geography among students of the Tenth middle school [22] .

This study chose a unit of science and technology course for ninth grade students to teach through cognitive trips across the web to find out the students' direction towards it, this study concluded that teaching on cognitive trip across the web did not affect students' attitudes towards science, and it only had a positive effect on the level of memory [23].

3. Methodology and Empirical study

3.1. Research hypotheses

There are statistically significant differences between the average scores of the students of the control and experimental groups in the post application of the achievement test and There are statistically significant differences between the average scores of the experimental group students in the pre and post application of the academic achievement test in favor of the post application. Research Methodology descriptive analytical method and Quasi-experimental method

3.2. Research procedures

To answer the main question of the research; which is: What is the effectiveness of cognitive trips across the web in developing academic achievement in the computer subject for second-grade of middle school students?

The following was done:

* Preparing a test for academic achievement in the units "Web sites" and "Java Introduction" in the Computer and Information and Communication Technology course for middle school students.

* Presenting the academic achievement test to a group of arbitrators to ensure its validity (Appendix No. (1), the list of arbitrators.

* Applying the academic achievement test to the exploratory group to ensure its stability. (Appendix No. (5) the final image of the achievement test.

* Applying the academic achievement test to the research group, a pre application.

* Teaching the units of "Web Sites" and "Java Introduction" for the experimental group students using cognitive trip across the web.

* Teaching the units of "Web sites" and "Java Introduction" to the control group students using the usual method.

* Applying the academic achievement test to the research group, in a post application.

* Treating the results statistically and analyzing them.

* Calculating the effectiveness of cognitive trips across the web in developing academic achievement that was determined using the Mac Jojian Effectiveness equation.

* Interpret the results and provide appropriate recommendations and proposals in light of the research results.

To answer the second question of the research; which is: What is the proposed perception of the two units "Web sites" and "Java Introduction" in the computer course scheduled for middle school students after reformulating them using cognitive trips across the web? The following was done:

* Reformulating the units of "Web sites" and "Java Introduction" by using cognitive trips across the web, presenting them to a group of arbitrators, and modifying them in the light of their opinions.

* Designing the two units in the form of an educational web site on the Internet according to the ADDIE form (Annex No. (7) the website screens.

* Communication with students via Facebook and the Gmail site that was designed.

* Preparing the teacher's guide to teach the two units using cognitive trips across the web and presenting it to a group of arbitrators and amending it in light of their opinions (Appendix 3 Teacher's Guide) and includes the following:

1. Introduction to the guide.
2. General teacher instructions.
3. Steps to deal with the website for cognitive trips across the web.
4. The general aims of the two units.
5. The topics of the two units include the educational activities that were uploaded to the website.

Time plan for teaching the two units "Web sites" and "Java Introduction" for the academic year 2019/2020, the second semester.

4. Data analysis

The achievement test was prior applied to both the control and experimental groups that consisting of (30) students for each group from a school affiliated to the Zarqa Education Department in Damietta Governorate to obtain the necessary statistical data. The T-Test was applied for independent samples from the Statistical Package for the Social Sciences program (SPSS).

Table 1. Time Plan for the Websites unit for the 2019/2020 academic year

No.	Topic	Weeks No.	Periods No.	Classes No.
1	Sample – some of sample tools	1	1	2
2	Html- continue some of sample tools	1	1	2
3	The project	1	1	2

Table 2. Time Plan for the Java Introduction unit for the 2019/2020 academic year

No.	Topic	Weeks No.	Periods No.	Classes No.
1	Basic concepts of the Java	1	1	2
2	Call the Java script code	1	1	2
3	The branching clause If	1	1	2
4	Verify the correctness of the entered data	2	2	4
5	continue verify the correctness of the entered data	1	1	2
6	The project	1	1	2
7	Html5	1	1	2

5. Results

In order to see the impact of using the two treatments on the performance of students, are presented in Table (3) shows T-test results of the significance of the differences between the average scores of students of experimental group in the pre and post application of the achievement test; where all the average scores of the experimental group students in the post application of the achievement levels were higher than in the pre application as well as the "T" values ranged between (5.75-20.88) for achievement levels, all of which are statistically significant at the level of significance of (0.001).

As for the achievement test as a whole, the total scores average of the experimental group students in the pre application were (32.90) and the total scores average of the post application were (21.37), while the "T" value was (20.95) and the level of significance was (0.001); which indicates there is statistically significant difference between the two groups in the achievement test for the favor of post application.

Table (4) shows the effectiveness of teaching by using Cognitive Trips across the Web in developing academic achievement among students of the experimental group, where the effectiveness ratios for achievement levels ranged between (0.70 - 0.89) and the effectiveness ratio for academic achievement as a whole was (0.74), which indicates that the use of Cognitive Trips across the Web was effective and led to the development of academic.

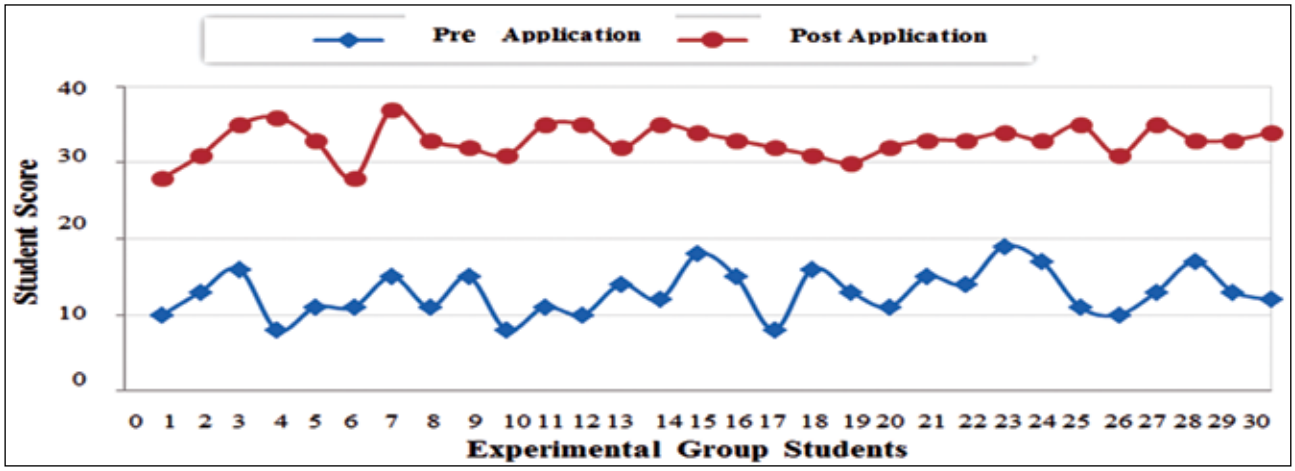

Figure 1. Shows that the averages scores of the experimental group students in the post application of achievement levels are higher than the averages of their scores in the pre- application, and achievement among students of the experimental group.

Table 3. It shows the significance of the differences between the average scores of students of experimental group in the pre and post application of the achievement test.

Achievement Levels	Study Groups	Average Score	Standard Deviation	T-Test			Statistical Significance
				T Values	Degrees of Freedom	Level of Significance	
Remembering	Pre application	6.10	1.99	20.88	29	0.001	Significant
	Post application	14.17	1.42				
Comprehension	Pre application	1.87	0.90	15.46	29	0.001	Significant
	Post application	5.47	0.94				
Applying	Pre application	2.23	0.97	14.49	29	0.001	Significant
	Post application	5.60	1.07				
Analyzing	Pre application	0.40	0.50	5.75	29	0.001	Significant
	Post application	0.93	0.21				
Synthesis	Pre application	1.67	1.09	12.72	29	0.001	Significant
	Post application	5.03	0.81				
Evaluation	Pre application	0.63	0.61	8.45	29	0.001	Significant
	Post application	1.70	0.47				
Achievement Test	Pre application	**12.90**	**2.98**	**32.77**	**29**	0.001	**Significant**
	Post application	**32.90**	**2.12**				

Table 4. It shows the effectiveness of teaching by using Cognitive Trips across the Web in developing academic achievement among students of the experimental group

Achievement Levels	Study Groups	Average Score	Maximum Score	Effectiveness Ratios
Remembering	Pre application	6.10	17	0.74
	Post application	14.17		
Comprehension	Pre application	1.87	7	0.70
	Post application	5.47		
Applying	Pre application	2.23	7	0.71
	Post application	5.60		
Analyzing	Pre application	0.40	1	0.89
	Post application	0.93		
Synthesis	Pre application	1.67	6	0.78
	Post application	5.03		
Evaluation	Pre application	0.63	2	0.78
	Post application	1.70		
Achievement Test	**Pre application**	**12.90**	**40**	**0.74**
	Post application	**32.90**		

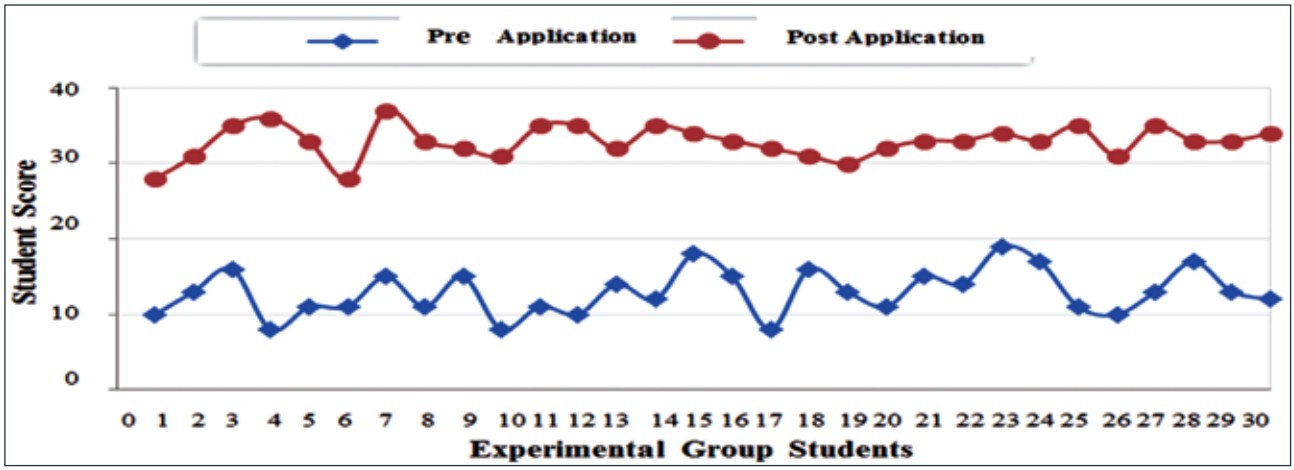

Figure 2. Shows the scores of the experimental group student in the pre and post applications of the achievement test.

6. Conclusion

The results proved the superiority of the experimental group students who studied the two units in the research using cognitive trips across the web in the post application of the achievement test compared to the post performance of the control group students who studied the two units in the usual way, where the average scores of the experimental group in the post application was (32.90), while the average scores of the control group in the post application was (21.37).

Figure 3. Shows Educational site for Cognitive Trips Across The Web Quest

The results also proved that there is an effective effect of teaching the two units by using cognitive trips across the web. The proposals to conduct the following studies aimed at identifying the effectiveness of cognitive trips across the web on other dependent variables in the computer, such as creative thinking skills and the student's attitude towards computers. A study aimed at identifying the direction of computer, information and communication technology female teachers in middle school towards using the cognitive trips across the web strategy and the obstacles in their use from their point of view. And A study aimed at identifying the effectiveness of a proposed training program to train female teachers on the strategy of cognitive trips across the web in developing their professional performance.

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Cross-laminated timber (CLT) application in multi-storey buildings

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Abstract

The CLT (Cross Laminated Timber) is the material known to be produced by technology of gluing together layers of wood panels. So far, the application of CLT has showed positive implications espetially regarding Fire Resistance and ecology footprint. The advantages of this material has been seen also in wide spectrum of application in buildings for both interior and structural elements. This paper aims to give brief overview of the CLT application in multi-storey buildings.

Key words: *CLT, multi-storey buildings, prefabricated elements, timber frame sructures*

1. Introduction

As a reflection of our reality, the modernity manifests itself in various technologies, including the ones utilised in the architecture. Contemporary architecture can be seen in two ways; a reality that manifests technical and technological achievements, and a reality that returns to its roots and tradition. Modern building materials are recognised to have perfect properties; responding both to exterior and interior demands of the buildings` surfaces.

Those can be utilised to respond to desire of having cozy atmosphere in a space meant for the accomodation. However, such response may be characterised as an apperent due to production of such materials and their characteristics in sense of ecology and human health aspects. The materials mentioned often have negative impact on human health due to radiating negative particles which in time lead to worsening of health condition, thus rughtfully one may pose a question weather given space is really pleasent. Sometimes it is the production methods of such materials that is affecting the enviroment and human health in numerous ways, which really poses a question to what extend those materials should be used.

What often gets forgotten is tradition and the fact it has found harmony between the needs of life, the environment, materials and the idea on utilising space. Thus, it can be said that the contemporary architecture can take a direction where tradition, cultural continuity and adaptability take their rightful place and become the guide for sustainable architecture. [1]

Tradition in the contemporary times and modernity is sometimes underlined through utilisation of certain building elements, construction forms, but certainly it is frequently acheived through the application of traditional materials. Wood, often used traditional building material, has played a major role for centuries, especially in terms of constructing the roof structure. Over time, the buildings become more complex, which displays the fact that for centuries man sought to create structures that are providing pleasant atmosphere for human settlement and living.

Yet, buildings with contemporary structured forms often come with construction challenges. To which extent the technology has enabled and enhanced the use of wood/timber in high-rise buildings construction is visible from the level of **CLT (Cross Laminated Timber)** Application.

CLTis a wood panel product made from gluing together layers. The innovative construction grants it excelence in sense of physical and mechanical properties. Its major application is in form of panels for wall or ceiling, thanks to great load-bearing capacity and structural rigidity in both directions (horizontally- through the layers planes/laminations and verticaly – on the surface plane/laminations of the panel element). Besides these two features, the CLT has good ecological, estethical, and energy properties.

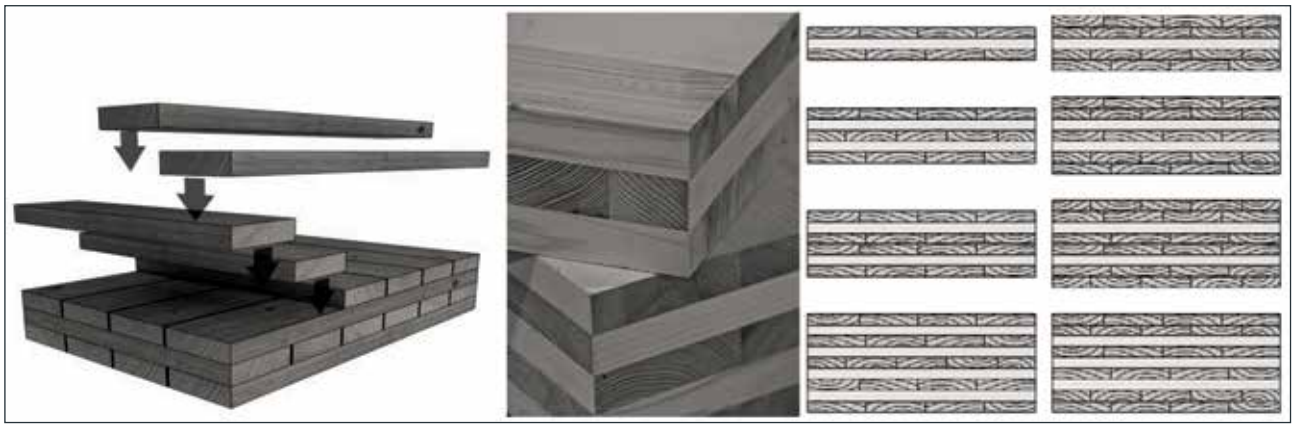


Figure 1. CLT (Cross Laminated Timber) [2]

2. CLT (Cross Laminated Timber) main characters

Traditional construction facilities mainly utilised wooden constructions as frame systems, made of solid wood linear elements. At the beginning of the 20th century, fast technology and industry developing was followed with the excessive application of steel and concrete. Particularly, reinforced concrete has almost completely replaced other building materials. However, reviving of traditional materials was an idea to take a part in developing contemporary materials. Thus, in the middle of the 20th century potential to use wood for large spanas was recognised in possibilities to produce glued laminated timber- glulam. Further on, a new wooden panel composite element known as cross-laminated wood – CLT was produced as a rigid panel element, composed of several perpendicularly adjacent layers, glued to each other.

This way arranged CLT structure provides great load-bearing capacity and structural stiffness in both directions (horizontally- through the layers planes/laminations and verticaly – on the surface plane/laminations of the panel element). Application of this material has shown many advantages including those of energy and aestethic properties of the material and natural and ecological values. Also, high level of prefabrication consequently caused short time needed for construction, while due to its relatively lightweight, as a construction element it enables for easier foundation engeneering. Most commonly it is utilised in construction of walls and ceilings, with good energy properties, such as storing moist and heat, which make the building more efficient. Eventhough CLT application so far has showed its solid and positive effects in Europe, North America and Asia, incliding its application for high rise builing constructions and bridges, [3] CLT production still needs to be improved and enhanced by introducing norms and regulations and to encourage its wider use.

3. Examples of the CLT application in multi-storey buildings

In the last decade, a number of tall buildings have been built, with CLT utilised as the structural material. Northern Canada and European countries generously found this type of structures as an advantage and approriate to be used for multi-storey buildings as well.

Mjøsa Tower building construction elements have been prefabricated, with the extreme precision of make. This result in a multifold time savings in the building construction, and enables for the corrections or adjustments be done on the site. The construction works progress is, in average, a level/storey per a week, which is 40% faster from construction progress when using concrete and classical wet construction.

The construction with 1302 prefabricated timber pillars and 464 CLT panels have provided for On-campus housing at Columbia College to be finished even prior to the expected deadline set. The construction works commenced, the loadbearing status and safety of the junctions and links have been tested on a scale model. The same approach has been used to enhance and perfect timeline schedule of the construction works for the building. The building proved

Table 1. Shows three examples from which it is visible that CLT is mostly used as a secondary load bearing, for walls, elevators and interious elements.

Building	Mjøsa Tower, Mjøstårnet[4]	On-campus housing at Columbia College [5]	The Treet, Bergen, Norway [6]
Photo			
Location	Brumunddal, Norway	Vancouver, Canada	Bergen, Norway
Floors	P+18	P +18	P+14
Height	85,4 m	53,0 m	49,0 m
Architects	Voll Arkitekter	Acton Ostry Architects	Artec AS,
Year of construction	2019	2017	2015

to be economically and ecologically sustainable, and is, due to its lighter structure, less prone to be affected and/or damaged by the seismic activities. [12]

And, in building The Treet, in Bergen, Norway installed timber in the builings structure and other elements, resulted in reduced emission of CO2 in which CLT has significant contribution.

4. CLT Properties

4.1. Fire Resistance of CLT

According to the Standard EN 1995-1-2, dimensioning of CLT elements is done by reduced cross-section method. The method is based in determining the charring depth, which in case of CLT element depents on several factors namelly:

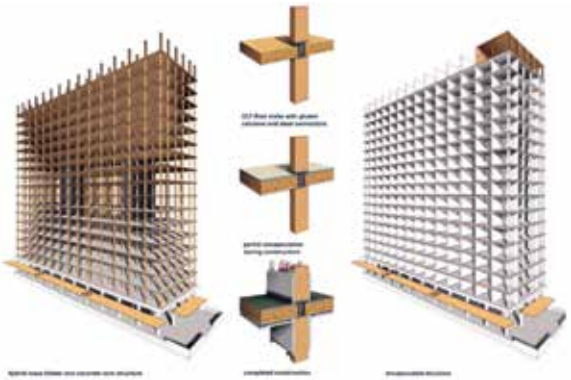
- Charring rate ß,
- Type of adhesive used – glue, and
- Fire protection.

Charring rate is directly dependant on weather there is space between the laminations within the truss layers:

- For CLT withouth spaces and/or maximum space up to 2 mm razmaka, charring rate is ß = 0.65 mm/min.
- For CLT with intralamination spaces of 2 mm up to 6 mm, charring rate is ß = 0.80 mm/min. [3]

Cros-laminated timber combustion value is 0.67 mm/min and it is possible to determine time of the flame existance/burning. If one side of 10 cm thick panel is exposed to heat of 1210°C, after 60 minutes only 9.5°C will penetraate through to the other side. Application of different fireprofing coatings can enhance the reaction of a panel to fire exposure. [3]

An important issue is, in fact, the durability of the material to keep its properties during a fire, and how long it can burn without weaking.. Wood is very predictable in fire - the outer layer of cross-laminated wood panel will initially ignite, and then build a charred layer of insulation that provides 30, 60 or more minutes of fire resistance, depending on the number and size of the panel.

Example	The Structural system Attributes	Advantages
 Mjøsa Tower structure[7]	Prefabricated, extra high durability laminated wooden panels have been used for the floor structure, and the entire elevator shaft has also been made in glued laminated timber. The structural system functions as a frame system, with wooden turnbuckles Concrete used in the last seven floors of the building, has been chosen for the need of additional pressure from the top of the building, which should reduce the movement of the wooden structure under seismic activities. [10]	-ecological, (lower carbon emissions and uses less energy) -easier transportation -lighter bases for buildings -construction/ building time gets shortened
 Columbia College structure [8]	Hybrid construction. The building base and the two kernels centrally positioned in it are made of reinforced concrete. The rest of the construction is made of CLT and massive glulam pillars. Bearing elements junctions are secured and reinforced by metal elements so as to ensure load distribution among the pillar and the panels.[11]	
 The Treet structure [9]	The construction is made of glulam load-bearing pillars, up to half a meter thick, beams and diagonal bracings, while tiled laminated timber is used to shape the floor and walls. The building is erected as a modular system, and the modules are assembled together on site. Every fourth level is encased in a load-bearing framework structure (Power Story) Roof is an independent prefabricated module with a reinforced concrete slab. These concrete slabs need to be situated on two different levels to connect the trusses and to prevent improve the dynamic behaviour of the builings. CLTelements are used independently from the main load bearing system and they do not give much of the support in the system for the needed stiffness. [9]	

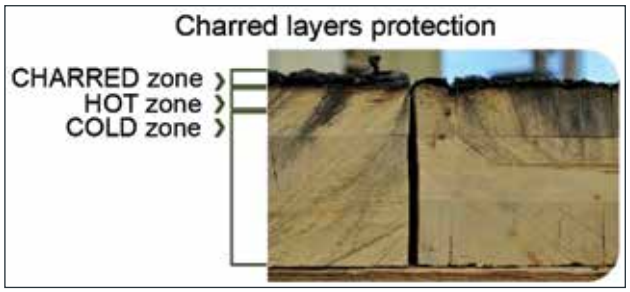


Figure 2. Impact of fire on CLT sample (translation:charred layers protection Charred zone- Hot zone -COLD zone) [13]

4.2. Earthquake-resistant or aseismic property of CLT

The generally good seismic behavior of CLT is primarily due to its high stiffness in the plane of the element and its relatively low dead weight. Numerous studies in the field of seismic action have been conducted for CLT so far, and most rely on Standard EN 1998-1-1 and calculation of earthquake resistance procedure based on the behavior factor q. The testings have been performed on CLT wall elements, as well as on the complete construction as well. The paramount parameters altered during the test are:

- Dimensions, contexture and compositions of the CLT,
- Fringe conditions and type of joints and
- Experimental configuration and method of load input

The testings conducted resulted in general conclusion that the load-bearing capacity during seismic action is not that much dependant on the load-bearing capacity of the material but on the load-bearing capacity and ductility of the junctions. Researches conducted in Europe, Japan and Canada have shown that CLT panel wooden construction is able to withstand strong seismic loads when the connections of ground floor structure panels and foundation structures, as well as the connections of wall and floor structure panels are made using metal angles and plates and mechanical fasteners (shaped nails, nutless screws, mandrels).

4.3. CLT Ecological footprint

Decisive features for which CLT is chosen as a constructive material are its ecological values and natural origin. Wood, due to its CO_2 storing property is material of excelence, while planting and reforistation reduce the global warming effects. CLT is certainly less environmentally friendly than traditional wooden structures, but on the other hand, it shows higher green qualities than other modern structural systems. Unlike the production of concrete and steel, CLT panels' production and their assembly does not produce CO_2.

However, CLT systems come with the need for a larger amount of raw material to produce elements, and also requirement of using other materials, such as glue.

Wood absorbs carbon dioxide from the air, but during the process it simultaneously releases oxygen into the air. Once a tree "soaks in" the carbon, it is later released from it only if it dries naturally or if it is burned. When wood is processed mechanically, carbon dioxide is retained in the engeneered material.

Using wooden products in building construction, means that the material utilised shall reduce carbon dioxide emission. CLT wood panels are produced by low polluting technologies, and with relatively low consumption of energy and water, and almost no waste in manufacturing processes.

Wood is also known as ecological material that is fully suitable for recycling and repurposing. Currently in CLT production facilities, waste material created in the course of CLT gets incinerated. [3]

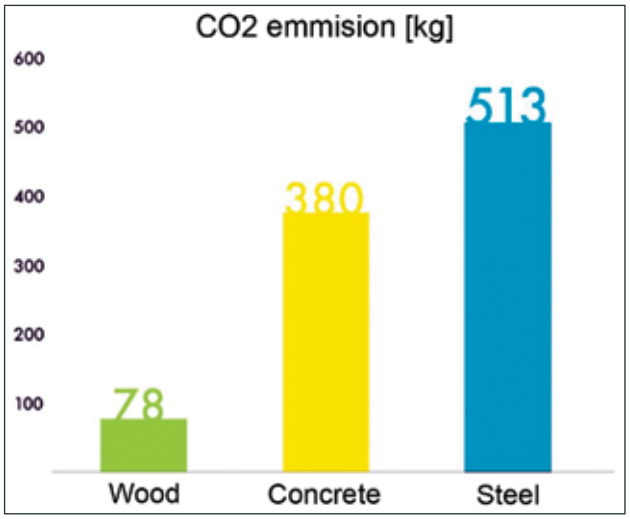


Figure 3. CO2 emmision for beams of 7.3 m in length manufactured from different materials, calculattion by Athena softver www.cecobois.com - Center of Expertise on Commercial Wood Construction (Cecobois) [14]

The glue used to bind the laminations for CLT is an importanc componenet, andcurrently the market has no bio-based glue that could meet the required bearing property. There are three most common adhesives/ glues present at the market, namely PRF, EPI and PUR which are formaldehyde-free. An important factor is the prospect of recycling waste during production, which is now most often incinerated. The most critical point is the emission of greenhouse gases during glue combustion which thanks to modern purification technology can be largely reduced.

5. Conclusion

Finally, it can be concluded that sustainability of the idea on material utilisation should be based in concept of sustainability in general, which is an intersection and common grounds found for aspects such as environemental, economical, sociocultural. This has been proved to be met in for the builings where the CLT was used as a building material, appropriate for interiours and as a strctural materials. Besides the ecological advantage, such CLT contribute to the easier transportation and lighter bases for buildings. Construction/building time gets shortened, and it need less energy and result in a lower carbon emission.

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