TECHNOLOGICAL DEVELOPMENTS AND THEIR EFFECTS ON ARCHITECTURE: ALUMINIUM COMPOSITE PANELS IN NORTHERN IRAQ AS A CASE STUDY

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Zhilwan Burhan Sulaiman: TECHNOLOGICAL DEVELOPMENTS AND THEIR EFFECTS ON ARCHITECTURE: ALUMINIUM COMPOSITE PANELS IN NORTHERN IRAQ AS A CASE STUDY

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To my parents …

ABSTRACT

In architecture, technological development process is considered as a key pillar of the development of society. Over the past few decades, many responsible actions focus on environmental conservation and energy and pollution reduction, and architecture has significant participation in this issue. However, the character of the architecture began to change because of the using of technologies and technological materials in particular. This has result in changing the character of local architecture in addition to the formal features of architecture in specific place. Therefore, the thesis attempt to highlight the effect of new technological materials on sustainability as one of the significant issues globally, and on the architectural character as one of the important aspects to keep the local architectural value in place and time. The aim of the thesis is to understand the effect of new technology as a fundamental variable to achieve sustainability in construction and their potential to keep local values within their solutions. To achieve the aim of case study buildings have been selected and studied from three main cities in northern Iraq (Sulaymaniyah, Erbil, and Dohuk). The thesis has focused on Northern Iraq as the study region and selected ACPs as most recognized and utilized new technological construction materials in different building categories in the region. The quantitative method has been conducted to assess the influence of ACPs on sustainability in the selected case studies, based on a prepared checklist. A qualitative method has been applied to evaluate the effect of ACPs on the architectural character in the region of study, through an unstructured interview with experts. The results of the current study have demonstrated the significant influence of ACPs on improving sustainability in the buildings. Moreover, it has shown the negative effect of these new technological materials on the character of architecture in Northern Iraq. Thus, the answer of the raised questions have been done, and several suggestions have recommended to improve the functionality of ACPs as new technological materials in Northern Iraq.

Keywords: Technology; sustainable materials; architecture character; compound aluminum composite panels (ACPs); Northern Iraq.

ÖZET

Teknolojik gelişme süreci toplumun gelişiminin temel direği olarak kabul edilir. Son birkaç on yılda, birçok sorumlu eylem çevre koruma ve enerji ve kirliliğin azaltılmasına odaklanmaktadır ve mimarlığın bu konuya önemli katılımı vardır. Bununla birlikte, özellikle teknolojilerin ve teknolojik malzemelerin kullanılması nedeniyle mimarinin karakteri değişmeye başladı. Bu, belirli bir yerde mimarinin biçimsel özelliklerine ek olarak yerel mimarinin karakterini de değiştirmiştir. Bu nedenle tez, yeni teknolojik materyallerin sürdürülebilirlik üzerindeki etkisini küresel çapta önemli konulardan biri olarak ve yerel mimari değeri yerinde ve zamanında tutmak için önemli unsurlardan biri olarak mimari karakter üzerinde vurgulamaya çalışmaktadır. Tezin amacı, yeni teknolojinin inşaatta sürdürülebilirliği sağlamak için temel bir değişken olarak etkisini ve yerel değerleri çözümlerinde tutma potansiyellerini anlamaktır. Vaka çalışması amacına ulaşmak için Kuzey Irak'taki üç ana şehirden (Süleymaniye, Erbil ve Dohuk) binalar seçilmiş ve incelenmiştir. Tez, çalışma bölgesi olarak Kuzey Irak'a odaklanmış ve bölgedeki farklı yapı kategorilerindeki yeni teknolojik inşaat malzemelerini en çok tanınan ve en çok kullanılan alternatifler olarak seçmiştir. Seçilen vaka çalışmalarında ACP'lerin sürdürülebilirlik üzerindeki etkisini hazırlanan bir kontrol listesine dayanarak değerlendirmek için nicel yöntem uygulanmıştır. ACP'lerin çalışma bölgesindeki mimari karakter üzerindeki etkisini uzmanlarla yapılanmamış bir görüşme yoluyla değerlendirmek için nitel bir yöntem uygulanmıştır. Bu çalışmanın sonuçları, ACP'lerin binalarda sürdürülebilirliğin iyileştirilmesi üzerindeki önemli etkisini göstermiştir. Ayrıca, bu yeni teknolojik malzemelerin Kuzey Irak'taki mimarlık karakteri üzerindeki olumsuz etkisini göstermiştir. Bu nedenle, gündeme getirilen soruların cevabı yapılmıştır ve ACP'lerin Kuzey Irak'ta yeni teknolojik materyaller olarak işlevselliğinin artırılması için birkaç öneri önerilmiştir..

Anahtar Kelimeler: Teknoloji; sürdürülebilir malzemeler; mimari karakter; bileşik alüminyum kompozit paneller (ACP'ler); Kuzey Irak.

TABLE OF CONTENTS

CHAPTER 3: METHODOLOGY

CHAPTER 4: ANALYSIS AND DISCUSSION

CHAPTER 5: CONCLUSION AND RECOMMENDATION

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ACPs:	Aluminum Composite Panels
BOQ:	Bill of Quantities
LC:	Life Cycle
PVDF:	Polyvinylidene Fluoride
DST:	Descriptive Statistical Tools

CHAPTER 1

INTRODUCTION

1.1 Background and the Significance of the Study

The content of the study depends on the idea that architecture is one of the important field, which can have significant role in solving the crucial problems. Architecture evolves through the interactions between design, space, materials, and technology. Climatic changes and environmental crises that facing the earth nowadays, is one of the most crucial problems. Therefore, to solve this crucial problem it is important to focus on the way that technology is affecting architecture, and achieving a low impact on the environment by sustainable architecture. On another side the cities are losing their Character through new technological materials. Therefore, the study tries also, to address the impact of technological developments on character in architecture, considering architecture as the human cultural heritage that can be combined with the requirements of the place and times. The technological development process that takes place in all branches, especially those related to architecture, has become important in this era, where the globalization has led to openness to the world. In light of this globalization, a huge architectural leaps took humanity from one stage to another in terms of technological development. It has discovered new building and construction materials, and complex construction systems, as well as advanced automated methods of implementation. Architects and structural designers began to use everything new materials in the world of technology. Construction systems have met many of the requirements of global architecture as well as modern means of implementation that began to save time and effort with better performance (Cheetham and Lewis, 2001). Furthermore, the technological development of materials in the past decades has resulted in distinguished projects aimed at conserving energy and reducing pollution, consequently reduce the impact on the environment. Taking into consideration that sustainability has become one of the main things and requirements in our world today, in light of the environmental challenges facing the world. Therefore, the notion of sustainability in architectural field becomes very crucial, especially, with the increasing of debate about the

environmental crisis (De Quiros, 2009). Environmental design principles have been adopted as a basis for architectural thought, from the early stages of the design process to the selection of suitable building materials to achieve sustainable buildings. This helps architects in the decision-making process, which has a major impact on achieving sustainable architectural structures within the local environment (Golmahamadi, 2000). Therefore, there is a need for highlighting the impact of technology on these buildings. This is through study and research, technology will be defined with an indication of its fundamentals and its impact on sustainability in architecture. As well as showing the nature of the relationship between technology and sustainable construction and clarifying the nature of that relationship within the construction of the Buildings. Aluminum Composite Panels (ACPs) has been selected to analyze as one of the most prevailed applicable new technological materials in buildings in northern Iraq. This material characterized by many features in terms of durability, economic, flexibility, etc., and considers one of the sustainable building materials (Mohaney and Soni),

Northern Iraq has been taken as study area because of the progressive development in the field of buildings and construction in the last decades. Several types of technologies including methods of construction and materials have been used in design and building's process in this region. Northern Iraq is located in the north-east of Iraq. This region has borders with Turkey from the north, Syria from the west, Iran from the east, and the rest part of Iraq from the south. The region located within the Federal Republic of Iraq according to the Iraqi Constitution, Article 62(Talib, 2005).

1.2 Problem Statement

There is a significant orientation toward sustainability in architecture, in the twenty-first century, especially after the determination of the environmental crisis that facing the earth, which is; global warming, depleting non-renewable sources in nature, pollution, etc. The technology and especially technologies in building construction has a big role in achieving sustainability. The role of architecture is remarkable in this context, because of the serious impact of building and construction sectors on energy consumption, which is one of the most

important factors in global warming and environmental pollution. The appropriate application of technology can result in the creation of sustainable buildings. Furthermore, the wrong use of the technology or improper use of new technological materials is leading to losing the architecture character for the local buildings within the places. This is when the architects and designers are not having a background and the potential of the adaptation of new technologies within the context of the culture, and place, which is one of the problems in new buildings in northern Iraq.

1.3 The Aim and the Objective of the Study

The main aim of this study is to reach the understanding of the potential of new technology as a fundamental variable to achieve sustainability in buildings construction and their potential to keep local values with their solutions. This is, through understanding the technology and adapting it to architecture in its own place and time.

The main parameters will be formulated and delineated to achieve this goal through the following objectives;

1. Explore the notion of technology in architecture, and the main factors to evaluate it in buildings.

2. Investigation of the relationship between technology and architecture.

3. Study the effect of material technology on building sustainability.

4. Determining the application and use of modern technologies in combination with the local buildings' elements and structures to achieve sustainability in buildings.

1.4 Questions of the Study

The study arises the following questions;

1. What is the effect of ACPs (Aluminum Composite Panels) on the implementation of sustainability in the architecture in Northern Iraq?

2. To what extent the application of the new technology as ACPs in local architecture will keep the architectural character of the buildings in northern Iraq?

3. How can new technological materials as ACPs serve the local character of architecture?

1.5 Limitation of the Study

There the study has been limited to the following;

1. The effect of technology on architecture will be limited to two side; the sustainability, and the character, as two crucial issues in architecture within the globalization.

2. Northern Iraq, as part of the Republic of Iraq, will be the limitation of the current.

3. The effect of technology on the outer shape of the buildings (the envelope) will be considered. The reason is, that these types of technologies will affect the visual shape and form of the buildings and influence the architectural character. Moreover, the envelope is the most effective architectural element to achieve sustainability. This is through controlling climatic impact on the buildings.

1.6 The Methodology

The study adopted the descriptive-analytical approach, to study the research problem to reach the appropriate solutions and results, through a progression from the theoretical approach to studies which are based on the methodology of observation and analysis of some cases and architectural models, which are constituting the practical part of the study, which supports theoretical ideas of the study. Therefore, case study methodology will be conducted in this study,

and. Based on this, qualitative and quantitative methods will be approached to reach the results in this study. The methodology of the study is clear through four stages, and the data will be collected through two ways; secondary resources, and primary resources. The four stages of the methodology are;

1. Obtain a data through searching references, books, diagrams, magazines, various and approved publications and researches that dealt with concepts on this topic as secondary data resources.

2. A personal interview are developed as a primary data resources for a specific research community from an audience of architects and specialists to get the results and opinions of them about the research problem.

3. Fieldwork, which is represented by field observations of a number of buildings as case study buildings in Northern Iraq, as primary data resource.

4. Analyze the findings and discuss the data obtained from practical part (interview and observations) and comparing that with the obtained data from theoretical data obtained from the theoretical part, and discuss the results.

1.7 Difficulties of the Study

Because of the critical political condition in the region of the study, it was difficult to obtain the plans and sections for the majority of the case study buildings. In order to get measured area for ACPs in the building façade. Thus, the area of ACPs materials has been obtained through checking the BOQ (Bill of Quantities) for the project, which was only the document that could obtained from the authorities about these projects.

1.8 Thesis Structure

This research has divided into five chapters, as follow;

Chapter One: It includes a general introduction, (the study problem and study questions, its goals and importance, and its methodology).

Chapter Two: The second chapter has included the framework and the theoretical basis for the study, to be built upon in reaching the study objectives. In this chapter the initial indicators for the practical part will be formulated.

Chapter Three: This chapter will be the methodology, the methodologies and the methods to approach the study will be explained and demonstrated.

Chapter Four: This chapter will explain the findings and analyze them based on theoretical discussion and the result of the study will be formulated in this chapter.

Chapter Five: It is the last chapter and will contain the conclusion and the answers of the study questions. Moreover, the recommendation will be written in this chapter too.

1.9 Summary

The chapter has identified the purpose of this study as well as the problems of the study and has raised several questions to be answered in the end of the study. Furthermore, the chapter has delineated the aims, and objective of the study. The outline of the methodology has been mentioned in this chapter, to show the main steps to reach the conclusion for the study. The chapter also, has determined the limitation of the study according to the scope of the study.

CHAPTER 2

THEORETICAL FRAMEWORK

2.1 Introduction

This chapter is theoretical part of the study, and it will highlight the most important issues related to this study, such as technology, architecture and technology, the role of materials in building construction. Furthermore, the types of technological architecture will be elucidated. The notion of character in architecture will be highlighted too. Sustainability and the characteristics of sustainable materials will be discussed. The aim of this thesis is to reach comprehensive understanding about several theoretical issues, which are related directly to the subject of the current study. This chapter will formulate the main lines and initial elements for this study, to be applied in the practical part of the study, in order to reach the conclusion, and answer the thesis questions.

2.2 Technology

The word "technology" comes from its Greek origin, which means all art that making what appears incomplete in nature, perfect (De Quiros, 2009). “How things are done" is the concept of technology by technologists and promotes the belief that technology is how men do or create”. Opposite to this perspective, Druker (1970) has defined technology as; it is not about the things: instruments, procedures and products; it is human action in particular, through which human beings push back the iron biological law. Hence, Druker believes that the human decided to fly not through biological evolution, but by mean of technology. For the purpose of this research, technology will be connected to architecture. Therefore, Architectural technology is defined as architectural technology and comprises knowledge and understanding which supports the construction and building design as an output and an operation (CIAT, 2015). The design aspect of architectural technology is based on knowledge and application of science, engineering, and technology and relates to the anatomy or physiology of buildings and their development,

performance, and processes. The reliability of building systems, materials, and components to achieve longevity is further linked with the durability and the toughness (Armstrong, 2016).

2.3 Architecture and Technology

Since Vitruvius put his famous trilogy on the goals of architecture (utility, durability, beauty), technology has formed an important pillar of the structure of that trilogy, (Harp, 2009). The technology pays attention to the product and how to achieve it with characteristics (higher, more efficient, faster, and better). Thus, the mechanism of technology work on architecture systems will be either (directly): the technological force works on these systems directly and the designer is responsible for these operations, or (indirectly), which has two methods:

1. This strength reflects in other areas, such as the use of new building material or an innovative method of construction or the development of one of the systems involved in the design process. The role of the architect here lies in the choice of the material or the appropriate way.

2. This may be in another technological product, the effect of which will be reflected in the architecture system or help the designer to do with its analytical processes on the essence of the issue of thought and shape engineering (Hadi and Allawi, 2010).

The technological design advancements in steady remodeling, where it is conceivable that the building materials and methods for execution and construction frameworks being used today don't use after the following purpose of time where these materials and others are renovated.

In other words, technology in architecture integration process could be involved two sides; (Ideological), which includes intellectual systems through ideas, concepts and in the design process, and (Physical), which involved the building materials and the construction systems (Eroğlu and Abbood, 2016). (See Figure .2.1.)

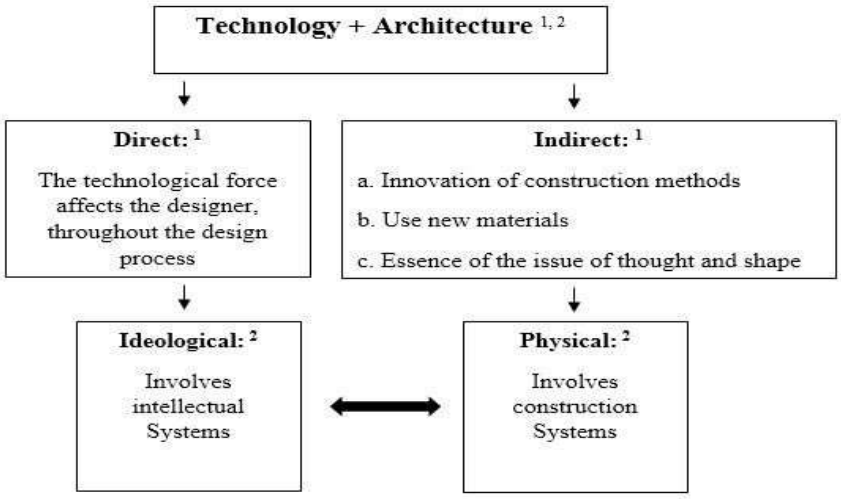


Figure 2.1: The influence of Technology on Architecture, from (Eroğlu and Abbood, 2016).

2.3.1 The potential of building materials

The use of any building material, in general, is determined by:

1. Structural capabilities: which are determined according to the behavior of the material, so it transfers the loads placed on it, the amount of these loads, which imposes a certain structural arrangement to be used when the building material is using.

2. Executive capabilities: These are determined according to the specifications of the material unit, dimensions, weight, amount of cohesion of the material, its expansion and its impact on external and internal weather factors, etc. This imposes an obligation to a specific method in transferring the material to the worksite and the methods of collecting and installing it, as well as the size and accuracy of the labor responsible for its use.

3. Possible cladding: It determines according to the external characteristics of the material, such as color, texture, and transparency, which affects the determination of the locations of the uses of the material and its suitability for the spaces (Agudiez, 2017).

2.3.2 The properties of construction materials and the relationship with technology

The properties of the material act as catalysts in the design process as they waiting for the creative user (designer) to interact with them and make them take certain patterns and ideas by using many methods of interacting with the material. The recent technological developments have had the effect of expanding the volume of material used in general, and the building materials in particular in the field of architecture (Golmahamadi, 2000). New building materials were used in addition to improving the properties of traditional building materials, changing the nature of their uses. Main features can be summarized in what modern technology adopts in building materials, namely (Skibniewski and Zavadskas, 2013):

1. Modern technology has given the possibility to efficiently produce high products for all styles of metal, plastic, or other materials. These materials make the products lighter, stronger, more solid and more solid than materials made from ordinary materials, especially withstanding tensile stress. This was what motivated the architectural designers to test new formations and release architectural creativity.

2. Capacity options and alternatives by adopting modern methods in the production of industrial materials, and facilitating the transport of materials away from their production centers, which overcomes the regional connections of these materials. The current technology gives the precision of design and manufacturing control, to give the products of his factory from the least amount of building materials, and enough to bear the fatigue for building construction according to the required specifications. Thus, this will reduce the cost and reduce the consumption of primary building materials resources (Agudiez, 2017).

According to Roaf et al., (2007), the most important factors that are taken into consideration and affect design decisions when choosing building materials are:

1. Location and details of the architectural elements,

2. Total cost and the requirements for maintenance, which is necessary for maintenance,

3. The level of the contribution of the chosen building materials in minimizing the climatic impacts of the building,

4. Durability and flexibility in design to allow adjustment to variables that occur over time (American Institute of Architects, 1992),

5. The life cycle (LC) of building materials and the possibility of reuse.

In general, the conventional design requires modern technology to give it the character of intelligence, also requires integration between it and the applications of this technology. In this case, a union between design and technology is essential in the emergence of smart production, and no one can deny it at the expense of the other. The three most important features associated with smart architectural designs are; 1) Flexibility; 2) Effectiveness; 3) Efficiency. (Wyckmans, 2005). (See Figure .2.2.)

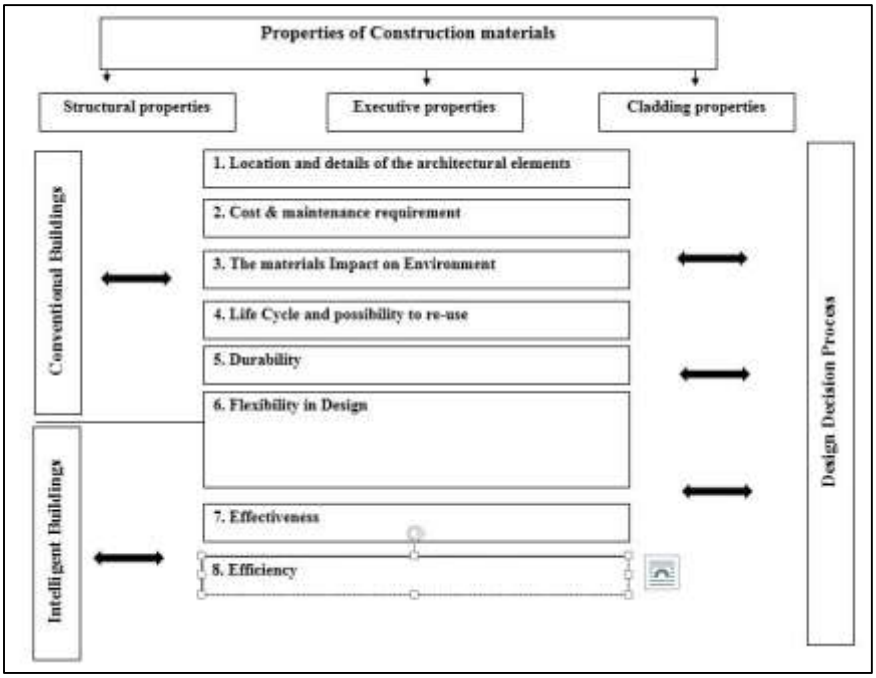


Figure 2.2: The properties of materials that affect the designers' choices, from (Roaf et al., 2007; Wyckmans, 2005).

Therefore, the intelligent buildings must fulfill the expected current requirements of their occupants while providing successful management of the systems involved in them with energy efficiency and effectiveness, as well as flexibility for economic performance.

2.4 Technological Architecture

It is the architecture that applies the technologies available in the era, whether in preparing designs for models of this architecture or in the ways and methods of implementing and operating them (Emmitt, 2013). There many categories of technological architecture, and will highlight the most important types in the next part.

2.4.1 The intelligent building's and technology

The term intelligent (smart) buildings appeared in the last period of the twentieth century. They are the buildings where the environmental systems integrate from the use of (energy, temperature control, temperature, lighting, sound, communications, etc.). These buildings use technology based on the use of 'microprocessors', in control systems through the use of 'Sensors' at strategic points that continuously feed smart information. This means using special electronic systems to operate some parts of the building, controlling some of the systems that the building contains, such as lighting, air conditioning, ventilation and energy systems, etc. (Beukers and Van Hinte, 1998). (See Figure 2.3.)

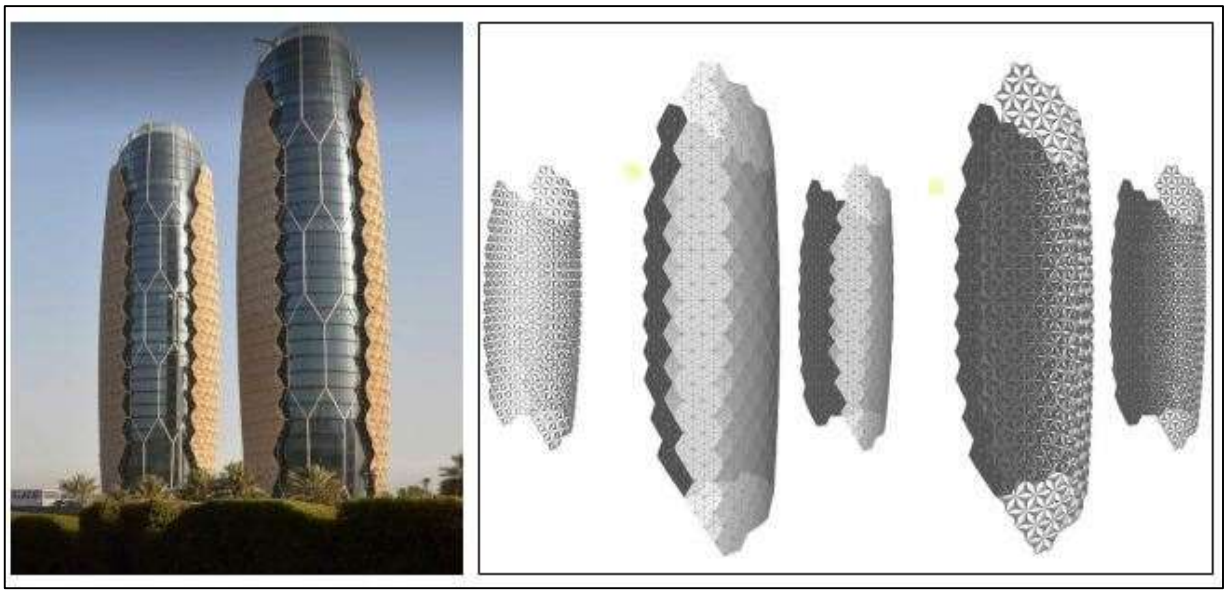


Figure 2.3: Al-Bahar Towers(Intelligent envelope Buildings)to control solar radiation and shading according to thermal performance requirements- Abu Dhabi, UAE, from(URL1 Archdaily).

There is no difference between the design that is and the rest of the design branches with regard to, design processes, and its challenges. Intelligent design is a branch of the architectural design and has the same goals and objectives, but it differs from the traditional architectural design in some special requirements that must be met to be described as intelligent (Wyckmans, 2005). As the design process in general consists of the following stages;

1. Analysis: Identifies all design requirements and returns or shrinks to a related group

Logically from the performance specifications,

2. Composition: In which solutions to individual performance specifications exist and are then combined together to form a complete design,

3. Evaluation and decision: In which design alternatives are tested in relation to performance specifications,

4. Reaching the optimal solution,

5. Replays (feedback), (Weissman et al., 2009).

2.4.2 Architecture of hi-tech and technology

It is an architectural school whose pioneer's ideology depends on the idea that (machine and art create a beautiful architecture). Moreover, they believe in science and they consider the current century to be the age of science. On the other hand, they believe in the understandable architecture that everyone (professionals and public) can clearly distinguish (Pawley, 1991).

They also aim to build a flexible building whose uses and functions can be changed easily so that it serves multiple purposes. This is in addition to the possibility of changing its parts, if a part of the building is weakened or damaged for some reason, it can be changed like a spare part.

The general features of hi-tech architecture can be summarized by (Pawley, 1991);

1. Use the latest technology and materials in construction processes,

2. Exaggeration in the use of manufactured materials (glass, metals, etc.) instead of natural materials such as stone,

3. Raise the slogan (machine + art) = (beautiful developed architecture),

4. Dispense with artisan workers and replace them with automated materials and parts,

5. The flexibility of the building, whether in terms of changing jobs or changing damaged parts.

The process of technological development of architecture has become very important in our time through (openness to the world, the discovery of new building materials such as high-quality concrete, the discovery of modern construction systems and high-speed automated means of implementation. All this development has affected the architectural design in particular, and architectural structures in general. The current architectural models inherited from previous eras prove that there is a proven relationship between the technological development available in each era and the shape and components of the architecture in that era (Eroğlu and Abbood, 2016). The technological development has taken many forms and has developed tremendously in all aspects of life. (See Figure .2.4.)

Figure 2.4: Al Example of the technology influence on architecture "The Guggenheim Museum, Bilbao, Spain, building made of glass, titanium & limestone", for Arch. Frank. O.gehry, 1997, from(URL2 Pinterest).

Hence, based on the previous explanation, the relationship between architecture and Hi-tech technology can be understood as creative ideas, mixed with technology, and environmental requirements. (See Figure .2.5.)

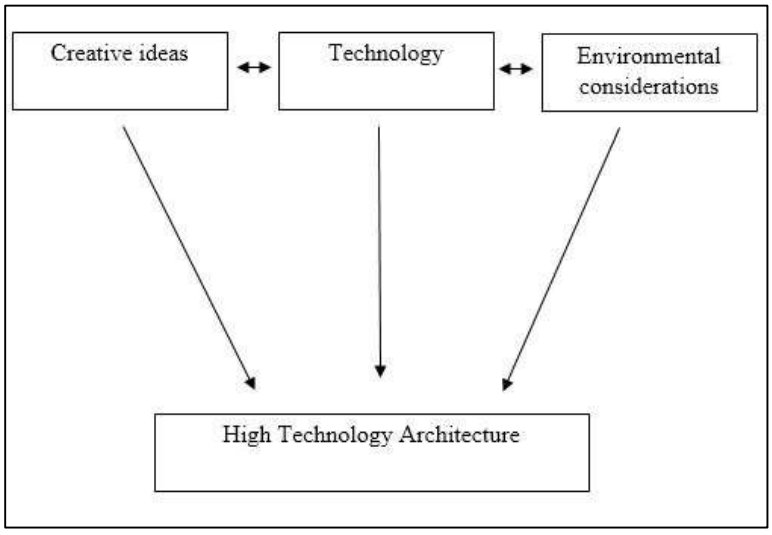


Figure 2.5: The elements that formulate High-tech. Architecture, from (Pawley, 1991).

2.5 Notion of the Character

Few of the architectural and urban works have been given a direct definition of the character, while the majority is that it suffices a general discussion of the subject from which the intended meaning of the character can be deduced. The character is the model that helps us recognize or remember the place. The character is divided into two levels: architectural character, urban character. The study will focus on the first level according to the scope of the current study (Lang, 1987, 137-162). To describe the character of a building is to look at its distinctive physical side. The major contributions to the overall structure of the building are the general aspects of its environment, construction form, roof and ceiling features such as smokestacks or domes, various construction projects such as porches or lawn windows, building slots or vacancies, including open galleries, arcades or balconies, and doors, etc., (FAIA, 1994).

2.5.1 Architectural character

Character defining features include several aspects, and the architectural character of any building is determined by the following features;

Building shape: An important aspect of its character can be the shape of a building. For example, the pattern of vertical and horizontal bands of openings, the decorative bands if available.

Materials and construction methods: Visual character is determined most commonly by the surface characteristics and construction; although, these aspects are often integrally related, the choice of materials originates often with color, texture, form, ornaments or craft details of the materials as a predominant element. The choice of construction is concerns with the techniques (construction ways) in the building character.

Location and setting: The element of the building location should not be ignored when defining the building's character. The setting of urban row houses clearly varies from a castle with its planned landscape. However, many examples can make a significant contributor to the character of the building and its relation with the location in the streetscape or its position in a rural area, (FAIA, 1994; Salvan, 1986). (See Figure .2.6.)

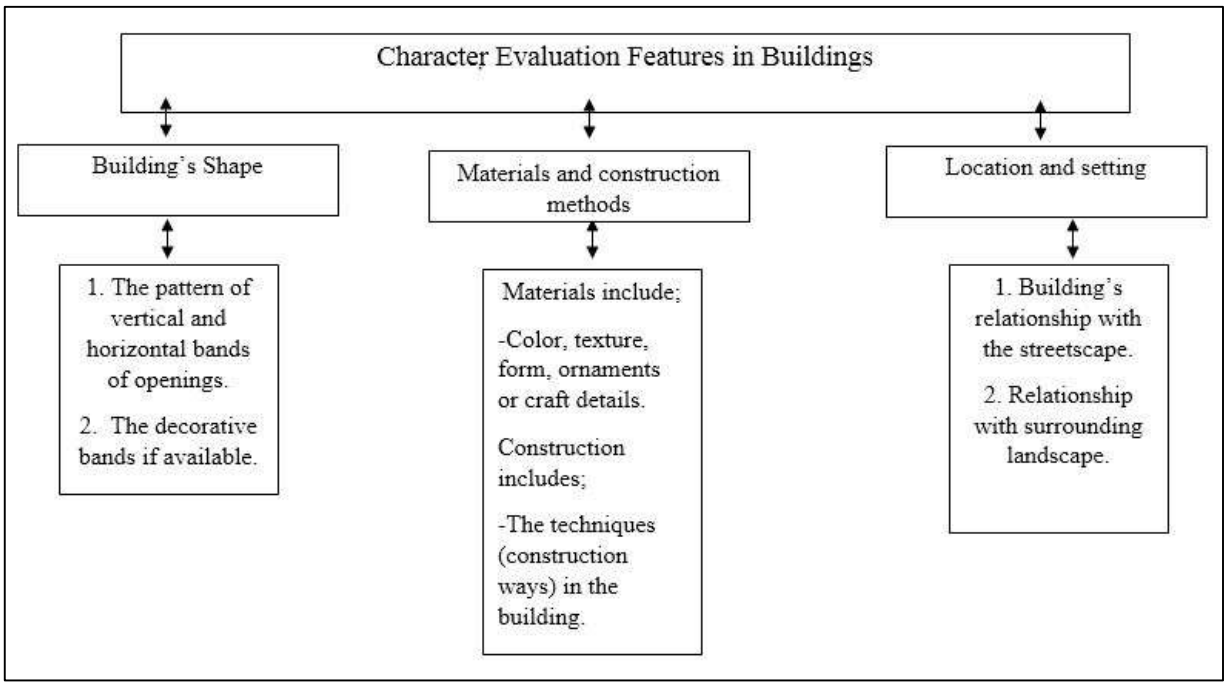


Figure 2.6: Features to evaluate character of architecture, from (FAIA, 1994; Salvan, 1986).

Moreover, many parameters can be taken as evaluation parameters to assess location and setting of the buildings within the city or the urban context which affect the character of architecture. These parameters are; 'Continuity, twinning, and harmony'.

1. Continuity: It is intended to use the tools and elements of the architectural formation of ACPs in an integrated manner in the buildings to achieve integration and continuity between the interfaces of the adjacent buildings. This is showing the facades when they are completed as one complement to each other, taking into account the differences in the entrances to the buildings, to achieve the distinct, and get to know the different buildings (USGBC, 1996; Brouwer et al., 2008).

2. Twinning or Repetition: The idea of twinning or repetition can be applied when the design is dynamic in nature, which allows us to form and demonstrate other formative relationships when it is repeated and integrated. Although the idea of repetition at the facade of the building

may be considered an architecturally poor treatment for merging the façades of adjacent buildings, it represents a peaceful solution to avoid falling into abnormal relationships in the final architectural form, whether in terms of architectural treatment, color difference, or the design itself (Finney, 2016).

3. Harmony: To achieve the required harmony, consider the following correlation alternatives:

- Architectural formation and the mass formation are studied in a manner that is consistent and harmonious with the neighboring buildings by treating the ends of the corners, the use of protrusions, the distribution of openings and the glass areas in relation to the solid blocks, etc.

- Types and Colors of Facade Finish: The types of facade finishes are controlled by comparing the facade to the adjacent buildings, and in a way that is compatible with the building's urban surroundings (Thapa, 2017).

Regarding the moral and functional importance of the character, the character awakens the spirit of belonging between residents and the city, as well as the environment of a belonging nature, which gives a sense of privacy. It increases the depth and culture of the human experience, and the reaction of the loss of architectural character that neglected the human aspects of the phenomenon of alienation, lack of affiliation, the spread of depression and isolation. This is because the lack of architectural commitment to traditions, customs and personality leads to a loss of stability and the collapse of their own culture (FAIA, 1994).

- ***Architectural Level*:** The character has a clear function in achieving the differentiation of places from one another, in the sense that it is easy to perceive the place of character as one continuous entity confirming the difference between it and other places.
- ***Behavioral Level*:** Some may consider the question of the shape and nature of cities and their architecture to take in the near future as luxuries. However, social research in the civilized world indicates the impact of the nature of cities and the quality of housing construction on social life, and the importance of this impact with regard to youth problems, the spread of crime and other social problems, such as the emergence of non-

aggressive behaviors starting with violence, crime, aggression on the environment and lack of commitment neglecting the humanitarian aspects.

- ***Economical Level*:** Considering originality and modernity as a goal, the authentic contemporary character must achieve the design goals, including the economic, and environmental considerations. The primary cost of conventional buildings, which are apparently considered high, could be more economical in the long run.

The most important general influences on the architectural character can include several components that affect the character. These components are including;

Cultural and Social: That is by considering architecture as a symbol. Every society or culture has a system and rules and has its own goals and aspirations. Culture and society have a significant role to play in expressing philosophical concepts through the building of expressive forms. This is through the use of images, archetypes, and metaphors to create sense in the architectural context by stimulating memories, perceptions and physical symptoms (Shayan, 2011).

Environmental, Geographical and Climatic: In particular, the climate has an effect on some architectural forms that are easily noticed. For example, by the movement towards the equator, the proportion of the window area to the wall area decreases. For warm areas, the sunray is avoided, hence, the window size is decreasing (Hochhäusl and Lange, 2018). Furthermore, the topography and the shape of the territory affect the form and shape of buildings, as per the relation with vegetation, sun rise/set, wind, view, etc., (Muhy Al-Din, et al., 2017).

***Technology*:** New building methods and their impact on architecture has a significant influences on the architectural character. This is through the type of new materials and the system of construction (Lang, 1987). These components influenced the architectural thinking of the facades of architecture, as the environmental component, the historical and political component,

the cultural component, the social component, the technical component, the aesthetic component (FAIA, 1994; Lang, 1987). (See Figure .2.7.)

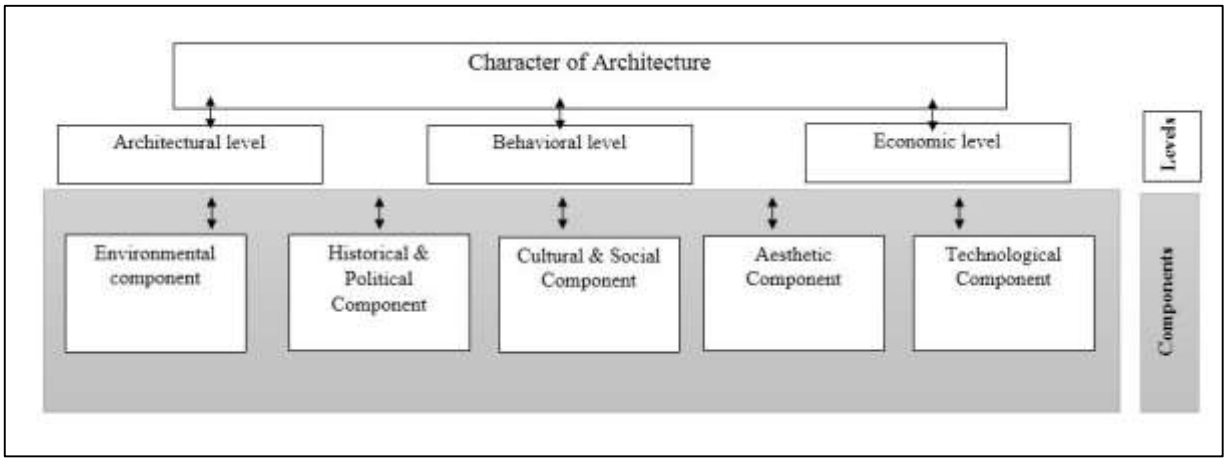


Figure 2.7: The levels of architectural character, and the components that influence character of Architecture, from (FAIA, 1994; Lang, 1987; Muhy Al-Din, et al., 2017; Shayan, 2011).

2.6 Fundamental of Sustainability

The Bruntland Commission published its report in 1987, "Our Common Future", trying to link the issues of environmental stability and economic development. in came out with a report that provided the first definition of sustainable development as, “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (United Nations General Assembly, 1987, p. 43). Despite, the definition is somehow vague, the concept aims to keep economic progress, with protecting of the environment in the long term range; it “Provides a mechanism for environmental policy integration and development methods” (United Nations General Assembly, 1987).

The notion of sustainability contains three main aspects, overlapped among these three main aspects creates the sustainability. Sustainable development could be explained in terms of environmental protection, economic growth, and social development (Adams, 2006). Those aspects should be taken in consideration to implement a required level of sustainable development. See Figure 2.8.

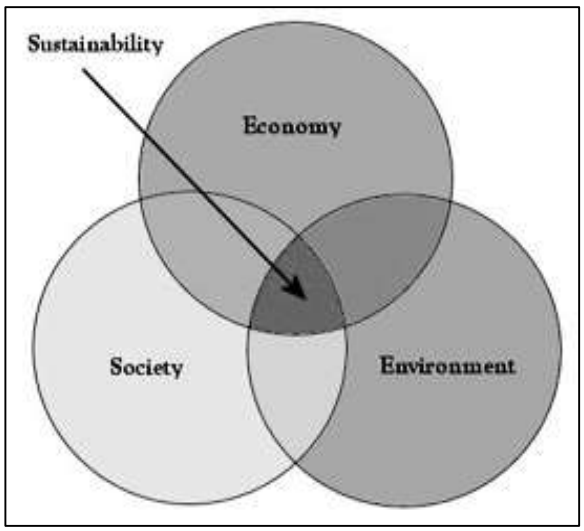


Figure 2.8: The Three main aspects of sustainability, from (URL3 Juneau).

Architectural and urbanism development can be considered one of the crucial issues for sustainable development, because of its long life-span and its direct and indirect impact on human's life.

Despite that built environment is one of the significant ways to reach the goals of sustainability; however, the researches demonstrate that it is one of the more neglected aspects of sustainability (Winston & Eastaway, 2008). Therefore it is important to find methods to ensure that new buildings and landscapes are sustainable.

A sustainable Architecture can be described as; cost-efficient, comfortable, and environment-friendly. Moreover, sustainable architecture could be defined as architecture that aims for integral quality, including social, economic, and environmental performance (Adebayo, 2013).

In the social dimension Sustainable architecture offers a preferable inner ambient that let occupants to stay indoor longer among friends and families and neighbor in the social context (Abidin, and Jaapar, 2008). One of the important factors to achieve sustainability in any community is providing low cost (Maliene, et al., 2008). Generally, architecture can achieve sustainability through the three aspects of sustainability: Environmental sustainability, economic sustainability and social - political sustainability (McConville, 2006). Table 2.1. show

the main parameters to achieve sustainable Architecture considering the three aspects of sustainability.

Table 2:1 The parameters to achieve sustainable Architecture. (McConville, 2006).

Economic Sustainability	**Environmental Sustainability**	**Socio-Cultural Respect**	**Community Participation**	**Political Cohesion**
		Social Sustainability		
Implies that sufficient local resources and capacity exist to continue the project in the absence of outside resources.	Implies that non-renewable and other natural resource are not depleted nor destroyed for short –term improvements.	A socially acceptable project is built on an understanding of local traditions and core values.	A process which foster empowerment and ownership in community members through direct participation in development decision – making effecting the community	Involves increasing the alignment of development projects with host country priorities and coordinating aid efforts at all levels (local, national and international)

2.6.1 Environmental sustainability aspect in architecture

There are several principles of environmental sustainable architecture and urbanism applied around the world, namely; (Rashid, 2014; Jin Kim, 1998); Employ energy efficiency in the built environment through the good orientation and the relation with sun path with the buildings and

urban area, in order to get better ventilation, natural lighting; Obtain good indoor/ outdoor air quality with implementing thermal, visual, and acoustic comfort; Selecting a suitable site location with the accessibility to public transport, and open space, services, in order to reduce energy consumption and reduce pollution level; Choosing materials that have low impact on the environment and human; Rainwater harvesting, recycling the water and water system equipment, and assuring maximum area (Amin, and Muhy Al-Din, 2018). The study will focus on the main concerned issues with the respect to the current study limitations, as will be demonstrated in the following parts.

1. Energy consumption

Energy efficiency is one of the important factor in buildings sustainability. Built environment has high effect on environment along the whole life time of buildings, which contains several points, as: construction process, material production, operation, repairing, removal and management of waste, and all these stages are consuming energy. The most benefit to improve buildings energy efficiency is reducing energy consumption. Another part of environmental benefits from energy efficient buildings are reducing air pollution and co2 emissions (Smiciklas, 2012). Hence, it is clear that good design can strongly mitigate energy consumption in the buildings; for example, the orientation and location of a building can affect sun path, the wind, day lighting and shading in the buildings. Innovation in design and construction method will play an important rule to provide efficient and eco-friendly buildings (Smiciklas, 2012), as well be explain more in next sub-chapter.

2. Material used

Select the proper materials for the building is an important fundamental for any architects or engineers to importing sustainable design idea to the building's design.

The cost of the material, is an important subject for evaluating analogous materials or materials selected in the similar function. While, cost of building materials include only the process of

manufacturing and transportation costs, not containing others cost such as social or environmental.

1. Material's life Cycle

The fundamental of Life Cycle Design represent a significant index for selecting the building materials (American Institute of Architects, 1992). Although, Building Materials can be defining by three steps, which are; pre- building step, building step, and post-building step;

The Pre-Building material step is including the manufacturing situation and transferring the material to the site, before assembling. This is the most important step which affect the environment, because it involves; extracting the raw materials which is find out in the nature, and then manufacturing process will be start, to prepare it for packaging and transporting steps.

The Building step is including a building material's life in use. It starts when the materials set out into a building's structure, and the maintenance, and prolong within the building life. Decrease of construction waste material, and recycled of waste material, is an important issue in this stage of the building life cycle.

The Post-Building step indicate to the building materials when it deterioration in the building. In this situation, may be the material be re-used partially or totally, and maybe some of its elements reuse in the other products, or be throw away totally.

The buildings destruction and major part of material disposal while causes the useless great environmental cost thus, the less material disposal in the construction after the expire of use bring up a worthy comprehension of this step in life cycle of the building, and it represent the achievement of sustainable principles for the designer (Dell'Isola and Stephen, 1981).

2. Features of Sustainable Building Materials

There are many aspects in the material of building, in order to achieve sustainable building design. Some of these aspects will be described in this section;

a. The material embodied energy*:* is the total energy needs for material production, which begin by collecting the raw materials. This consist of applying all kind of the energy for equipment collection, and the methods of material manufacturing operation, also the transportation process to transfer raw material to a processing facility. This energy causes fossil fuels to burn, which is a non-renewable resource, as well as it's emitted the dangerous gasses to the atmosphere and has negative impact on the environment which cause acid rain, global warming, and climate changes (Minke, 2006). As much as the embodied energy in the materials become more and more, represent higher amount of energy needs to produce it, thus it causes the more impact on the environment. So, the local materials which found in nature have lower embodied energy in compare with the manufactured ones. For instance, the adobe bricks production (shaped clay and dried naturally) in a sustainable perspective required lower energy and emitted lower pollution compare with manufactured concrete block which consist cement as known as high polluted material as one of the element producing this material (Asif et al., 2005; McConville, 2006).

b. Energy efficient material: is an important tool to reach a sustainable building. The goal to employ energy efficient materials is to decrease the energy consumption which is transfer to a building site. The cost of energy in long term are mostly related with the materials employed in building construction. The energy efficiency of the material in the building can be evaluate by using some factors like U-value (Heat transfer coefficient value). The materials with lower transfer of heat within the envelope of the buildings, can be decrease the heating or cooling requirement in the building (Koenigsberger, et al., 2010). Other factors are luminous efficiency, shading coefficient, and fuel efficiency Quantify. assessing material's efficiency in the building

can be carry out in order to assist in the comparison and choosing the building materials and defining the best material for the building (American Institute of Architects, 1992).

c. Non- or lower-toxic components in the materials: it results the materials with lower impact on the tenant's health and works. Wherever, applying the toxic materials can affect IAQ (Indoor Air Quality) and bring health danger to the building occupants. Some materials which use in the building such as adhesives are spreading hazardous emission for a short period, during and after assembling. While, others kind of materials like paintings or some kind of building materials (Asbestos sewerage pipes) could affect the occupant's health all over the building's life (Jin Kim, 1998; Zainul Abidin and Pasquire, 2005).

d. Long-lived and low maintenance material: is the material which needs lower frequent replacement, so decrease the expense of replacement and re-assembling. These types of materials are sustainable because, will require less raw materials and will produce lower landfill waste through the building's life span (American Institute of Architects, 1992; Pullen et al., 2009).

e. Cost- efficient or lower- cost materials: which can define as materials that hit the economical dimension in sustainability. Applying the low cost building materials for building construction could cause to accomplish low cost housing, which bring the opportunity for low income group peoples (Ilberg, and Rollins, 2007; Dell'Isola and Stephen, 1981; McConville, 2006). (See Figure .2.9.)

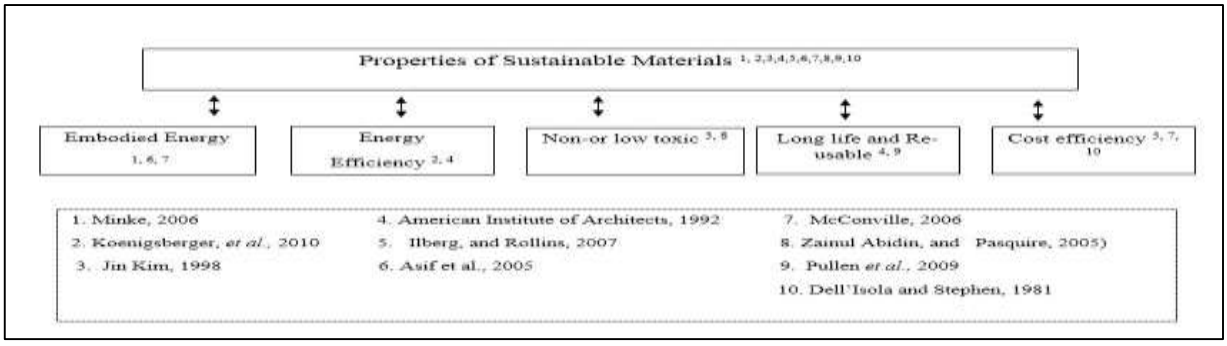


Figure 2.9: The properties of sustainable materials.(Author,2021).

2.7 Aluminum Composite Panels (ACPs)

2.7.1 Background

In recent years, the facades of buildings have been covered by the aluminum composite panels (interior and exterior cladding) to cover the increasing demands on buildings and architecture. These panels are known as multi-colored aluminum or composite panels to expand the creativity in designing the facades of buildings in various forms by expanding the formal options in front of the designer. The application of these panels is flexible comparing with the traditional concept of facades. With the development of buildings in the shape and buildings' facade, the demand has increased on ACPs, due to the addition of these claddings a distinctive modern look that combines elegance with an economy in addition to providing thermal insulation of buildings in addition to the ease of maintenance and cleaning work for such facades (European aluminium association, 2014). (See Figure 2.10.)

Figure 2.10: Evaporative Porsche building, one of the pioneer's aluminum panels projects in Stuttgart, Germany, from (URL4 Aarchiexpo).

The reason for using ACPs as cladding is to improve any defected wall or to provide aesthetics to the facade of the building. ACPs have several colors and sizes with various shapes and types. It can be applied in any type of buildings. There are many finishes of ACPs, as matte finish, polished finish, marble, and wooden finish, etc. ACPs are also applicable to be synthesized with other materials such as glass. There are many examples of applying glass with ACPs. For example, 'Burj Al Arab' building in Dubai has cladding of ACPs combined with glass in its facades. (See Figure 2.11.)

Figure 2.11: ACPs facades of Burj Al Arab iconic building in Dubai-UAE, from (URL5 Skyscrapercenter).

2.7.2 Components of ACPs

ACPs are pre-manufactured construction materials, composed of two aluminum sheets. The aluminum plate thickness is 0.5 mm and filled by a 3 mm polyethylene core, thus, the overall width of the ACP is 4 mm, which differs accordingly. The outer face of the aluminum sheet in ACP is plated with PVDF (Polyvinylidene fluoride). Commonly, ACPs' thickness standards are

3mm, 4mm, and 6mm, changing with the changing of the polyethylene thickness (Mohaney and Soni, 2018). The manufacturing of these panels mainly consists of three processes, namely; co-extrusion, laminating with precast adhesive films, and laminating extrusion. (See Figure 2.12.)

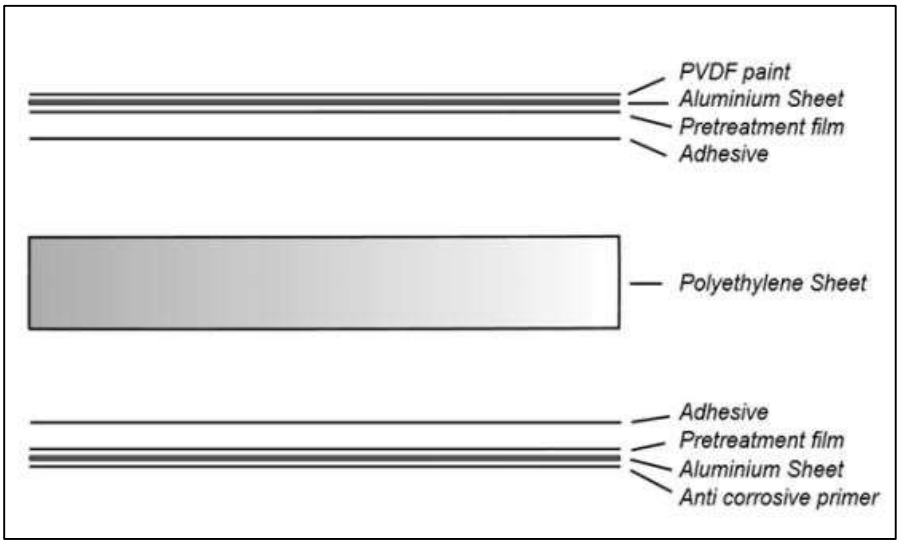


Figure 2.12: The components of ACP, from (Mohaney and Soni, 2018).

This material is commonly fix on the iron or aluminum structure as cladding materials to cover the exterior or interior wall. (See in Figure .213.)

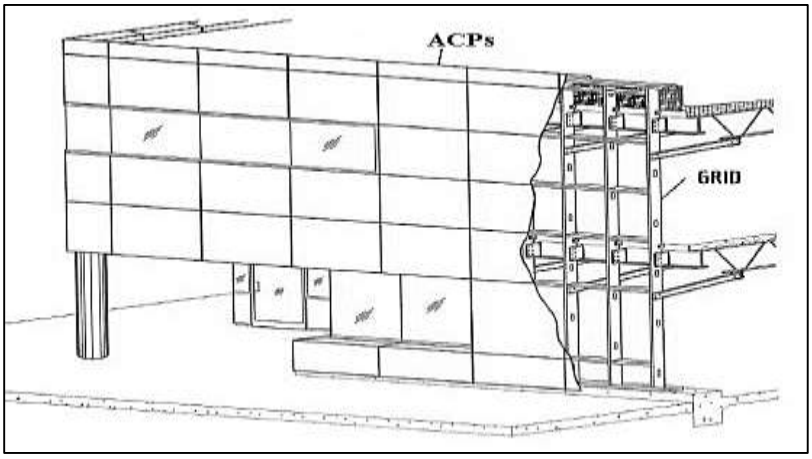


Figure 2.13: Structural system support for ACPs cladding, from (Etalbond, 2015).

2.7.3 Sustainable characteristic of ACPs

Aluminum is considered a sustainable material as it is 100% recyclable, without losing anything from its quality. It is, also, a highly durable material, and ACPs that apply to the buildings' elevations have energy-efficiency capacity, through airtightness, solar heating control (European aluminium association, 2014).

The most important advantages of ACPs are; the panel has excellent mechanical properties through its lightweight, and it demonstrates weather and chemical resistance. Furthermore, it is rigid but easily shapeable and flat and has a high acoustic and thermal isolation. The CAP is considered cost-effective construction materials comparing with other types of construction materials. Moreover, it is eco-friendly materials and has a low impact on the environment because of its long life and recycling potential. (See in Figure 2.14.)

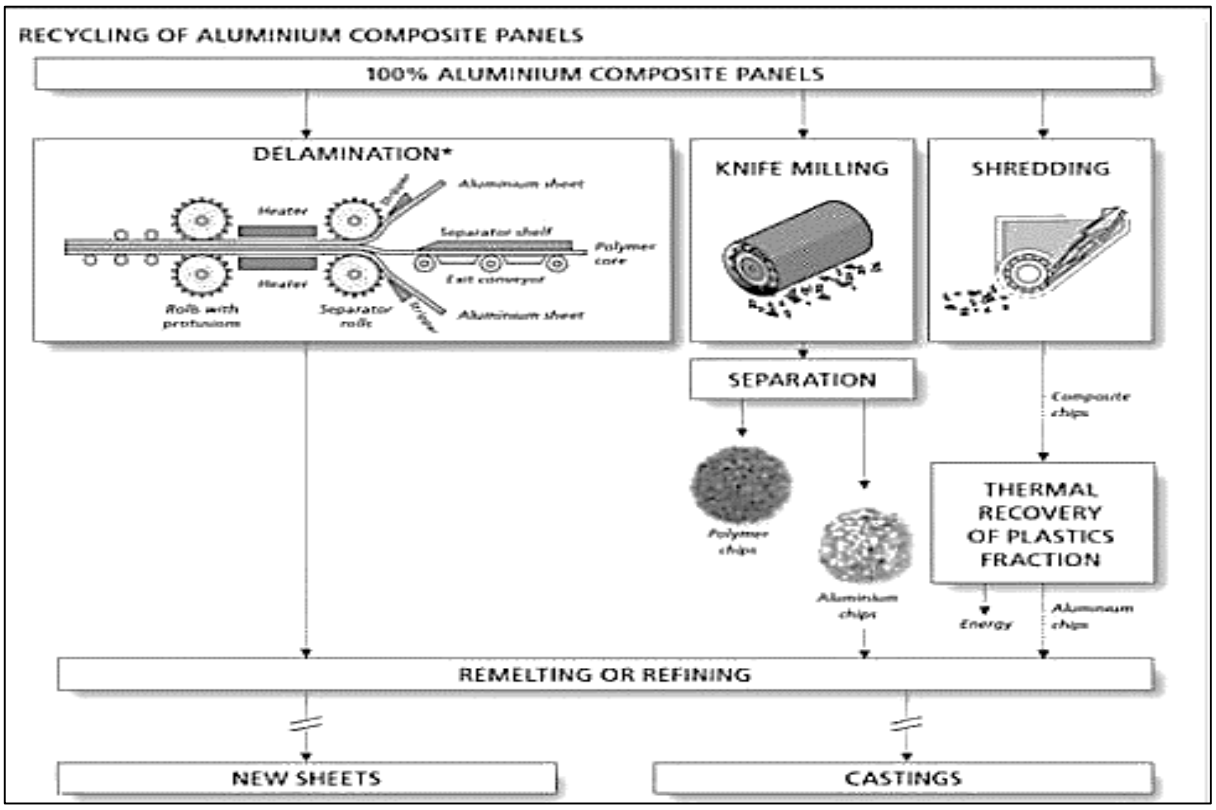


Figure 2.14: The potential of re-cycling ACPs, from (European aluminium association, 2014).

This material has the property of durable outer coating performance and easy and low-cost maintenance process with least requirement for the maintenance. However, there some dis-advantages of ACPs too, which are; the panels may suffer from erosion particularly during harsh weather. Moreover, adding waterproofing is important for ACP when it is used on external surfaces (Mohaney and Soni, 2018).

2.8 Summary

In this chapter, the most important theoretical issues for the study have been highlighted. Hence, keywords like 'technology' and the relationship between technology and architecture has described. The influence of technology on architecture, directly and indirectly, has been shown, as seen in Figure 2.1. As a response to the limitation of the study, the properties of construction materials have been studied and analyzed. The properties of these materials and their relationship with technology have been identified. The most important factors that affect design decisions during the selecting of building materials have been delineated. Moreover, the features of materials to be applied in intelligent buildings have been demonstrated too, as shown in Figure 2.2. Technological architecture has been highlighted and its types have been explained in this chapter with the elements that compounding this type of architecture, and some examples of this type of buildings have been shown.

Another important keyword has been explained which is 'architectural character'. The levels of character in architecture have been demonstrated, and the most important components that affect architectural character have shown too, as seen in Figure 2.6. Other keywords are "sustainability" and 'sustainable materials' have been discussed in this chapter in order to come out with the most important properties for sustainable construction materials, as seen in Figure 2.9. The concept of aluminum composite panels ACPs has been highlighted and most important technical and sustainable characteristics have been shown in this chapter, based on the literature.

The chapter tried to demonstrate these keywords in order to formulate initial factors to evaluate the potentials of specific materials in terms of the following requirement; (sustainability,

architectural character, and technology) in the study region. This is through developing a checklist to evaluate these requirements in specific new building materials developed based on the technology. The aim of that is reaching a decision about the sustainable potential of these technological construction materials. Moreover, the character of architecture in the region of study will be evaluated. The effect of these materials on the local architecture character will be tested based on initial indicators that have formulated from the literature and theoretical framework. More elaboration about the methodology and the methods approached in this study will be introduced in the next chapter.

CHAPTER 3

METHODOLOGY

This chapter will demonstrate the methodology for the current study, and introduce the region of the study, and the case study will be illustrated in this chapter. Furthermore, the assessment checklist for evaluating sustainability in the utilization of new technological materials as ACPs will be determined. In addition to this, the structured interview, which is developed by the researcher will all the questions will be illustrated in this chapter. The way of analyzing the obtained data will be mentioned in this chapter too.

3.1 Outline of the Methodology

A quantitative and qualitative research method was used to achieve the research goals and to answer the research questions. Quantitative method is approached by the researcher to test the condition of the new technological construction materials and their sustainable potential in Northern Iraq. For this purpose, field observation has been conducted depending on developed a checklist which has formulated based on initial indicators found from literature to evaluate sustainability in the new construction materials. The most prevailed new technological construction materials applied in the buildings in the study region is ACPs (Aluminum Composite Panels). Hence, the checklist have been applied on the case studies with ACPs, applied in their structure. The qualitative method will be approached to reach an understanding of the effect of these new technological materials on the local architectural character in northern Iraq. Therefore, the structured interview has been developed and thirty architects and experts in the field of study in northern Iraq have been interviewed for this purpose. Hence, the outline of the study have been illustrated in the following diagram, and each of the methods and methodologies have been shown, and each of which will be elaborated in the next parts. (See Figure 3.1.)

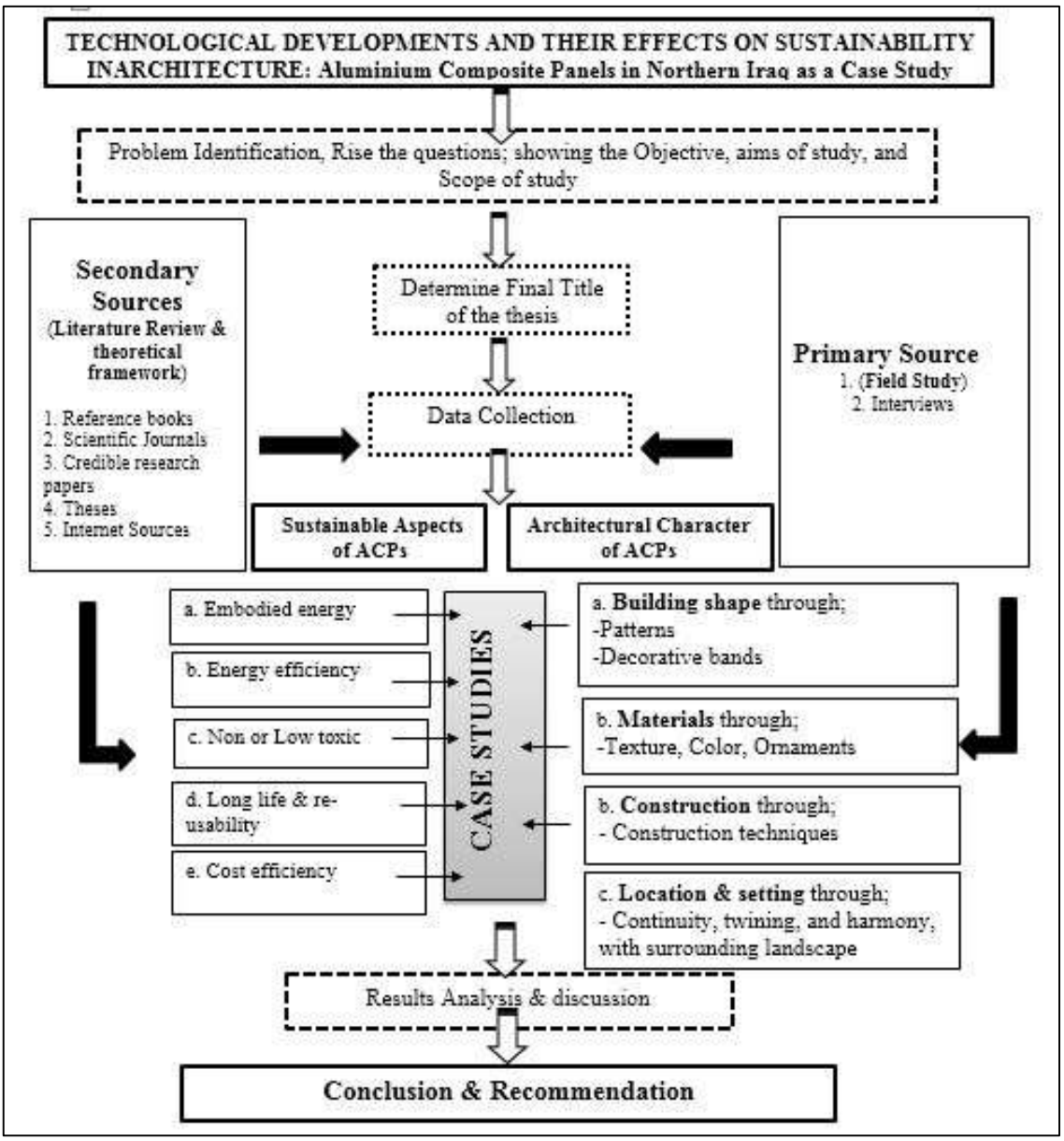


Figure3.1: The outline of the study methodology. (Author,2021).

3.2 Study Area

The study area is in Iraq and in the north part of Iraq, in particular. The region has a total area of 42,812 Km2, as demonstrated in Figure 3.2. Northern Iraq share almost 17% of the overall area of the Republic of Iraq. Northern Iraq is involving three governorates; Erbil, as a capital of

the region, Sulaymaniyah, the cultural and industrial capital, and Duhok the trading center. The latitudes of Northern Iraq range from 34.7° to 37.4 ° N and the lengths of 42.4° to 46.25 ° E (Rashid, 2014).

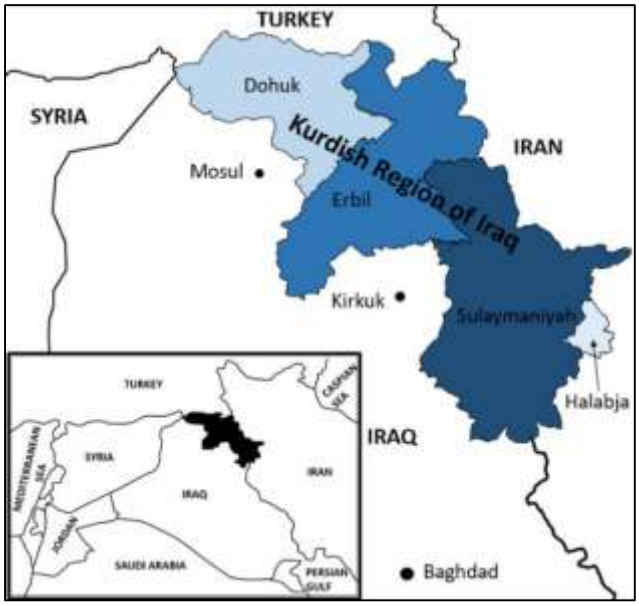


Figure 3.2: Northern Iraq as part of Republic of iraqi Federal, from (Mohammed et al., 2019).

3.3 Data Collection

The real-life case studies from Northern Iraq will be chosen to verify and improve the credibility of the research, then data collection and analysis will be conducted using secondary and primary data sources. Secondary sources through direct analysis for observed phenomena from the site, while the primary sources by approaching books, articles, credible internet sources, as well as documentaries such as; Cad files, plans and sections. Two ways are used in collecting data in this study. The first way was the analysis of the case studies buildings which are applied with (ACPs) base on-site observation and analysis of the documentary (Plans, sections, etc.) have been conducted to evaluate the sustainable effects of these materials on the case studies. A checklist has been developed to evaluate the advantages of these new technological materials based on obtained indicators from theoretical analyses and the survey of the literature. The

second way was developing structured interview to evaluate the effects of ACPs on the local architecture character, based on specific structured questions developed according to formulated indicators obtained through theoretical analysis and literature review. Sample of interviewees have been selected from architects and academic people in the field of architecture and sustainability within the geographical area of northern Iraq.

3.4 Case Studies

A case study methodology' is applicable when the aim of any research is to answer 'why or how' questions. It is effective to be used in any study when cannot affect the events or cannot grip them, and when studying an existing phenomenon (Yin, 2003).

This study requires types of private buildings (buildings that may possibly adopt local values due to the importance of their location or function within the cities of northern Iraq) and that may contribute effectively to achieving design sustainability, as buildings of distinct design nature which have used ACPs as cladding in their elevations as an important example for technological materials used in architecture.

Therefore, the case study buildings have been varied from commercial and service buildings to buildings that were renovated. The aim was to verify the impact of the application of material ACPs on these case study buildings in the region of study. Hence, six case studies will be selected in the three governorates of Northern Iraq's region (Two in each governorate). This is, to cover the region of the study with examples about the application of ACPs as new technology material. An analytical descriptive approach method was used to prove the results for locally chosen case studies.

3.4.1 Case study selection criteria

Erbil the following criteria has been taken in consideration during the selection of the case studies;

1. All the buildings should be covered (partially or completely), by ACPs materials on their elevations,

2. The buildings should be located in the three main cities of Northern Iraq, which are, Sulaymaniyah, Erbil, and Duhok, to cover all the regions of the study,

3. The selected buildings should be located in distinguish places within the cities, in order to assure their influence on the urban texture of the cities,

4. The buildings should not be houses to assure the process of the design for the building by architects (not as some houses which are not involving any expert like designers or architects in the building process).

1. The Case studies of 'Sulaymaniyah' city

Two buildings have been selected in Sulaymaniyah city to be analyzed in terms technological construction materials effect on the sustainability in the buildings, and the effect of these materials on the character of architecture in the city.

a. ***'North bank' building***

The building is located in on Salim Street in Sulaymaniyah, and located in the western part from the center of the city. (See Figure 3.3.)

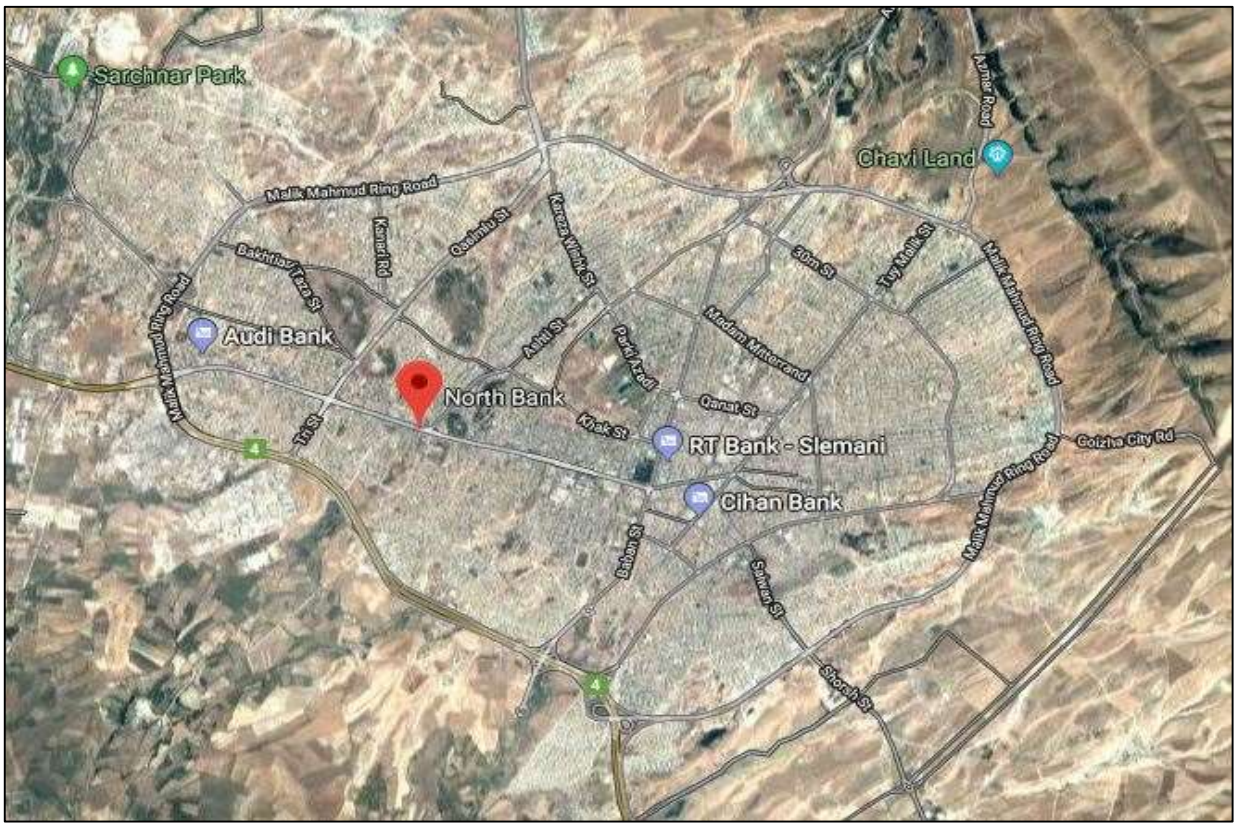


Figure 3.3: The location of North Bank building in Sulaymaniyah- Iraq. (Retrieved from Google earth).

The building has been built in the early of 2000's, and it is raising 40 meters from the ground, and the total area of the building is 450 square meters. The building is consist of ten floors, and all the building is occupied by North bank- Sulaymaniyah branch. The façade is cladding by ACPs. (See Figure 3.4.)

Figure3.4: North bank building in Sulaymaniyah- Northern Iraq. (Sulaimanyah, 2019).

b. ***City star shopping center***

This building has been constructed in 2008, in the city of Sulaymaniyah, and located in the center of the city in 'Aqary' sector. (See Figure 3.5.)

Figure 3.5: Location of City Star Shopping Center within Sulaymaniyah City. (Retrieved from Google earth).

The building has built on a land that covers 3000 square meters including parking area. It involves twelve floors, and includes shopping centers in addition to some private offices. The total height of the building is 49 meters. The building facades are completely covered by ACPs and glass. (See Figure 3.6.)

Figure 3.6: City Star Shopping Center in Sulaymaniyah- Northern Iraq. (Sulaimanyah, 2019).

2. The case studies of 'Erbil' city

As mentioned for the buildings in Sulaymaniyah city, other two buildings have been chosen as case studies in Erbil (the capital of Northern Iraq) to be analyzed.

a. *Erbil international hotel*

The building is functioning as a hotel on the 60-Meter-wide ring road at Erbil. It is located on the 'Barzany Namr' road, behind 'Gilkand' Park. (See Figure 3.7.)

Figure3.7: The location of Erbil International Hotel in Erbil city- Northern Iraq. Shopping Center in Sulaymaniyah- Northern Iraq. (Retrieved from Google earth).

The buildings has been renovated in 2004, and the total area of the building with its land scape is 3750 meters square, and 2400 square meter without the landscape. The building consists of ten floors, and 34 Meters high from the ground, the majority of the hotel's elevations are covered by ACPs. (See Figure 3.8.)

Figure 3.8: Erbil Int. Hotel in Erbil- Northern Iraq. (Erbil, 2019).

b. ***Family mall***

It is located in Northern Iraq in Erbil city, on the 100-meter ring-road or 'Peshawa Qazi road, and constructed in 2010. (SeeFigure 3.9.)

Figure 3.9: The location of Family mall in Erbil- Northern Iraq. **(**Retrieved from Google earth**).**

The project is 2 Floors with 20 m2 height, and contains 3 total units covering almost 25, 000 square meters; 5,000 square meters for Hypermarket, Carrefour, covers 9, 990 m2, and Home Istanbul covers 9,608 m2. The building frontage has covered with ACPs. (See Figure 3.10.)

Figure 3.10: Family mall in Erbil- Capital of Northern Iraq. (Erbil, 2019).

3. The case studies of 'Duhok' city

In Duhok city as one of the three governorate of Northern Iraq, two case studies have been selected to be analyzed as other four case studies in Sulaymaniyah and Erbil.

a. *Khani hotel*

The building is located in Duhok city in the northern part, near the junction between 'Zakho' road and 'Kawa' road. (See Figure 3.11.)

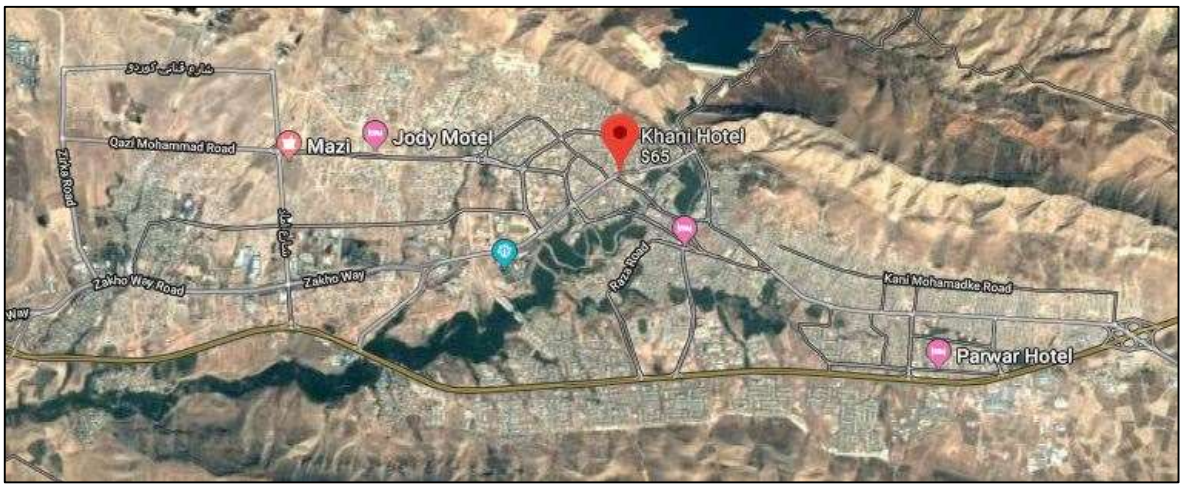


Figure 3.11: The location of Khani hotel in Duhok- Northern Iraq. **(**Retrieved from Google earth**).**

The building is contains seven floors including the ground floor, and the total height of the building is 25 meters from the ground. The total area that the building is built on is 400 meters square. The building elevations are cladding by ACPs. (See Figure 3.12.)

Figure 3.12: Khani- Hotel in Duhok in Northern Iraq. (Duhok, 2019).

b. ***Health directorate building***

This building is governmental administration building, located on the South-east of the city. The building is facing the highway of 'Barzan', (Zawita) way. (See Figure 3.13.)

Figure 3.13: The Directorate of Health location in 'Duhok', Northern Iraq. **(**Retrieved from Google earth**).**

The building is consist of four floors, and the total area of this building is 1350 meters square. The height of the building is 15 Meters, and covered by ACPs. (See Figure 3.14.)

Figure 3.14: The building of Health Directorate in Duhok in Northern Iraq. (Duhok, 2019).

3.5 Field Observation

The observation is one of the usual methods used to gather information by direct analysis, which could neutralize the inclination of the individual and obtain information by present events (Kothari, 2004). The observation has been applied to evaluate the sustainable effect of ACPs materials in the case study buildings in northern Iraq. A Checklist has been developed to

evaluate the sustainable properties for ACPs materials which has been selected to be studied as one of the most prevailed new technology building materials in the region of study. For sustainability analysis several sustainable materials properties have been analyzed, which are (embodied energy, energy efficiency, toxic impact, the life cycle of the material and reuse possibility, cost-efficiency), as explained in subsection (2.6.1.2.) in chapter two. Other two properties have been added to the checklist as sustainable properties of new technological material. There properties are; Durability and effectiveness, in addition to flexibility, based on the smart characteristics of new technological materials which affect sustainability, as mentioned previously in sub-chapter (2.3.2) in chapter two. As it is obvious, these properties have been formulated according to the literature, depending on several indexed types of research and credible references. See Table 3.1.

Table 3.1: The assessment checklist for sustainable factor presence in the buildings with ACPs. (Author,2021).

No.	**Sustainable materials factors**	**References**
1	Low Embodied Energy of the material	(Minke, 2006; Asif et al., 2005; McConville, 2006)
2	Energy Efficiency of the material	Koenigsberger, et al., 2010; American Institute of Architects, 1992
3	Non-or low toxic materials	Jin Kim, 1998; Zainul Abidin and Pasquire, 2005
4	Long life and Re-usable character of the material	American Institute of Architects, 1992; Pullen et al., 2009
5	Cost efficiency of the material	Ilberg, and Rollins, 2007; Dell'Isola and Stephen, 1981; McConville, 2006;

6	Durability, effectiveness and quality of the materials	Roaf et al., 2007; American Institute of Architects, 1992; Wyckmans, 2005
7	Flexibility of the materials in design and construction processes	Wyckmans, 2005; Roaf et al., 2007

3.6 The Method of Evaluation

The sustainable materials assessment checklist with involved factors has were analyzed by DST (Descriptive Statistical Tools), and the weighting has been counted as a measure to realize the rate of sustainability in each case study, in terms of applying the ACPs materials. This is based on the strength and activity of the factors which are seven factors according to the following categorization;

- Highly active: for the strong presence of the factor (weighted by 3).
- Mid active: for regular presence of the factor (weighted by 2).
- Low active: for the low presence of the factor (weighted by 1).

Each of which divided into three smaller scales to find (high contribution, and weighted by (3), mid contribution, and weighted by (2), and low contribution, which is weighted by (1). The smaller scale will be evaluated depending on the availability as 'quantity and quality' of ACPs in each case study, with respect to the relationship with the specific factor and will be multiplied by the main active condition of the factor. For example, if the total area of ACPs in one case study is higher than others, and the case is to evaluate the 'Low Embodied Energy of the material' (See Table 3.1), all the buildings will be evaluated (highly active). The buildings are evaluated by (Highly active and weighted by '3') because ACPs are effective material in terms of the required energy for production as will be explained in chapter four. See Figure 4.1. in Chapter Four. However, the quantity or the area of ACPs material is different from case study to another, therefore the buildings with higher areas of ACPs on their facades will have higher

embodied energy then have a lower contribution in achieving sustainability, thus, they will be weighted (1), and vice Versa. Thus, the weight of the activity (3) will be multiplied by the contribution which is (1), and the total weight will be (3). For the lower area of ACPs, the high activity weight which is (3), will be multiplied by high contribution which is weighted (3), and the result will be (9). Hence, the total obtained score for the materials to be 100% sustainable based on the seven factors of the checklist is '63'. The same procedure will be applied to the factors related to the quality of ACPs. More elaboration will be done in chapter four.

The aim of this is to find the weight of each factor's contribution in each category in the case study buildings in order to make a comparison between the selected case studies in terms of sustainability rates. The assessment will be carried out by the researcher based on theoretical analysis, after the field observation. In Appendix A, a sample of the checklist is shown.

3.7 Interviews

Semi-structured questions have been prepared to acquire the necessary information from 30 selected professionals. Divided into; government and private architects, academics, and designers. Some of the interviews have been conducted via Skype, or telephone, due to the difficulties to be in place at time because of the difficulties to manage that with some interviewee, who were very busy whole the time. The interview has been preferred instead of the questionnaire, because of the interview has more chances to express the opinion of the participant than questionnaire with its limited questions. Thus, through the interview, more debate about the subject could take place during the answering of questions even if it is structured questions.

The most effective factors on the character in architecture has been found are (Shape, material, construction technique, and location or setting of the building), as explained in sub-chapter (2.5.1) of chapter two. Hence, semi-structured questions regarding the effect of the ACPs on the character in architecture have been asked to the interviewee, as formulated from the literature, as follow;

1. What is the effect of the ACPs on the case studies architectural visual shape in terms of the pattern of vertical and horizontal bands of openings, and their effect on the character of local architecture in the region of study?

2. Taking the case studies as samples, how you evaluate the effect of the ACPs as new technological material on the character of architecture through its parameters (color, texture, and craft details)

3. Will the ACPs affect the main construction techniques in the buildings, in such a way that could affect the character in architecture?

4. Regarding the building settings and location, how the ACPs affect the architectural character through its parameters (continuity, twining or repetition, and harmony) with the surrounding context?

3.8 Summary

The chapter has elaborated on the methodology of the study, and the outline of the study methodology. The case study as a methodology has been explained and the location and description of case study building have been illustrated. Six case study buildings have been selected based on the specific criteria in three main cities of the region of Northern Iraq. Each city with two case studies in order to cover all the region and get clear picture about the application of ACPs in all the cities of Northern Iraq. The data collection methods have been illustrated too, through different ways, as observation and applying a checklist which includes the quantitative method for acquiring data. The qualitative method has been applied through interviews. Although a semi-structured interview has been conducted, with specific questions, the opinion of the participants has been taken into consideration as a qualitative method to approach the study.

CHAPTER 4

ANALYSIS AND DISCUSSION

Through field surveys (observation and interview), in addition to documentary analysis, the chapter will address the influence of ACPs on the sustainability of case study buildings. This is based on the analysis of the obtained results from the developed checklist. Furthermore, in this chapter the results of the five questions that asked to the interviewees will be found in order to evaluate the effect of ACPs materials on the character of architecture in Northern Iraq.

4.1 Survey Results

The practical part of this research was consist of field survey which have divided into two methods;

1. The first method is observation and analysis based on the developed checklist by the researcher, depending on the previous study by other researchers and a thorough review of the literature.

2. The second is an interview, and the interview has been selected from Northern Iraq and they were 30 architects, expert in the field of architecture and sustainability, as well as designers.

The survey was carried out in six buildings, which were used as case studies in Northern Iraq, two of which in each governorate, from the three governorates of the region (Sulaymaniyah, Erbil, and Dohuk).

4.1.1 Observation and analysis, based on the developed checklist

The evaluation of the data that obtained from the field observation according to checklist form for each case study building were as follow;

1. ***Evaluation of Low Embodied Energy of ACPs Material****:* As illustrated in the literature in chapter two, ACPs are highly applied in buildings because of the low maintenance and energy efficiency of these materials. Hence, the first observation of the buildings will be the percentage of the ACPs that is covering the elevations. Based on this fact, and because the embodied energy for producing ACPs is relatively low commonly if compared with other main construction materials like steel and concrete. (See Figure 4.1.)

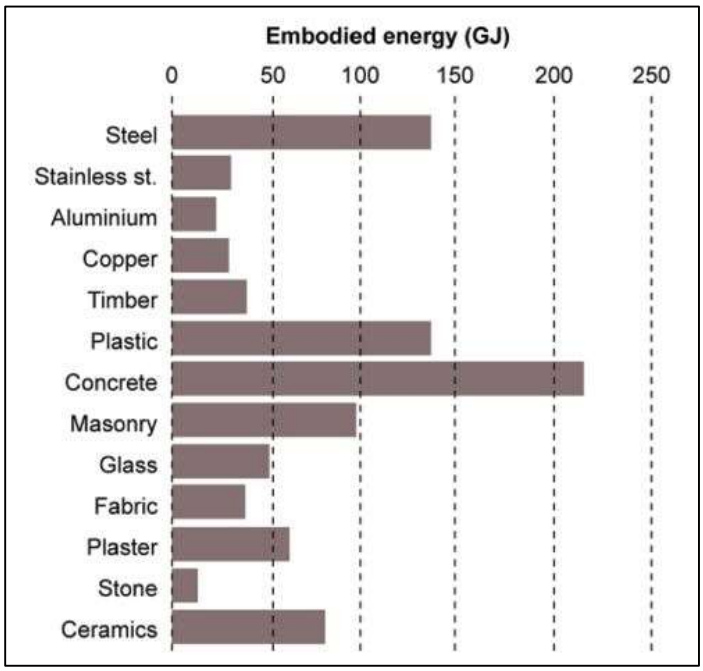


Figure 4.1: The embodied energy for Aluminum, comparison with other construction materials by (GJ)-Giga joule. (Milne, 2013).

Thus, the embodied energy in this type of materials are low, and because of this point the evaluation of embodied energy in each case study will be based on the total area of ACPs in the case study buildings' elevations. This is to make a comparison between the case study buildings and determine the most sustainable building in terms of ACPs effects on these selected buildings.

2. *Evaluation of Energy Efficiency of ACPs Material*: Ventilated façade is a construction system in which the internal wall and the external façade of the building are divided. The separation between the exterior wall and the outside cover allows the air to flow. The separation enables the building by thermal and acoustic protection. Hence, the right exterior covering is critical as it provides weather protection, provides the building with structural stability, provides ventilation and is energy efficient (Schmid, and Marinitsch, 2016). (See Figure 4.2.)

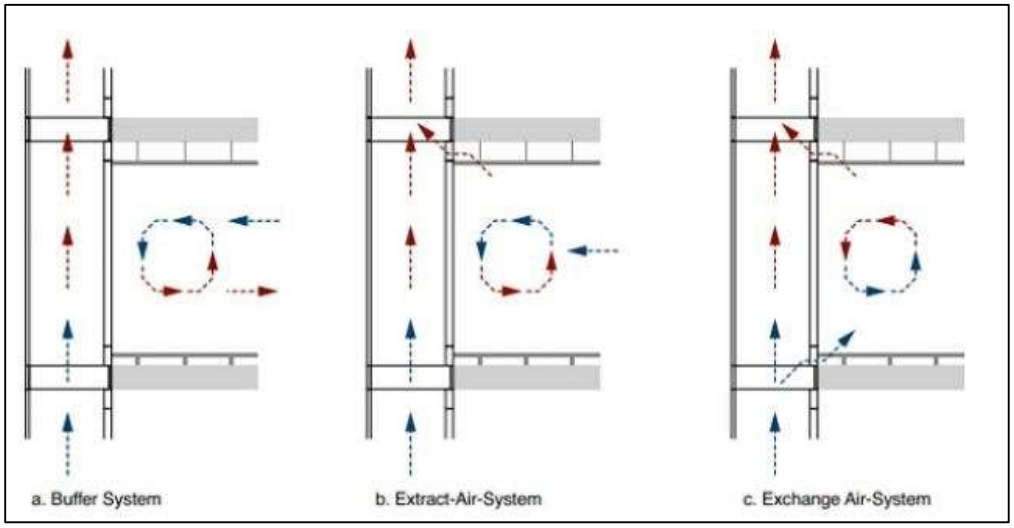


Figure 4.2: Ventilated façade because of the separation between exterior wall of buildings and outside cover, from (Schmid, and Marinitsch, 2016).

ACPs are considers one of the most effective cladding in this regards (Eurobond — Aluminium Composite Panels, 2019).

Therefore, regarding the energy efficiency, the evaluation will be based on the ACPs thermo-physical properties and the ability to retain or control heating and cooling exchange between inside and outside, considering ACPs as one of the cladding materials on the buildings' envelopes (Cengel, 2011). This will be analyzed based on the type of the ACPs components and their thermo-physical properties (See Figure 4.3). in addition to the percentage of the covered envelope by ACPs.

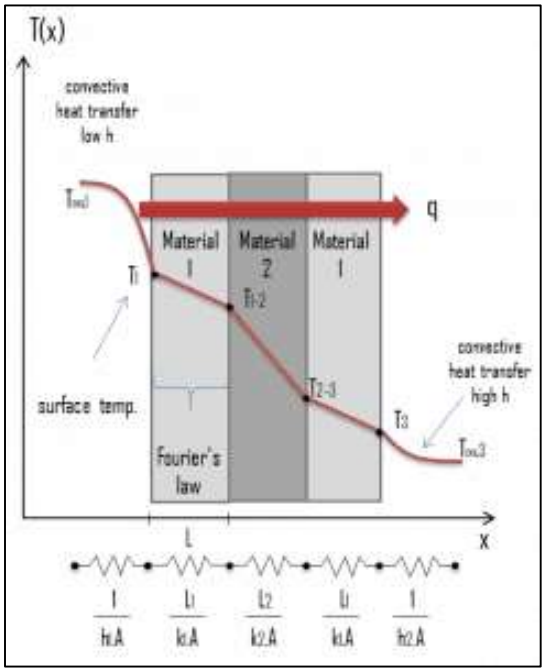


Figure4.3: Thermal resistance of the envelope based on the materials thermo-physical properties, from (Cengel, 2011).

3. ***Evaluation of Non-or Low Toxic of ACPs Materials****:* Various studies have shown that ACPs' materials do not represent a risk to building users or the environment. Recent types of research show that alloys used, whether covering or anodizing and the substances utilized are neutral. No negative impacts of aluminum building products on the quality of inner air or on the ground, and groundwater (European aluminium association, 2014). Therefore the evaluation of the toxic effects of ACPs will be assessed based on the type and the materials components of the ACPs in each case study buildings.

4. ***Evaluation Long life and Re-use of ACPs Material****:* The high value of aluminum intrinsically encourages its recycling to be important. Aluminum scrap can be recycled repetitively without loss of value or characteristics. The energy needed for recycling is also a small part of the needed for the initial production, which often reaches 5 percent of it, and this

will result in environmental benefits. Aluminum is often combined with other materials, such as steel or plastics, commonly isolated mechanically from aluminum (European aluminium association, 2014). Thus this item will be evaluated also same previous factor, based on the type of ACPs components materials and their recycling characteristics in each case study.

5. ***Evaluation of Cost efficiency of ACPs material****:* Costs for ACPs are often lower than many cladding materials such as marble and natural or artificial cladding stones. In fact, ACPs contribute to preserving the quality of the outer appearance of a property without the large cost of maintenance incurred by many alternatives. When the low maintenance cost and energy efficiency are taken into account along with investment costs, the estimated outcome is remarkable in cost efficiency, especially for big projects (How to Estimate the Cost of ACM 'Aluminum Composite Material' Exterior Wall Cladding Systems, 2013). The evaluation of the cost will be compared with the other cladding materials price in the region of study, like marble, stones, etc. Furthermore, the types of the ACPs will be evaluated according the local market price. The façade cladding area and type of ACPs will be identification for evaluating this factor in the case studies.

6. ***Evaluation of Durability, Effectiveness and Quality of the Materials:*** The metal's strength and rigidity of the ACPs and the lightness of the material make transportation and handling simpler on-site, reducing the risk of work accidents. This uniquely ACP property allows architects to meet the necessary performance specifications, meanwhile, reducing the dead load on a construction supporting structure, this is a key benefit for the application of cladding (European aluminium association, 2014). This item will be evaluated based on the area of ACPs cladding on the envelope of each case study.

7. ***Evaluation of Flexibility of the Materials in Design and Construction Processes****:* The lamination method provides an almost infinite variety of shapes and sections that allow designers to incorporate a large number of functions into a single profile. Curved, flat, or sandwiched with other materials can be made of coated plates and composite sheets. Therefore, either in factories or on the building site, aluminum can be drilled, heated, twisted, shaped,

welded, etc., (European aluminium association, 2014). The evaluation of this factor will be based on the type and the components of ACPs in the case study buildings. To make a comparison among the case studies regarding the rate of sustainability because of using ACPs, the analysis for two main factors will be investigated and calculated; first is the area of ACPs in each building; the second is the type of ACPs and materials components, as will be demonstrated in the following parts.

1. *The Case Studies of 'Sulaymaniyah' City*

As explained in chapter three, two case study in Sulaymaniyah have been selected, which are "North Bank" building and "City Star shopping center". Both of the buildings have been covered in their elevations by ACPs. The analysis will be carried out to calculate the area of ACPs that used in each of which depending on the buildings documentary, and the type of ACPs in each of them based on physical observation.

a. *'North bank' building*

The ACPs have been used in this building to cover two elevations and the windows openings are left with single glass. (See Figure 4.4.)

Figure 4.4: The cladding area of ACPs and the opening and window area in North Bank building. (Sulaimanyah, 2019).

Based on the analyzing of the project documentary the total area of APCs that applied on the outer walls have been found equal to 774 square meters (According to the B.O.Q for the project). According to the physical observation and direct measurement the type and components of the ACPs in the building has been determined. (See Figure 4.5.)

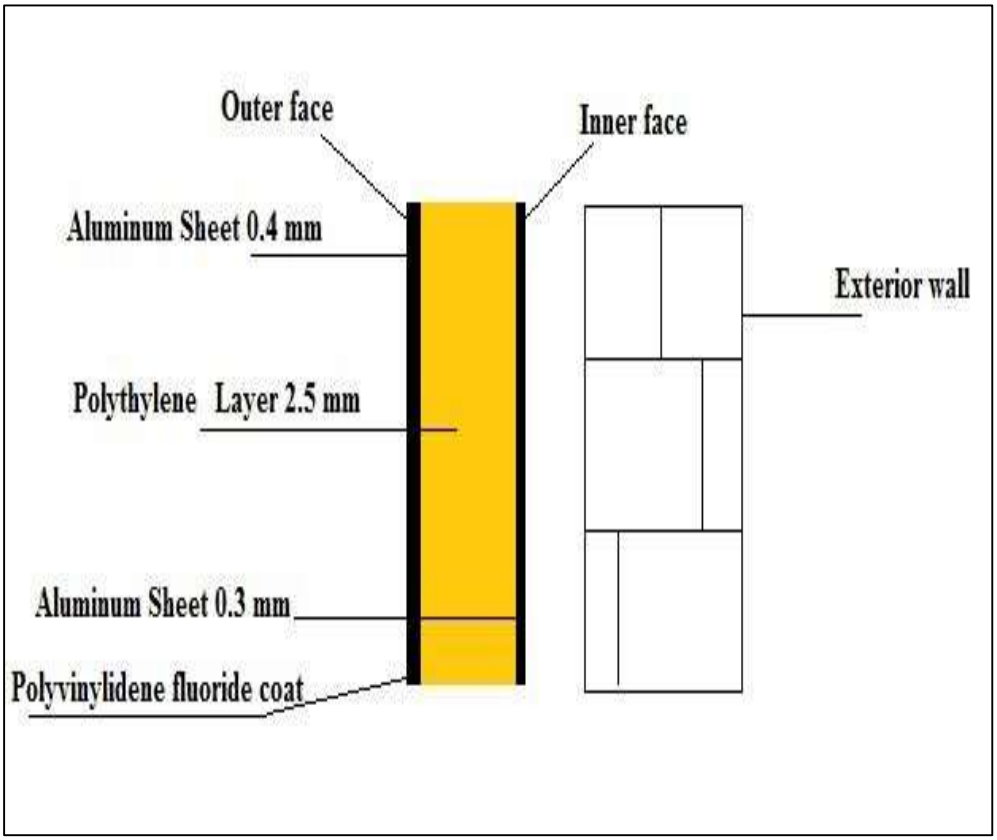


Figure 4.5: A section in ACPs of North bank building in Sulaymaniyah showing component materials. (Municipality of Sulaimanyah, 2019).

Each square meter of this type of ACPs was priced by 35.5 US dollars, according to the B.O.Q, for the project.

b. ***City star shopping center***

The building facades are mixed by ACPs and Curtain walls as shown in Figure 4.6. The total area of ACPs in the envelope of the building was found 3,148 square meters, based on the projects documents.

Figure 4.6: City Star Façade compound by ACPs and Curtain walls. (Sulaimanyah, 2019).

The ACPs type of the building has been observed and measured directly by the researcher and the components of the materials have been analyzed. Figure 4.7 demonstrate the materials of ACPs for "City Star shopping center" in Sulaymaniyah. The cost of one square meter of this type of APCs has been executed by 41.50 US dollar according to the document of the project.

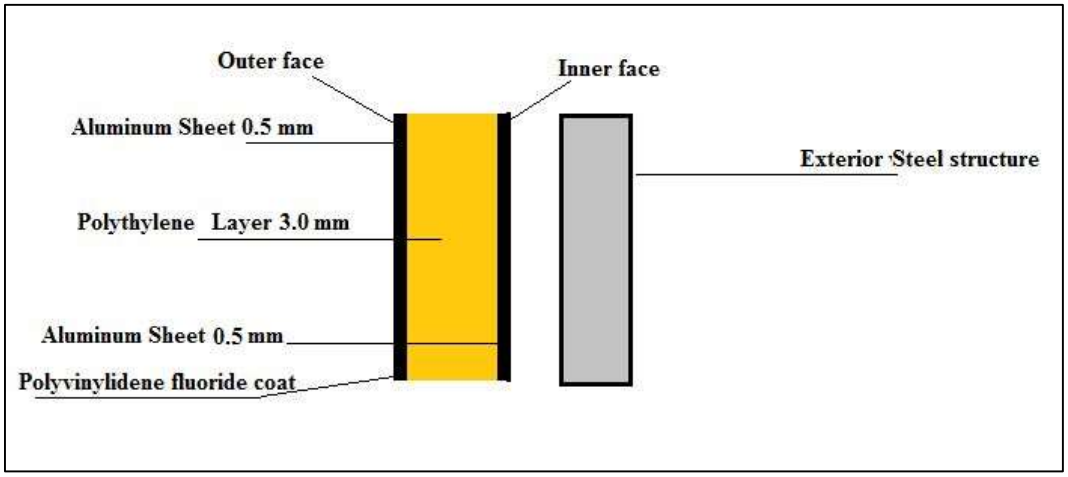


Figure 4.7: A section in ACPs of City Star shopping center in Sulaymaniyah showing component materials. (Municipality of Sulaimanyah, 2019).

2. ***The Case Studies of 'Erbil' City***

The analysis of the ACPs types and total area for the both selected case study buildings (Erbil international hotel, and Family mall) has been carried out as follow;

a. ***Erbil international hotel***

According to the site visit and observation of the façade of this building is mixing; Glass, ACPs, and marble. (See Figure 4.8.)

Figure 4.8: The facade materials of Erbil Int. Hotel. (Erbil, 2019).

The total area of APCs on the outer facades have been found 1,075 square meters (According to the documentary of the project that obtained from Municipality of Erbil). The type of ACPs according to the documents of the project has been found as seen in Figure 4.9. The price of the ACPs that fixed in this building was priced by 39.50 US dollars according to the documents of the project that obtained from the administration office of the hotel.

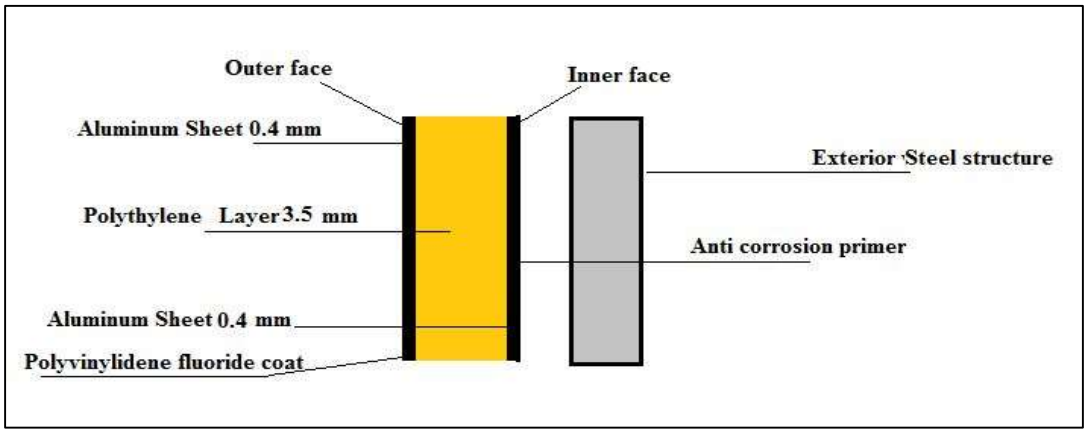


Figure 4.9: A section in ACPs of Erbil International Hotel in Erbil. (Municipality of Erbil, 2019).

b. ***Family mall of erbil***

The building elevations are covered by ACPs and glass, with small portion of 'Arch-ton' (cladding bricks). (See Figure 4.10.)

Figure 4.10: Western elevation of family mall building in Erbil, showing the covering materials (ACPs, glass and Arch-ton bricks). (Erbil, 2019).

The total area of ACPs has been found 7,520 square meters, and the price of each square meter was 40.00 US dollar, according to the documents, obtained from the maintenance office of the mall. (See Figure 4.11.)

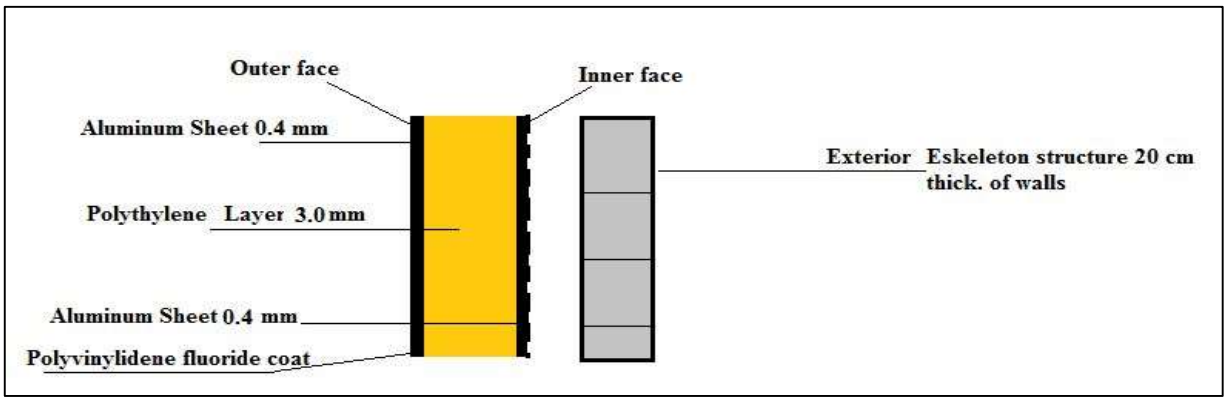


Figure 4.11: The section of ACPs for Family mall building in Erbil. (Municipality of Erbil, 2019).

3. *The Case Studies of 'Dohuk' City*

The ACPs types for both selected case study buildings (Khani hotel, and Health Directorate building) have been investigated and analyzed as follow;

a. *Khani hotel*

The material that covers the building from all the sides are ACPs as seen in Figure 4.12. and the total area of the ACPs have been estimated by direct measurement in the site.

Figure 4.12: The ACPs of Kahni hotel in Dohuk. (Dohuk, 2019).

Thus, the total area of the ACPs have found 1,120 square meters. The cost of each square meter was 39.75 US dollar according to the owner of the hotel. (See Figure 4.13.)

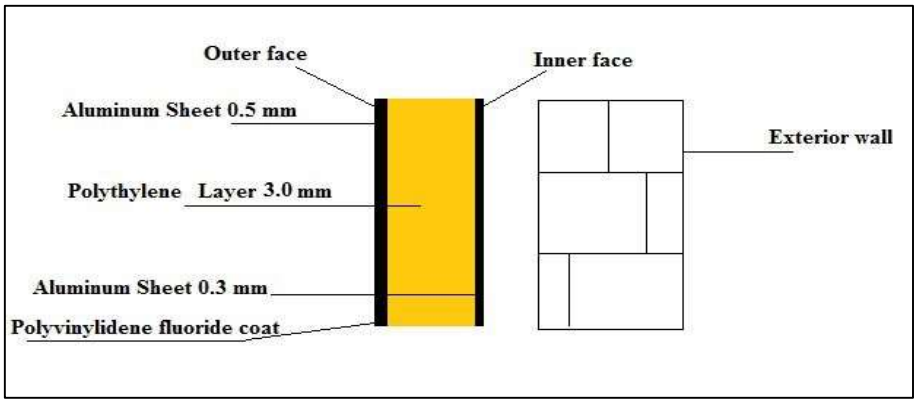


Figure 4.13: A section in the ACPs of Khani hotel in Dohuk. (Municipality of Duhok, 2019).

b. ***Health directorate building***

The envelope of the governmental building 'Health Directorate building' has been observed and found that it is compound of glass and Aluminum Composite Panels (ACPs), this building has been analyzed. (See Figure 4.14.)

Figure 4.14: The building's outer walls of Health Directorate in Duhok. (Dohuk, 2019).

The total area of the ACPs in this building based on the building project's document was 2,044 square meters, and the cost per one square meters was 42.50 US dollar square meters. (See Figure 4.15.)

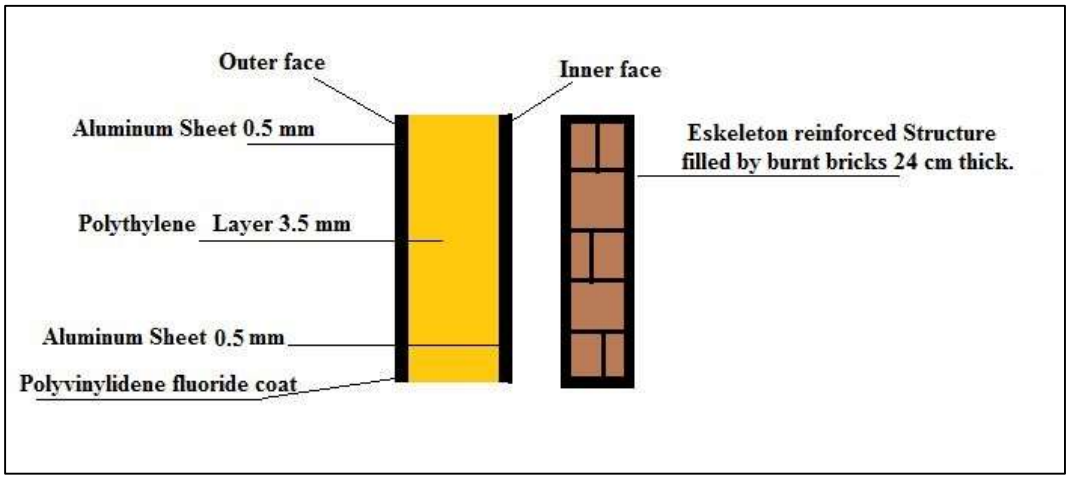


Figure 4.15: A section in Health Directorate building ACPs. (Municipality of Duhok, 2019).

Hence, according to the previous analyses for the area, types and price of ACPs in the six case studies in three main cities of Northern Iraq, the following remarks have been identified. The most expensive type was costing 42.50 US dollar, which is in the sixth case study. The reason is that the section demonstrated thicker Aluminum sheets and more thick polyethylene layer. The analysis has found that the price is varies based on the changes in these materials thickness. Therefore, the price in the first case study was the cheaper and was 35.50 US dollar. Furthermore, the fourth case study (Family Mall in Erbil) has the most area of ACPs in its elevations, while first case study (North bank- Sulaymaniyah), had less area of ACPs. See Table 4.1.

Table 4.1: The area and price of ACPs in each case study building. (Author, 2021).

No of Case study	Name of the case study	Area of ACPs by (m^2)	The Price of ACPs per (m^2) by US dollar
1	North Bank - Sulaymaniyah	744	35.50
2	City Star- Sulaymaniyah	3,148	41.50
3	Erbil Int. Hotel- Erbil	1,075	40.50
4	Family Mall- Erbil	7,520	40.00
6	Khani Hotel- Dohuk	1,120	39.75
6	Health Directorate- Dohuk	2,044	42.50

Based on the previous findings, the checklist of assessment of sustainability of ACPs for each case study will be evaluated.

1. ***North Bank Building in Sulaymaniyah***

In the first case study, the observation based on theoretical analysis has found that ACPs of this building regarding low embodied energy is (highly active). Furthermore, the building is using less area of ACPs and has less thickness of polyethylene material compared with other case study buildings, hence, the energy of production will be less. Therefore, it has highly contributed to the first properties of sustainable factors. Regarding the second factor of sustainable materials (Energy efficiency of the material), the ACPs have a high effect on energy efficiency in the buildings as mentioned in the analysis of the ACPs thermo-physical properties and section, as well as the coverage area of the envelope by ACPs in the first case study. Thus, the factor is considered 'highly active'. The ACPs have covered less area of the building envelope than other buildings (two sides only). This indicates that ACPs in this building have less potential for protecting the building from external environmental effects (heating and cooling). Therefore, the building has a 'low contribution', if it compared with other case study buildings. The third

factor (non-or low toxic materials), has been considered ‘Mid active’ because the components of the ACPs have demonstrated some materials which have such type of toxic effects like polyethylene which hold some chemical components. In this regard, and because the area of the ACPs is lesser in this building compared with other selected buildings, in addition to a lesser thickness of polyethylene in this type. Thus, they considered to have a lower toxic impact and categorized by ‘high contribution’ within the ‘Mid active’ for this factor. For the fourth factor (Long life and Re-usable character of the material), all the types of ACPs are highly active in this regard, as mentioned at the beginning of this chapter based on the theoretical analysis. ACPs commonly, consist of Aluminum and polyethylene as has shown in the section of each type. The Aluminum materials are 100% recyclable, while, the polyethylene is less recyclable, hence as much as the polyethylene layer in ACPs is thinner than the recycle properties is higher. Therefore, the ACPs in North bank building was less than other types of ACPs for other buildings, thus, it was categorized as ‘highly contributed’. The fifth factor (Cost efficiency of the material), has been considered as ‘Mid active’, because despite ACPs are not expensive comparing that with marble or natural stone cladding, but it is not cheap comparing that with other types of cladding as (plastering, painting, etc.). So, the cost per square meter will be the guide to make a comparison among the case studies. In this regard, and because the cost of the ACPs per square meter in this building is low, the cost efficiency will be ‘highly contributed’. The sixth factor which is (Durability, effectiveness, and quality of the materials), the properties of ACPs materials have considered as ‘Highly active’, because of the strength and rigidity of these materials as explained previously in this chapter. The quality of the ACPs types will be the assessment tools for the contribution of this materials and comparison factor among the selected case studies. The ACPs in this case study demonstrated the less quality than other types as shown in sections. Hence, the contribution of the factor among other case studies have been evaluated by ‘Low contribution’. The last factor of sustainable materials properties was (Flexibility of the materials in design and construction). This factor has been found ‘Highly active’ in ACPs material commonly because it gives the designers and architects the possibility of an infinite variety of shapes and sections. Therefore, the evaluation was based on the visual types of the ACPs which were depending on the quality of the ACPs in the building, color, and

texture. Hence, the ACPs in this building were less in quality, consequently in the price, but in the same time had different colors, thus, the contribution considered as (Mid contribution). The total obtained score in terms of the sustainable potential of ACPs in the first case study has been found equal to '42' scores out of 63 which is the total score to achieve sustainability in materials by 100%. See Table 4.2.

Table 4.2: The assessment of sustainability of ACPs in first case study (North bank in Sulaymaniyah). (Author, 2021).

No.	**Sustainable materials factors**	**Evaluation the percentage of sustainable factors in the case studies**								
		Highly active (3)			**Mid active (2)**			**Low active (1)**		
		High contr. **(3)**	Mid contr. **(2)**	Low contr. **(1)**	High contr. **(3)**	Mid contr. **(2)**	Low contr. **(1)**	High contr. **(3)**	Mid contr. **(2)**	Low contr. **(1)**
1	Low Embodied Energy of the material	●								
2	Energy Efficiency of the material			●						
3	Non-or low toxic materials				●					
4	Long life and Re-usable character of the material	●								

5	Cost efficiency of the material	●	
6	Durability, effectiveness and quality of the materials	●	
7	Flexibility of the materials in design and construction	●	
	Scores	(3*3)+(3*1)+(3*3)+(3*1)+(3*2)=30	(2*3)+(2*3)=**12**
	Total Score of Sustainability for 1st case study= 42 out of 63		

The previous analysis and evaluation methods will be applied for all the remaining case studies too, in the same procedure of evaluation as will be demonstrated in the assessment of the total score of sustainability in the remaining case studies.

2. ***City Star Shopping Center in Sulaymaniyah***

As explained previously the same evaluation for the ACPs in this building in terms of integration with the seven factors to evaluate sustainable properties of the applied ACPs, and the results demonstrated that the score of sustainability was '39'. See Table 4.3.

Table 4.3: The evaluation of sustainability for ACPs in second case study (City Star shopping center in Sulaymaniyah). (Author, 2021).

No.	Sustainable materials factors	Evaluation the percentage of sustainable factors in the case studies								
		Highly active (3)			**Mid active (2)**			**Low active (1)**		
		High contr. **(3)**	Mid contr. **(2)**	Low contr. **(1)**	High contr. **(3)**	Mid contr. **(2)**	Low contr. **(1)**	High contr. **(3)**	Mid contr. **(2)**	Low contr. **(1)**
1	Low Embodied Energy of the material			●						
2	Energy Efficiency of the material	●								
3	Non-or low toxic materials					●				
4	Long life and Re-usable character of the material		●							
5	Cost efficiency of the material						●			
6	Durability, effectiveness and quality of the materials	●								
7	Flexibility of the materials in		●							

	design and construction		
	Scores	(3*1)+(3*3)+(3*2)+(3*3)+(3*2)=**33**	(2*2)+(2*1)=**6**
	Total Score of Sustainability for 2nd case study= 39 out of 63		

3. ***Erbil International Hotel in Erbil***

The assessment of the third case study based on the checklist has been carried out to evaluate the influence of ACPs on sustainability, and the results demonstrate the score of sustainability in this building was '39', as seen in Table 4.4.

Table 4.4: The evaluation of sustainability for ACPs in third case study (Erbil Int. Hotel in Erbil). (Author, 2021).

No.	**Sustainable materials factors**	**Evaluation the percentage of sustainable factors in the case studies**								
		Highly active (3)			**Mid active (2)**			**Low active (1)**		
		High contr. **(3)**	Mid contr. **(2)**	Low contr. **(1)**	High contr. **(3)**	Mid contr. **(2)**	Low contr. **(1)**	High contr. **(3)**	Mid contr. **(2)**	Low contr. **(1)**
1	Low Embodied Energy of the material	●								
2	Energy Efficiency of the material	●								

3	Non-or low toxic materials			●	
4	Long life and Re-usable character of the material		●		
5	Cost efficiency of the material			●	
6	Durability, effectiveness and quality of the materials		●		
7	Flexibility of the materials in design and construction		●		
	Scores	(3*3)+(3*3)+(3*1)+(3*2)+(3*2)+(3*2)=**33**		(2*1)+(2*2)=**6**	
	Total Score of Sustainability for 3rd case study= 39 out of 63				

4. ***Family Mall in Erbil***

The evaluation of sustainability level for ACPs in the fourth case study (Family Mall in Erbil) has been achieved based on the same procedure that explained in the first case study, and the results demonstrated that the obtained sustainability scores was 38, as seen in Table 4.5.

Table: 4.5: The evaluation of sustainability for ACPs in fourth case study (Family mall in Erbil). (Author, 2021).

No.	**Sustainable materials factors**	**Evaluation the percentage of sustainable factors in the case studies**								
		Highly active (3)			**Mid active (2)**			**Low active (1)**		
		High contr. **(3)**	Mid contr. **(2)**	Low contr. **(1)**	High contr. **(3)**	Mid contr. **(2)**	Low contr. **(1)**	High contr. **(3)**	Mid contr. **(2)**	Low contr. **(1)**
1	Low Embodied Energy of the material			●						
2	Energy Efficiency of the material		●							
3	Non-or low toxic materials					●				
4	Long life and Re-usable character of the material		●							
5	Cost efficiency of the material					●				
6	Durability, effectiveness and quality		●							

	of the materials	
7	Flexibility of the materials in design and construction	●
	Scores	(3*1)+(3*2)+(3*2)+(3*2)+(3*2)+(3*3)=**30** (2*2)+(2*2)=**8**
	Total Score of Sustainability for 4th case study= 38 out of 63	

5. ***Khani Hotel in Dohuk***

The building ACPs have been analyzed to evaluate with the same procedure to obtain the score of sustainability, and the results demonstrated that this building score is '40'. See Table 4.6

Table 4.6: The evaluation of sustainability for ACPs in fifth case study (Khani Hotel in Dohuk). (Author, 2021).

No.	**Sustainable materials factors**	**Evaluation the percentage of sustainable factors in the case studies**								
		Highly active (3)			**Mid active (2)**			**Low active (1)**		
		High contr. **(3)**	Mid contr. **(2)**	Low contr. **(1)**	High contr. **(3)**	Mid contr. **(2)**	Low contr. **(1)**	High contr. **(3)**	Mid contr. **(2)**	Low contr. **(1)**
1	Low Embodied Energy of the material	●								

2	Energy Efficiency of the material	●			
3	Non-or low toxic materials			●	
4	Long life and Re-usable character of the material	●			
5	Cost efficiency of the material			●	
6	Durability, effectiveness and quality of the materials		●		
7	Flexibility of the materials in design and construction	●			
	Scores	(3*3)+(3*2)+(3*2)+(3*1)+(3*2)=**30**		(2*2)+(2*3)=**10**	
	Total Score of Sustainability for 5th case study= 40 out of 63				

6. ***Health Directorate Building in Dohuk***

The last case study building is building ACPs have been analyzed to evaluate their influence on sustainability in the building through testing the factors of sustainability in the material, as made

for previous case studies. The total score for sustainability in this case study has found equal to '37'. See Table 4.7.

Table 4.7: The evaluation of sustainability for ACPs in fifth case study (Khani Hotel in Dohuk). (Author, 2021).

No.	**Sustainable materials factors**	**Evaluation the percentage of sustainable factors in the case studies**								
		Highly active (3)			**Mid active (2)**			**Low active (1)**		
		High contr. **(3)**	Mid contr. **(2)**	Low contr. **(1)**	High contr. **(3)**	Mid contr. **(2)**	Low contr. **(1)**	High contr. **(3)**	Mid contr. **(2)**	Low contr. **(1)**
1	Low Embodied Energy of the material		●							
2	Energy Efficiency of the material	●								
3	Non-or low toxic materials						●			
4	Long life and Re-usable character of the material			●						
5	Cost efficiency of the material						●			
6	Durability, effectiveness and quality of the materials	●								

7	Flexibility of the materials in design and construction	●	
	Scores	(3*2)+(3*3)+(3*1)+(3*3)+(3*2)=**33**	(2*1)+(2*1)=**4**
	Total Score of Sustainability for 2nd case study= 37 out of 63		

The small differences among the rates of sustainability because of the ACPs application in the selected case studies are returns to the effect of the ACPs materials and the cost of these materials, in addition to their embodied energy assessment by the area or the quantity of these materials in each building, which are affecting the scores negatively. Furthermore, the good quality of the components with more thick polyethylene layer could influence the scores positively, because it is increase the thermo-physical properties of the material which help the building to reduce energy consumption. The cost was one of the main factors to increase or decrease the scores through 'cost-efficiency' factor. The evaluation demonstrated that as much as the cost is lower the scores are higher, to achieve economic aspect of sustainability, in addition to other factors which are evaluating environmental and social aspect of sustainability.

4.1.2 Evaluation and analysis, based on the interview

The interview has been developed by asking four questions to thirty professionals (Architects, academicians, and designers), the findings of the interviews are aimed to evaluate the effect of ACPs on the architectural character in northern Iraq. The result of the answers to questions have been demonstrated as follow;

"1. What is the effect of the ACPs on the case studies architectural visual shape in terms of the pattern of vertical and horizontal bands of openings, and their effect on the character of local architecture in the region of study?"

Regarding this question, the answers of the interview have been divided into two categories;

The first part has believed that the ACPs are weakening the character of local architecture because ACPs in the existing situation is not showing the local patterns of the architecture in Northern Iraq. This is because these types of materials are not employed in such a way by architects or designers to serve this purpose, and the reason for that is the disconnection between designers or architects and the manufacturers to create the required details to achieve this goal. This opinion consists of 11 out of 30 participants, which means 37% of the selected sample.

The second part has another opinion about the issue, who are the remaining 19 participants, which formulate 63%. They believe that this type of material is part of new technology and when it is added to any building will convert this building form into an international style. In this case, they believe that adding ACPs in any building means giving the buildings the international style and will not be able to use these materials to preserve the character of local architecture. The reason is their patterns, shapes, and forms which enforce their final visual shape on any building. From the result of this question, the findings demonstrate that all the experts admit that ACPs are not helping to conserve the character of local architecture in the region of the study in the existing scenario. However, some of the experts have believed that there are possibilities to have a positive influence on the character if the cooperation happened among designers or architects and manufacturers. Another part of participants has believed that using ACPs is one of the indicators of an international architectural style which is far from a local character of architecture in any place. They are depending on the concept that these types of material are part of new technologies and formulating technological architecture and will be far from the local character of architecture. The Table 4.8 below demonstrates the main items results that debated in this questions according to the interviewees' answers.

Table 4.8: The main items regarding the answer of the first question with by percentage. (Author, 2021).

No.	Main Opinions which out come from the question	Agree	Dis-agree
1	The existing scenario of ACPs are affecting local architectural character negatively	100%	0%
2	Possible to employ ACPs to serve character of architecture in the study region	37%	63%
3	ACPs are part of the new technology which indicates technological architecture and it is international shape of architecture. Hence, it is not possible to serve the local character of architecture	63%	37%

"2. Taking the case studies as samples, how you evaluate the effect of the ACPs as new technological material on the character of architecture through its parameters (color, texture, and craft details)?"

According to the experts that participated in the interview, all the participants demonstrated that ACPs materials have negative effect on the character through the evaluation of the case studies. The characteristic of ACPs materials, in terms of colors, which is almost is different from the stones and bricks and have different shining level than them and had shown significant contrast. Texture of the ACPs also, have different characteristic which is not compatible with the texture of the adjacent buildings that are covered with the local materials. The same thing is true for the craft details like the building corners or edges.

"3. Will the ACPs affect the main construction techniques in the buildings, in such a way that could affect the character in architecture?"

According to the answers of the interviewees, 50% of them said that the main construction techniques are not going to be affected by using ACPs, because these materials are cladding materials and applies on the building body after completing of the main structure. Consequently, the character of architecture will not be affected. Another 20% of the participants has affirmed the effect on architectural character, because they believes that the whole construction techniques are depending on each other like a chain. Therefore, the application of ACPs will change the technique of construction in whole the building process. In another side, 30% of the participants have insisted that these materials will affect the construction techniques, and impose especial types of construction methods to fix these materials on the facades, but it will not affect the character of architecture, because the new construction techniques will be limited to finishing parts. (See Figure 4.15.)

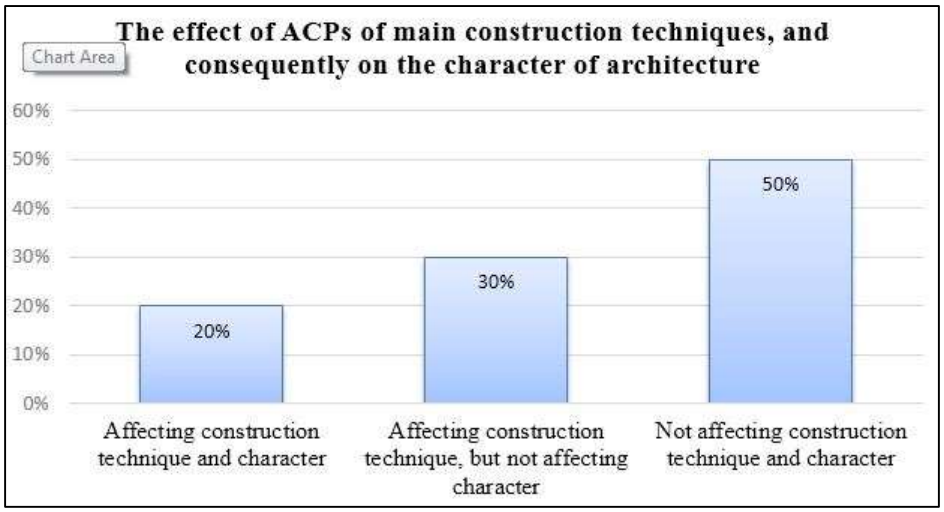


Figure 4.16: The answers of the interviewees' regarding the effect of ACPs on the main construction techniques and character of architecture. (Author, 2021).

"4. Regarding the case study buildings' settings and location, how the ACPs affect the architectural character through its parameters (Continuity, twining or repetition, and harmony) with the surrounding context?"

The following answers of this question has been obtained;

***Continuity*:** 100% of the participants addressed that there is no continuity in the selected case study buildings because of using ACPs materials. This is because, there is no integrated manner in the case study buildings to achieve continuity between the interfaces of the neighboring buildings.

Twining or repetition: All the participants have agreed that the ACPs have achieved twining and repetition because of their similar and repetitive shaped, hence they demonstrate other formative relationships when they are repeated and integrated.

Harmony: the participants' opinion regarding the harmony was negative, and they considered no harmony in the selected case study buildings with their neighbor buildings because of applying ACPs. The participants return the reason for the main elements to evaluate 'Harmony' in architecture, which are, Architectural formation, and the types of facade finish. The participants considered that architectural formation and the mass are not harmonious with the neighboring buildings. In addition to this, the elevations or facades of selected case study buildings have demonstrated not harmonic comparing to the adjacent buildings, and also, incompatible with the surrounding urban context.

According to the interview result regarding the fourth question to evaluate the effect of ACPs on architectural character based on the case studies location and setting, the ACPs considered to have significant effect on the character of architecture. The main parameters of assessment (continuity, twining or repetition, and harmony) have been evaluate and found that only the repetition and twining are achieved based on the characteristics of ACPs material. This is means that two parameters out of three are not achieved in the case studies with ACPs facades. Hence, this indicates that ACPs have negative impact of the character of architecture in terms of the building location and setting within the cities in northern Iraq. (See Figure 4.16.)

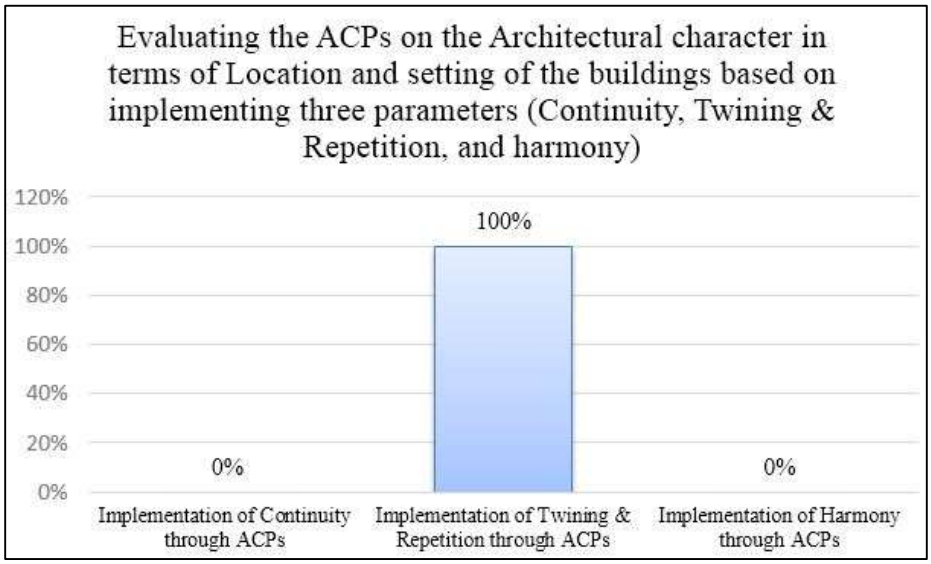


Figure 4.17: The effect of ACPs on the character of architecture based on three parameters. (Author, 2021).

The interview about the character of architecture and the ways that ACPs are affecting has been carried out and the results according to the expert's opinion in northern Iraq demonstrated that ACPs are affecting the character of architecture in the region of study significantly, based on the evaluation of the selected case studies by the experts.

4.2 Summary

This chapter has found and analyzed the obtained data from the selected case studies in Northern Iraq to evaluate the effect of new technological material (ACPs) on the architecture in two main ways, which are the sustainability in architecture, and the character of local architecture.

Assessing the influence of ACPs on sustainability in the buildings has been achieved through development of 'A checklist', and quantitative method has been approached to reach the results. The analysis of the rate of sustainability evaluation based on the checklist prepared by the researcher has demonstrated that ACPs in all the buildings have a good influence to increase sustainability in the buildings. This is through showing that no (Low active) assessment in all

the buildings regarding the evaluation of sustainable factors in the ACPs properties. Despite the small difference among the rate of sustainability caused by using ACPs, but, the first case study has demonstrated the highest sustainable influence by ACPs, through getting the highest score. The lower influence of sustainability has been demonstrated in the case study '6'. However, all the case studies demonstrated that the influence of ACPs on the buildings in terms of sustainability is not less than 59% and reaches 67% which is indicating that ACPs have a significant influence on the implementation of sustainability in the buildings. See Table 4.9.

Table 4.9: The percentage of sustainability with higher and lower score of sustainability in the case study buildings because of the influence of ACPs. (Author, 2021).

No. of Case studies	Name & location	Score of Sustainability	The Percent of achieving Sustainability (Case study's sustainability score/63)
1	North Bank building- Sulaymaniyah	42	67%
2	City Star shopping center- Sulaymaniyah	39	62%
3	Erbil International Hotel- Erbil	39	62%
4	Family Mall- Erbil	38	60%
5	Khani Hotel- Dohuk	40	63%
6	Health Directorate building- Dohuk	37	59%

Thus, sustainability has been evaluated in the selected case study buildings and the results have shown that the application of ACPs is influencing sustainability positively and increase the sustainable potential in all the selected case study buildings around northern Iraq.

Evaluating the impact of ACPs on the character of local architecture in the region of study has been implemented base on the development of interview with thirty experts in the field of study, the interview included four main questions regarding the integration between ACPs as new technological materials and the character of local architecture in Northern Iraq. The qualitative method has been approached to obtain the results. The character of local architecture has been evaluated based on the main four aspects, which were (visual shape, materials, construction techniques, and setting or location). Each of which has considered in one question, where the answers of the first question show that 100% of the experts' opinion is that ACPs are affecting local architectural character negatively because of the characteristic of visual shape for these materials. However, 67% of the experts have seen that employing ACPs to serve the character of local architecture is not possible in terms of visual shapes, while 37% of the interviewees have seen that possible. In the same context, the answer of the second question, which was regarding to the materials of ACPs, and how could integrate with architectural character, the all experts demonstrate that have negative effect on the character of local architecture, because of the huge differences in color, texture, and details, which are considered as strange on the local character of architecture. The answer to the third question which was regarding the effect of ACPs on the main construction techniques that in the result affect the character has shown different answers but the majority of the experts agreed that the character of architecture is not affected by ACPs, as demonstrated in Figure 4.15. The last question was regarding the setting and location of the building and how it could affect the character, when ACPs are applied in the building. The results of the experts' opinions have shown again that ACPs are affecting negatively the character of local architecture. This is through evaluating the main three parameters of assessment which are; continuity, twinning or repetition, and harmony, as seen in Figure 4.16. Consequently, the interview has demonstrated the negative effect of ACPs on the character of local architecture in northern Iraq, based on the opinion of experts in evaluating the selected case studies.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Introduction

The relationship between architecture and technology is a relatively new discipline and witnessed a significant debate in terms of the advantages and disadvantages of this relation. The practice of technology in architecture is underpinned by several factors related to science, society, economy, philosophy, and aligned to industry. The study tried to highlight the effect of new technological materials on sustainability as one of the most important issues globally, and on the architectural character as one of the important aspect to keep the local architectural value in place and time. This thesis has focused on ACPs as most recognized and utilized new technological materials in Northern Iraq, which is applicable in different buildings categories. To achieve the aim of the study six case study buildings have been selected from three main cities in northern Iraq (Sulaymaniyah, Erbil, and Dohuk). Two case studies from three cities in northern Iraq has been selected to cover all the region of study. The criteria to select the case studies was identified to be covered by ACPs materials on their elevations either partially or completely. Moreover, the located of the buildings should be in especial places within the cities, to guarantee their effect on cities urban texture. The study tried to avoid houses and focus on bigger types of buildings in order to assure the design line process in the buildings. In another words, the buildings should be designed by architects and engineers, because a lot of residential buildings especially houses are constructed without the interference of architects and engineers. Quantitative method have been approached to evaluate the influence of ACPs on the rate of sustainability in the selected case studies in order to understand the effect of new technology in terms of construction materials on sustainability. Thus, a checklist has been developed and involved the main factors affect sustainability in sustainable materials. These factors has been formulated based on the survey of literature and theoretical analysis. Qualitative method has been conducted to understand the effect of ACPs on the architectural character in the region of

study. To achieve this objective, thirty experts (architects, academicians, and designers) have been interviewed and asked to evaluate the effect of ACPs of the character of architecture. For this purpose, four questions has been directed to the participants regarding the evaluation of ACPs effects (as new technological material) on the architectural character. The evaluation factors for the character of architecture have been formulated by four factors according theoretical analysis and literature review. These factors are; visual shape, materials characteristics, construction techniques, and setting and location of the building within surrounding urban texture. Each one of these factors has been asked in one question to evaluate the final interview results and come out with the final results. After conducting these processes, the study come out with the conclusion and the questions of the thesis were answered.

5.2 Answering the Study Questions

The study has raised three main questions in the beginning of this study in the first chapter. The following chapters have been developed and the answer of each question was implemented.

The first question was; ***"What is the effect of ACPs (Aluminum Composite Panels) on the implementation of sustainability in the architecture in Northern Iraq?"*** The answer of this question based on the study outcomes was as follow;

The outcomes have shown that ACPs has significant role in enhancing sustainability in the buildings. In terms of environmental aspect, the results have demonstrated that ACPs increase sustainability. This is through reducing heat gain/loss in the building because of the thermal properties of ACPs to control the required heating and cooling inside the building, which consequently, reduce the demands on the power. On another hand, the ACPs have demonstrated that ACPs are reducing embodied energy in the building construction. The reason for this is because these materials properties has low embodied energy compared with steels and concrete, and other construction materials. In the same context, economic aspect of sustainability is promoted by using ACPs. The investigation about ACPs demonstrated that the cost of ACPs according to the northern Iraq construction market is not very cheap but it is also not expensive

in comparison with other types of building claddings. Moreover, ACPs will considered cheap construction material if put in consideration the facilities of these materials in terms of saving time of construction and the required construction teams and equipment. The materials have also, good durability and safety, as well as good flexibility for design innovation, and this is achieving the social aspect of sustainability.

The second question was; ***"To what extent the application of the new technology as ACPs in local architecture will keep the architectural character of the buildings in northern Iraq?"*** The answer of this question as per the results of the study was as follow;

The study has shown that ACPs have a negative effect on the character of local architecture. The results have been formulated based on the evaluation of four main factors which are (visual shape, material, construction techniques, and location & set within the urban context). All these factors have been evaluated through interviews and demonstrated that ACPs are threatening or weakening the character of architecture in the region of the study. The reason is because of the different shapes that formulate by ACPs in the building and the shape of corners or edges, due to the character of these technological materials. In addition to this, the materials characteristic in terms of color, texture, shining rate, and details are creating a great contrast with the local building materials as stones and traditional cladding, and consequently affecting the character of local architecture negatively. According to the findings, construction techniques for ACPs also, are not affected by architectural character. However, the study has found that ACPs affect the location and setting within the urban context, based on the evaluation parameters for evaluating this factor which is (continuity, repetition or twinning, and harmony). The result of the study has addressed that ACPs are affecting continuity, and harmony negatively, and only the repetition and twinning positively, which indicate the negative effect on the setting within the urban context, due to the major negative effect of these materials. Finally, the results have shown that ACPs are affecting the character of local architecture in a negative way, and these materials are not keeping the architectural character, but on contrary, removing the character of local architecture in northern Iraq.

The third question was ***"How can new technological materials as ACPs serve the local character of architecture?"*** the answer for this question will be depending on the expert opinion and the results analysis based on the outcomes, as follow;

According to the results of the study through the interview, a part of interviewees have suggested to modify the shapes, colors, and textures of ACPs to harmonies the character of local architecture.

This solution according to the researcher opinion needs further research to evaluate the most effective characteristics of the local architecture in northern Iraq. In addition to this, to formulate a standards or guideline for the designers to select the most proper visual shapes, material's color, texture, surface shining rate, and craft details to reach a level of ACPs with keeping local character in architecture. This subject is out of the scope of this study, and it is a suggestion for future work that can be done to enrich this field and reinforce it with more comprehensive knowledge.

5.3 Conclusion and Recommendation of the Study

The current study has concluded;

1. Technology, and especially technology in construction materials has a huge impact on all of the ideas and practices in contemporary architecture. Here it must be emphasized that there is an intermediate place between the rejection of technology and the need to treat it as an unavoidable or indispensable reality. This relates to an understanding of the advantages and importance of this technology in contemporary life at the global level and how it should be tamed to serve issues related to architectural work at the local level.

2. The study showed that technology interferes effectively and clearly in defining the architectural form. Nevertheless, the final form of buildings that use ACPs has reflected on buildings and created new forms of buildings that are not related to the original fabric of cities in the northern region of Iraq.

3. New technological materials ACPs have a clear role in developing sustainability in buildings that use this technology of materials. this will help to achieve integration between the systems of ecological technological design buildings contributes to the provision of More efficient buildings are able to serve the purpose for which they were designed and with a higher level of performance.

4. The vision to the technological materials in construction, in general, must be seen through the concept of inputs (embodied energy in construction, operating energy, etc.), and outputs (environmental pollution resulting from the process of manufacture, construction, waste resulting from demolishing), without neglecting the formal and architectural features of the place. Thus, creating harmonized buildings in terms of buildings' masses forms.

More recommendation will be suggested in the next part in view of the importance of the problem presented and its complexity and the presence of many bodies that may affect society's vision of sustainability and architectural character.

1. Increasing the cultural awareness of designers and architects to realize design elements, in conjunction with making use of contemporary technological capabilities in the creation, and the spirit of the intellectual age, to create architectural configurations that are in line with the cosmic and local requirements and are characterized by honesty in the relationship between the designer and the beholder.

2. Presenting practical results and proposals to produce a local architecture that is in line with the spirit of the times and its capabilities, based on realism and practicality in the application. This is through the assistance of government bodies to legislate rules and laws.

3. Establishing the training centers for technicians in the field of manufacturing technology for building materials and different finishes materials, as well as implementation requirements.

REFERENCE

Abidin, N. Z, & Jaapar, A. (2008). Sustainable Concept Awareness in Malaysia Construction Practices.

Adams, W.M. (2006). The Future of Sustainability: Re-thinking Environment and Development in the Twenty-first Century. Report presented to the IUCN Renowned Thinkers Meeting.IUCN, the world conservation union.

Adebayo, C. O. (2013). *Comfort Factors in Low Cost Houses: Case Study at Batu Pahat, Johor Malaysia*. Master Thesis, University Tun Hussein Onn Malaysia. Malaysia: University Tun Hussein Onn Malaysia.

Agudiez, G. (2017). High-Tech Architecture and Its Urban, Cultural, Historic and Economic Landscape of the Carrasco International Airport in Montevideo, Uruguay. *Journal of Archit. Eng. Tech.*, 6(2). DOI: 10.4172/2168-9717.1000201.

American Institute of Architects (1992). *Environmental Resource Guide Subscription*. Washington, United States: American Institute of Architects.

Amin, R. M., and Muhy Al-din, S.S. (2018). Evaluation of the Sustainable Aspects in Housing Sector to Overcome Housing Stress in Northern Iraq. *Journal of Contemporary Urban Affair*, 3 (1), 67- 81.

Armstrong, G. (2016). Reusing rumours: a review of research citing barriers to adaptive reuse. *In Proceedings of Association of Architecture Schools of Australasia 9th International Conference. University of Technology, Sydney* (pp. 147-154). Retrieved from http://www.utsarchitecture.net

Asif, M., Muneer, T. &Kubie, J. (2005). Sustainability analysis of window frames. *Building Services Engineering Research & Technology* 26(1): 71-87.

Beukers, A., and Van Hinte, E. (1998). Lightness: *The inevitable renaissance of minimum energy structures*. Rotterdam: 010 Publishers.

Brouwer, J., Mulder, A., and Martz, L. (Eds.). (2008). *The Architecture of Continuity*. Rotterdam, Netherlands: V2-Publishing.

Cengel, A. Y. (2011). Heat and Mass Transfer. McGraw-Hill Education.

Cheetham, D., and Lewis, J. (2001). Productivity, Buildability and Constructability: Is Work Study the Missing Link? *In: Akintoye, A (Ed.), 17th Annual ARCOM Conference, 5-7 September 2001, University of Salford. Association of Researchers in Construction Management*, Vol. 1, 271-80.

CIAT. (2015). what is a Chartered Architectural Technologist? Retrieved from https://ciat.org.uk/about-us/whatis-a-chartered-architectural-technologist.html

Burns, R. (2000). *Introduction to Research Methods*. London, UK: Sage.

Dell'Isola, A. J., and Stephen J. K. (1981). *Life Cycle Costing for Design Professionals*. New York: McGraw-Hill.

De Quiros, A.C.B. (2009). *Evolution of Workplace Architecture as a Consequence of Technology Development.* Ph.D. Thesis, RMIT University, Melbourne. Australia.

Emmitt, S. (2013). Architectural Technology: *Research and Practice*. UK: Wiley-Blackwell.

Eroğlu, B. and Abbood, A. H. (2016). Influence of Technological Evolution on The Architectural Form and Structure System of High – Rise Buildings. Retrieved from file:///C:/Users/user/Downloads/abdlhadi.pdf

Etalbond, Aluminium composite material. (2015). Technical manual. Retrieved from http://eurowindowsystems.com/files/technicalmanual.pdf

European aluminium association. (2014). Sustainability of Aluminium in Buildings. Retrieved from https://www.european-aluminium.eu/media/1311/en-sustainability-of-aluminium-in-buildings.pdf

Eurobond — Aluminium Composite Panels. (2019). How ACP panels help in wall ventilation and increase building strength. Retrieved from, https://medium.com/@eurobondseo/how-acp-panels-help-in-wall-ventilation-and-increase-building-strength-4d5f6e866db6.

FAIA, L. H. N. (1994). Architectural Character—Identifying the Visual Aspects of Historic Buildings as an Aid to Preserving their Character. Retrieved from https://www.nps.gov/tps/how-to-preserve/preservedocs/preservation-briefs/17Preserve-Brief-VisualAspects.pdf

.

Finney, T. (2016). Repetition and Transformation: *The Housing Project and the City of New York*. Doctoral thesis, University of Technology, Sydney. Australia, UOT.

Golmahamadi, A. (2000). *The Globalization of Culture and Identity*. Tehran University, Tehran, Tehran. Iran.

Hadi, A.D., and Allawi, H.A. (2010). Influence of Technological Evolution On Formal Structure of High – Rise Buildings [تأثير التطور التكنولوجي على البنية الشكلية للابنية العالية] (Arabic). *Engineering and Technology Journal*, 28(1), 13-29.

Harp, C. (2009). Three Principles of Good Architecture. Retrieved from https://blog.clinicalarchitecture.com/three-principles-of-good-architecture

Hochhäusl, S., and Lange, T. (2018). *Architecture and the Environment. Architectural Histories*, 6(1): 20, pp. 1–13. DOI: https://doi.org/10.5334/ah.259.

Cladding Systems. (2013). How to Estimate the Cost of ACM 'Aluminum Composite Material' Exterior Wall Cladding Systems (2013) Technical Paper. Retrieved from https://cdn.ymaws.com/www.aspenational.org/resource/resmgr/Techical_Papers/2015_Feb_TP.pdf.

Ilberg, A., and Rollins, C. (2007). *Low Cost House Construction Manual*. USA: Engineers without Borders.

Jin Kim, J. (1998). Sustainable Architecture Module: *Qualities, Use, and Examples of Sustainable Building Materials*. USA: National Pollution Prevention Center for Higher Education.

Koenigsberger, OH, Ingersoll, TG, Mayhew,A. , Szokolay, S V. (2010) . *Manual of Tropical Housing and Building. Hyderabad*: India, Universities Press.

Lang, B (Ed.). (1987). *The Concept of Style. Ithaca*: Cornell University Press.

Maliene, V., Howe, J. & Malys, N. (2008). Sustainable Communities: Affordable Housing and Socio-economic Relations, Local Economy, 23(4), 267-276, DOI: 10.1080/02690940802407989.

McConville J. R. (2006). *Applying Life Cycle Thinking to International Water and Sanitation Development Projects: An assessment tool for project managers in sustainable*

development work. Master thesis, Houghton, Michigan. Michigan Technological University. USA: Michigan Technological University.

Milne, G. (2013). Embodied energy. Retrieved from https://www.yourhome.gov.au/materials/embodied-energy

Minke, G. (2006). Building with Earth: *Design and Technology of a Sustainable Architecture*. Berlin, Germany: Birkhäuser – Publishers for Architecture.

Mohammed, H., Jaff, D., and Schrock, S. (2019). The challenges impeding traffic safety improvements in the Kurdistan Region of Iraq. *Transportation Research Interdisciplinary Perspectives,* http://dx.doi.org/10.1016/j.trip.2019.100029.

Mohaney, P., and Soni, G. (2018). Aluminum Composite Panel as a Facade Material. *International Journal of Engineering Trends and Technology (IJETT),* 55 (2), 75-80. Retrieved from file:///C:/Users/user/Downloads/Aluminium_Composite_Panel_as_a_Facade_Ma.pdf

Muhy Al-Din, S., Iranfare, M., Surchi, Z. (2017). Building Thermal Comfort Basedon Envelope Development: Criteria for selecting right case study in Kyrenia- North Cyprus. *Energy Procedia (Open Access),* 115, 80-91. doi.org/10.1016/j.egypro.2017.05.009.

Pawley, M. (1991). High-Tech Architecture: History vs. the Parasites. *Architectural Association School of Architecture*, 21, pp. 26-29. Retrieved from https://www.jstor.org/stable/29543727?seq=1

Rashid, R.H.M. (2014). *The Use of Water for Sustainable Rural Development: A Case Study in the Kurdistan Regional Government.* Doctoral Thesis, University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Romania.

Roaf, S., Fuentes, M. and Thomas, S. (2007). *"Eco House: A Design Guide",* Oxford, UK: Architectural Press.

Shayan, H. (2011). Criteria for defining architectural identity. *Journal of the village*, 70

Skibniewski, M. J., and Zavadskas, E. K. (2013). Technology development in construction: a continuum from distant past into the future. *Journal of Civil Engineering and Management,* 19(1), 136-147. DOI: 10.3846/13923730.2012.756060.

Salvan, G.S. (1986). *Architectural character & the history of architecture*. Quezon City: JMC Press.

Schmid, F., and Marinitsch, S. (2016). Methods and Technologies for Advanced Building Skin Design; *Advanced Building Skins 2016 Bern.*

Smiciklas, J. (2012). Sustainable Buildings: Go Green. Retrieved from https://www.itu.int/dms_pub/itu-t/oth/4B/04/T4B0400000B0012PDFE.pdf

Talib J. T, (2005). *Geopolitical foundations of national security in the Kurdistan region, (Arabic), (المقومات الجيوبوليتيكية للامن القومي في اقليم كردستان)*. KRI, Iraq: Kurdistan center for strategic researches, 580, 6/32/5, Sulaymaniyah.

Thapa, R. (2017). Rhythm in Architecture: An Aesthetic Appeal. *Journal of the Institute of Engineering*, 13(1): 206-214

United Nations General Assembly. (1987). *Report of the world commission on environment and development: Our common future*. Oslo, Norway: United Nations General Assembly, Development and International Co-operation: Environment.

URL2 Paintrest. Retrieved from https://www.pinterest.com/pin/383509724500222178/?lp=true

URL3 Juneau, Retrieved from, Juneau Commission on Sustainability: http://www.juneau.org/clerk/boards/Sustainability/about/about-sustainability/what-is-sustainability.php

URL1 Archdaily. Retrieve from Arch Daily, https://www.archdaily.com/270592/al-bahar-towers-responsive-facade-aedas

URL4 Archiexpo. Retrieved from Archiexpo, https://www.archiexpo.com/prod/stahlbau-pichler/product-85878-1062273.html

URL5 Skyscrapercenter. Retrieved from skyscrapercenter http://www.skyscrapercenter.com/building/burj-al-arab/402

USGBC (US Green Building Council). (1996). Sustainable Building Technical Manual. Public Technology Inc.

Weissman, A., Gupta, S.K., Fiorentini, X., Sudarsan, R., Sriram, R.D. (2009). *Formal Representation of Product Design Specifications for Validating Product Designs.* United States: U.S. Department of Commerce, National Institute of Standards and Technology.

Wyckmans, A. (2005). Intelligent Building Envelopes: Architectural Concept & Applications for Daylighting Quality. *Doctoral Thesis, Norwegian University of Science and Technology.*

Winston, N., & Eastaway, M. P. (2008). Sustainable Housing in the Urban Context: International Sustainable Development Indicator Sets and Housing. *Social Indicators Research,* 87(2), PP: 211-221.

Yin, R. K. (2003). Case study research: *Design and methods (3rd Ed.). Thousand Oaks*, CA, United States: Sage Publication.

APPENDICES

APPENDIX 1

CHECKLIST FOR EVALUATION SUSTAINABILITY IN THE CASE STUDY BUILDING

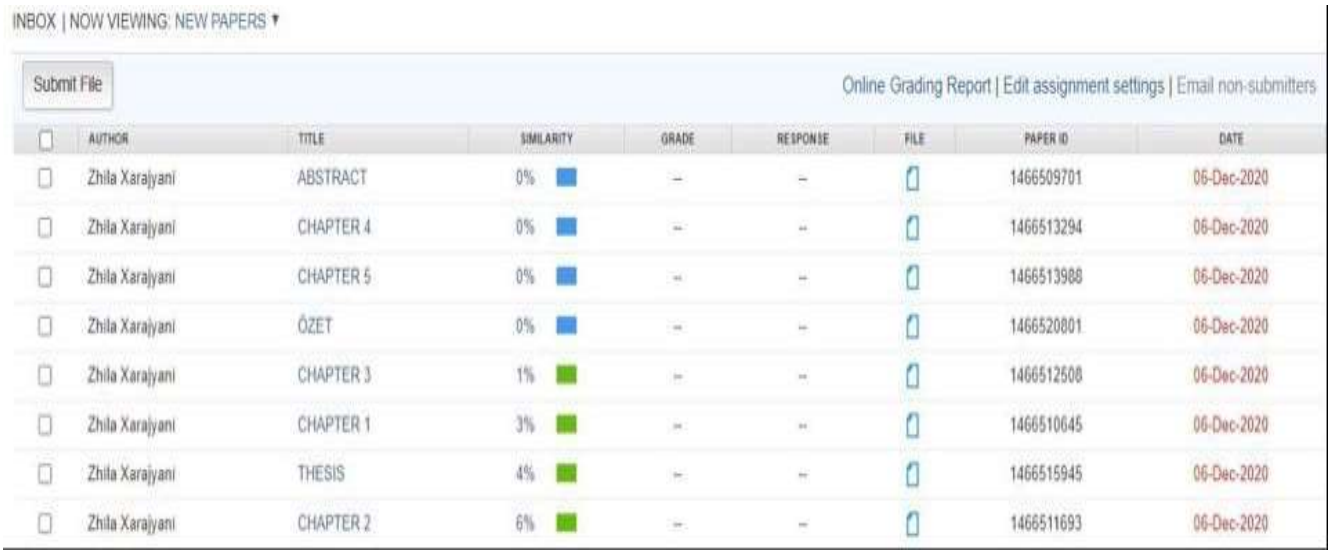
Table 5.1: The sample of Checklist that applied on the case study buildings.

No.	**Sustainable materials factors**	**Evaluation the percentage of sustainable factors in the case studies**								
		Highly active (3)			**Mid active (2)**			**Low active (1)**		
		High contr. **(3)**	Mid contr. **(2)**	Low contr. **(1)**	High contr. **(3)**	Mid contr. **(2)**	Low contr. **(1)**	High contr. **(3)**	Mid contr. **(2)**	Low contr. **(1)**
1	Low Embodied Energy of the material									
2	Energy Efficiency of the material									
3	Non-or low toxic materials									
4	Long life and Re-usable character of the material									

5	Cost efficiency of the material	
6	Durability, effectiveness and quality of the materials	
7	Flexibility of the materials in design and construction	
	Scores	
	Total Score of Sustainability for each case study ----out of 63	

APPENDIX 2

PLAGIARISM CHECK



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