University of Mohammed Kheider- Biskra
Faculty of Science and Technology
Department of Architecture

MASTER'S DISSERTATION

Domain: Architecture, urbanism and city professions
Field: Architecture
Specialty: Urban Architecture

Presented and defended by:
Azzouz Chouaib

On: Sunday 26th June 2022

Theme: Green-tech

The project: Fire station

Examiner's committee

M.	1st Tayeb Keltoum	MC (B)	University Of Biskra	President
M.	2nd Mebarki Rym	MA (A)	University Of Biskra	Examinator
M.	3rd Matallah Mohamed Elhadi	MC (B)	University Of Biskra	advisor

Academic year: 2021- 2022

DEDICATION

This thesis is dedicated to my family, specially my Mom and Dad. Without their selfless efforts and endless support, I would not be where I am right now. I would also like to dedicate this work to my Nana Halima. To my sisters Nor El Houda, Saida, Nariman, Aicha, Zieneb, Maroua, Hibatellah, Safia, who have not stopped advising me, encouraging and supporting me throughout my studies, may Allah protect them and offer them health and happiness.

And my gratitude goes to my supervisor Dr. Mohamed Elhadi Matallah, whose help, suggestions and constructive criticism brought me this far and was the back bone to finish this dissertation

And To my best friend who's going to insist that he's done half the work at least, Assil.
You did not.

With all my heart, I give thanks to ALLAH, almighty, for having given me the strength to survive, as well as the audacity to overcome all the difficulties and many graces in all areas of my life and that of my family. Also Khalil was there.

ABSTRACT

This past summer, we saw images of wildfires devastating northern Algeria. Immense, forested areas were destroyed, loss of human life, properties engulfed in flames, large economic and ecological damage. The current forest fire prevention strategy in Algeria is based on the principle of "minimum damage", reflecting the lack of firefighting resource capability for protecting the entire forestlands.

Providing fire safety is a complicated context that is related with issues such as staff, vehicle and equipment, function, organization, technology. Clearly, it is necessary to improve the fire services (in terms equipment and personnel, financial resources) in high-risk areas to reduce response and intervention times in initial attack.

Seeking to have a unique identity as a green fire station is paramount importance. Given that it is very important to protect the environment of the region, the users and the inhabitants of the city have understood that the landscape image is materialized mainly in urban green spaces, and particularly in the public constructions, which offer the city multiple images of nature.

In recent decades, the world has been burning with growing intensity. Climate change has exacerbated the threat, as increasing temperatures and changing rainfall patterns add fuel to the problem. As trees grow, they help stop climate change by removing carbon dioxide from the air, storing carbon in the trees and soil, and releasing oxygen into the atmosphere

The relationship between the greenery concepts and the aesthetic is an integral relationship between them, each enhancing and complementing the other. A complex relationship calls for feelings of belonging and appreciation for these urban green spaces and the prevailing local life. In fact, a deep appreciation of the value of the place and the image that the building reflects is the main reason for the admiration that this space will have. It is an important factor in building design, as it is the visible part of buildings. Architectural work, and so it is the first factor in judging the building pass or fail. Where we see that architecture in Algeria has lost its luster, because of the public facilities adopted the speed of construction without planning, it designs living spaces that meet functional needs and neglect the aesthetics of the building and the well-being of the users. Building image and its effects on the external environment.

In order to improve the fire station role for climate change mitigation both on urban and building scales, our research is based on three main axes; first: we focused on the greenery concepts and its benefits and aesthetic effect in the design of fire stations. Then in the second chapter, an analysis of four examples was formulated to identify the different recommendations for the design of fire stations using the green technologies. Finally, the last chapter constitutes the stages followed in the design process to achieve the objective of having an architecture well anchored**.**

Key words: Fire station, fires, green-tech, integration of plants, greenery concepts, Response Time, site selection.

الملخص

في الصيف الماضي ، رأينا صورًا لحرائق غابات تدمر شمال الجزائر. تم تدمير مساحات شاسعة من الغابات ، وخسائر في الأرواح ، واشتعلت النيران في الممتلكات ، وأضرار اقتصادية وبيئية كبيرة. تستند الاستراتيجية الحالية للوقاية من حرائق الغابات في الجزائر إلى مبدأ "الحد الأدنى من الضرر" ، مما يعكس نقص قدرة موارد مكافحة الحرائق لحماية أراضي الغابات بأكملها.

يعد توفير السلامة من الحرائق سياقًا معقدًا يرتبط بقضايا مثل الموظفين والمركبات والمعدات والوظيفة والتنظيم والتكنولوجيا. من الواضح أنه من الضروري تحسين خدمات مكافحة الحرائق (من حيث المعدات والأفراد والموارد المالية) في المناطق عالية الخطورة لتقليل أوقات الاستجابة والتدخل في الهجوم الأولي.

السعي للحصول على هوية فريدة كمحطة حرائق خضراء أمر بالغ الأهمية. نظرًا لأنه من المهم جدًا حماية بيئة المنطقة ، فقد أدرك المستخدمون وسكان المدينة أن صورة المناظر الطبيعية تتجسد بشكل أساسي في المساحات الخضراء الحضرية ، وخاصة في المباني العامة ، التي تقدم للمدينة صورًا متعددة طبيعة سجية.

في العقود الأخيرة ، كان العالم يحترق بكثافة متزايدة. أدى تغير المناخ إلى تفاقم التهديد ، حيث أدت زيادة درجات الحرارة وتغير أنماط هطول الأمطار إلى تفاقم المشكلة. مع نمو الأشجار ، فإنها تساعد في وقف تغير المناخ عن طريق إزالة ثاني أكسيد الكربون من الهواء ، وتخزين الكربون في الأشجار والتربة ، وإطلاق الأكسجين في الغلاف الجوي.

العلاقة بين مفاهيم المساحات الخضراء والجمالية هي علاقة تكاملية بينهما ، كل منهما يعزز الآخر ويكمله. تتطلب العلاقة المعقدة مشاعر الانتماء والتقدير لهذه المساحات الخضراء الحضرية والحياة المحلية السائدة. في الواقع ، فإن التقدير العميق لقيمة المكان والصورة التي يعكسها المبنى هو السبب الرئيسي للإعجاب الذي ستحظى به هذه المساحة. إنه عامل مهم في تصميم المباني ، حيث أنه الجزء المرئي من المباني. العمل المعماري ، ولذا فهو العامل الأول في الحكم على المبنى سواء نجح أو يفشل. حيث نرى أن العمارة في الجزائر فقدت بريقها ، بسبب اعتماد المرافق العامة لسرعة البناء دون تخطيط ، فهي تصمم مساحات معيشية تلبي الاحتياجات الوظيفية وتهمل جماليات المبنى ورفاهية المستخدمين. صورة المبنى وتأثيراته على البيئة الخارجية.

من أجل تحسين دور محطة الإطفاء للتخفيف من آثار تغير المناخ على المستوى الحضري والمباني ، يعتمد بحثنا على ثلاثة محاور رئيسية ؛ أولاً: ركزنا على مفاهيم المساحات الخضراء وفوائدها وتأثيرها الجمالي في تصميم محطات الإطفاء. ثم في الفصل الثاني ، تمت صياغة تحليل لأربعة أمثلة لتحديد التوصيات المختلفة لتصميم محطات الإطفاء باستخدام التقنيات الخضراء. أخيرًا ، يشكل الفصل الأخير المراحل المتبعة في عملية التصميم لتحقيق الهدف المتمثل في وجود بنية جيدة التثبيت.

الكلمات المفتاحية: محطة الإطفاء ، الحرائق ، التكنولوجيا الخضراء ، تكامل النباتات ، مفاهيم المساحات الخضراء ، وقت الاستجابة ، اختيار الموقع.

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General Introduction

I. Introduction

High demographic growth, increase in urbanization and climate change, causes the consumption of natural resources to increase and growing dangers (as forest fires and gas explosion, factory fires, flooding, Auto accidents, etc.) Which are hardly controlled by fire crews who come from surrounding towns and cities to help. This leads to the need of additional fire services in the area.

The mission of the fire service is to protect life, property, and natural resources from fire and other dangers. With increasing demands, the fire service must employ the best tools, techniques, and training methods to meet the public's expectations.

The primary responsibility of a fire station is to extinguish fire and offer rescue services. Moreover, to provide effective service the crews must respond in a minimum amount of time after the incident has been reported and with sufficient resources to initiate fire suppression, rescue or emergency medical activities.[1]

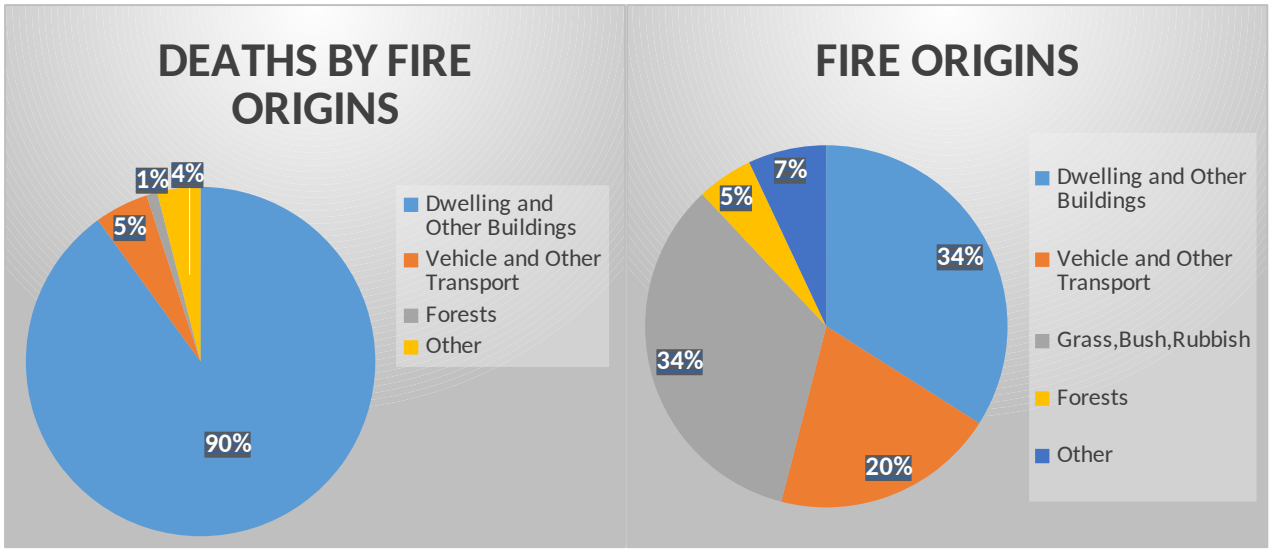


Figure 1: Distribution of Fire Origins and Fire Deaths by Fire Origin in the World[2]
Source: Prof. Dr. N.N. Brushlinsky, Prof. Dr. S.V. Sokolov, (2021). World Fire Statistics.

Green technologies have been in the industry for more than a decade, adoption of green technologies especially in the field of architecture and construction for ensuring sustainable development in the present era.

The term can be broadly defined as technology that has the potential to significantly improve environmental performance relative to other technology.

The need for green technology arises because natural resources are declining and pollution has increased due to the abundant use of non-renewable sources.

The application of greenery systems in architecture, in the green technology field, and in particular systems integrated with the building envelope both horizontal like green roofs, or vertical as green walls, can be found more often in new constructions.

[1] ESRI. (2007, January). GIS for fire station locations and response protocol. . Retrieved march 15, 2022, from https://www.esri.com/content/dam/esrisites/sitecore-archive/Files/Pdfs/library/whitepapers/pdfs/gis-for-fire.pdf
[2] Prof. Dr. N.N. Brushlinsky, Prof. Dr. S.V. Sokolov, (2021). World Fire Statistics, Centre of Fire Statistics of CTIF (World fire statistics Report № 26 of Centre of Fire Statistics of CTIF) Retrieved April 12, 2022, from https://www.ctif.org/sites/default/files/2021-06/CTIF_Report26.pdf

II. Problem Identification

The present day world is experiencing a number of problems like the different kinds of pollution (air, water and land pollution) also a shortage of natural resources, climate change, etc…

All this highlights the urgent need to protect the environment and preserve it for the future generations, leading us toward adopting green technologies in architecture, which can be beneficial to society as well as the environment. and thanks to the efforts of the researchers in this field we can attain the objectives of green technology through greenery concepts.

- How to use the green-tech in the architectural design of fire stations?
- How can we integrate green elements (plants) into buildings by improving the quality environment that produce better air, acoustics, biodiversity, and eventually liveability?

III. Objectives

- Finding out new strategies to integrate plants into the fire station design.
- To develop a unique identity for the fire station.
- To provide a hospitable work environment.
- Determine a new conceptual approach to a fire station

IV. Methodology

In this research, different methods of investigation are employed:

The theoretical phase:

Aiming to explore the documents and research attaining to this field of study, this allows us to treat the first and third chapters by understanding the theme of study “green-tech” and the basic principles of a fire station.

Analytical and comparative analysis:

Based on an analysis of case studies that have a relationship to the theme studied “green-tech”, a comparison table was made to distinguish the different ways of implementing greenery concepts.

Practical phase:

The design process of a project subjected to the principles of the research theme.

V. Structure of the Dissertation

This research is divided into three distinct chapters, preceded by a general introduction and followed by a general conclusion. It is structured as follows:

General Introduction:

It presents an introduction to the dissertation, which sets out the problem of the study, the questions that need to be answered and the objective of the research, the methodology of the research, the structure and work plan of the dissertation.

First chapter: Basics on fire stations & Green-tech

At the level of this part we will have the different definitions on the concept and the project and the new concepts which are adapted to the design of the fire stations.

Second chapter: General analytical study of the project

In this stage, the case studies were analyzed at the urban and architectural level with a site analysis, all these studies concluded a proposed program.

Third chapter: Design Path

Reminder of the objectives and determination of the project and the desgin process elements, recommendations, results, general conclusion, future avenues of the research.

Chapter 1:

Fire Stations & Green Technologies

1.1 Fire Stations

1.1.1 Introduction

Fire is defined as any instance of uncontrolled burning, including combustion explosions and fires out on arrival according to The National Fire Protection Association - NFPA.

Fire is one of the emergencies with its sudden and fatal characters, providing immediate and effective response to fires is important because emergency is a situation that poses an immediate risk to health, life, property or environment.

Response means activities designed to address the immediate and short-term effects of the disaster and/or emergency or with its second meaning the deployment of an emergency service resource to an incident[3]

Fire-Fighting Operations including rescue, fire suppression, and property conservation in buildings, enclosed structures, aircraft interiors, vehicles, vessels, aircraft, or like properties that are involved in an emergency situation[4]

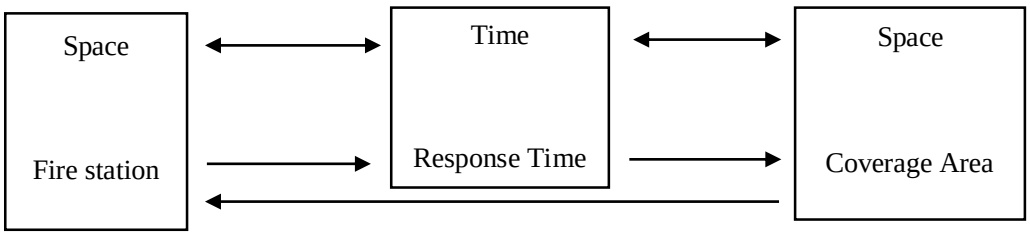


Figure 2: Space and Time Relations within the Scope of Fire Response
Source: Author

Fire station can be defined as one of the land uses within an urban space, which is responsible from fire scene placed in another urban space called coverage area. Emergency fire response consists of accessing from a fire station to a fire scene in its coverage area within the targeted time period called response time.[5]

1.1.2 Definitions

Fire station has various definitions

Fire station is one of the emergency service facilities which mentioned within the definition of community infrastructure.[6]

In Algeria, fire station (The Algerian Civil Defense) is a unit of the Algerian government responsible for firefighting, rescue services, and emergency response.[7]

[3] NFPA, 2003.
[4] DOD. (2019). Fire and emergency services (f&es) program. . Retrieved April 11, 2022, from https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodi/605506p.pdf
[5] Çğğdem Hacioğlu. (2010b, December). Spatial requirements of fire stations in urban areas: a case study of ankara (thesis). Kth Royal Institute Of Technology. https://etd.lib.metu.edu.tr/upload/12612761/index.pdf
[6] U.S. Air force civil engineer center. (2013b, December). *Facilities dynamic prototypes design for fire station - satellite*.
[7] National school of civil protection. (2012, April). Organization and management program. General Directorate of Civil Protection.

1.1.2.1 Terminology

Fire suppression: The activities involved in controlling and extinguishing fires.

Aerial firefighting: The use of aircraft, including fixed-wing aircraft and helicopters, and other aerial resources to combat wildfires. Smokejumpers and rappellers are classified as aerial firefighters, delivered to the fire by parachute from a variety of fixed-wing aircraft, or rappelling from helicopters.[8]

Fire apparatus: A fire department emergency vehicle used for rescue, fire suppression, or other specialized functions.

Wild land fire: An unplanned and uncontrolled fire spreading through vegetative fuels, including any structures or other improvements thereon.

Accountability: The process of emergency responders (fire, police, SAR, emergency medical, etc...) checking into and making themselves announced as being on-scene during an incident to an incident commander or accountability officer. Through the accountability system, each person is tracked throughout the incident until released from the scene by the incident commander or accountability officer.

Alarm: (1) system for detecting and reporting unusual conditions, such as smoke, fire, flood, loss of air, HAZMAT release, etc.; (2) a specific assignment of multiple fire companies and/or units to a particular incident, usually of fire in nature; (3) centralized dispatch center for interpreting alarms and dispatching resources.

Dispatch: Refers to person or place designated for handling a call for help by alerting the specific resources necessary.

EMS: Emergency medical service(s).

HAZMAT: Hazardous materials, including solids, liquids, or gases that may cause injury, death, or damage if released or triggered.

SCBA Self Contained Breathing Apparatus which you have your oxygen tank and mask, keeps you from breathing in smoke or hazardous gases. Part of your personal protective equipment (PPE).

NFPA: The National Fire Protection Association, a research group which sets a number of standards and best practices for *firefighting, equipment, and fire protection in the United States, and also adopted in many other countries.[9]

1.1.2.2 Response time

Response time is a critical component in the control and mitigation of an emergency incident.

Response time refers the time that begins when units are en route to the emergency incident and ends when units arrive at the scene according to NFPA.

NFPA defines that the total time of fire responding is distributed as dispatch time, turnout time and travel time from the station to the fire incident scene.[10]

[8] DOD. (2019). Fire and emergency services (f&es) program. . Retrieved April 11, 2022, from https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodi/605506p.pdf

[9] City of carmel, Fire Department Terminology. Retrieved on May 25,2022 from https://www.carmel.in.gov/Home/ShowDocument?id=195

[10] NFPA 1710, Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments

1.1.2.3 Coverage area

Coverage area or response area are defined as the fire stations area of action

- The goal is reducing the response area of the stations to not exceed 1,500 calls annually per stations.
- The response area for the stations should be reduced in order to promote better response time.[11]

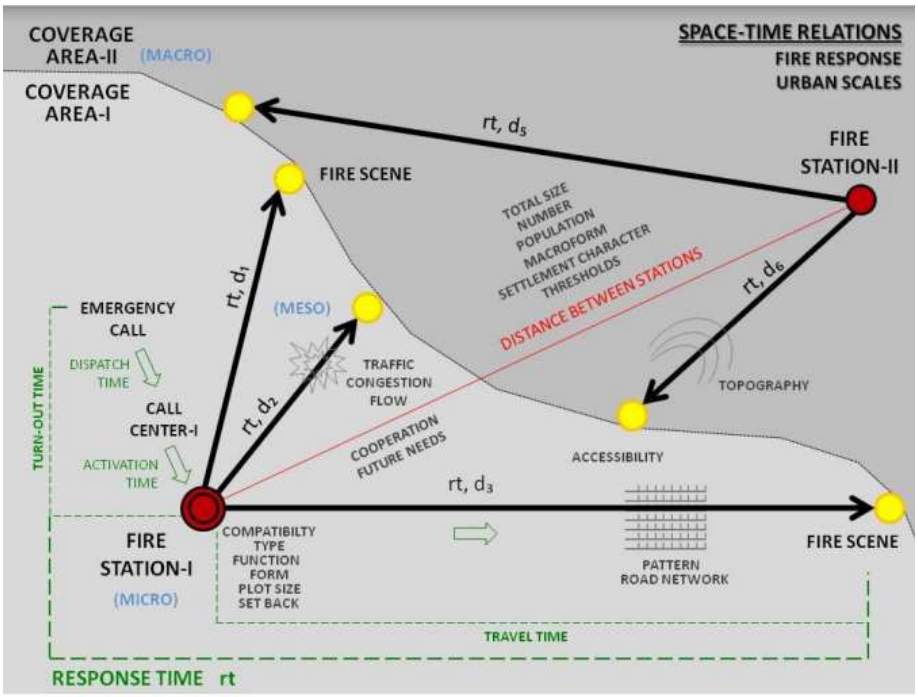


Figure 3: Fire Station - Response Time - Coverage Area Relations
Source: Çğğdem Hacioğlu, 2010.

1.1.3 History

The Algerian civil defense

Following the **Algerian revolution** and the exit of the **French colonial powers** in 1962, the responsibility of managing the Algerian firefighters fell to individual municipalities.

On April 15, 1964, under the presidency of **Ahmed Ben Bella**, the national civil protection service was created to standardize and professionalize the corps of Algerian firefighters and rescue workers.

However, the municipal administration and financing of the services was left intact.

This structure changed in 1976 when the service was replaced by the Algerian Civil Defense, nationalizing administration and day-to-day operations.[12]

[11] Çğğdem Hacioğlu. (2010b, December). Spatial requirements of fire stations in urban areas: a case study of ankara (thesis). KTH Royal Institute of Technology. https://etd.lib.metu.edu.tr/upload/12612761/index.pdf
[12] National School of Civil Protection. (2012, April). Organization and management program. General Directorate of Civil Protection.

1.1.4 Classes of stations

Fire stations are identified according to many indicators such as:[13]

- Settlement character (urban, suburban or rural stations),
- Type (headquarter/main, central, satellite or sub-station),
- Permanency (permanent or temporary stations),
- Service periods (auxiliary/support, day shift or full time services),
- Facility types regarding other emergency management services (stand-alone, joint/ integrated/ combined or shared-use facilities),
- Responsibility zones (owned by municipality, army or private company),
- Organization (career or voluntary),
- Size (small, medium or large)
- Future needs (additional fire company, training area, community room for public interaction or reserve apparatus storage needs).

These indicators of fire stations influence the spatial requirements through the planning and design process.

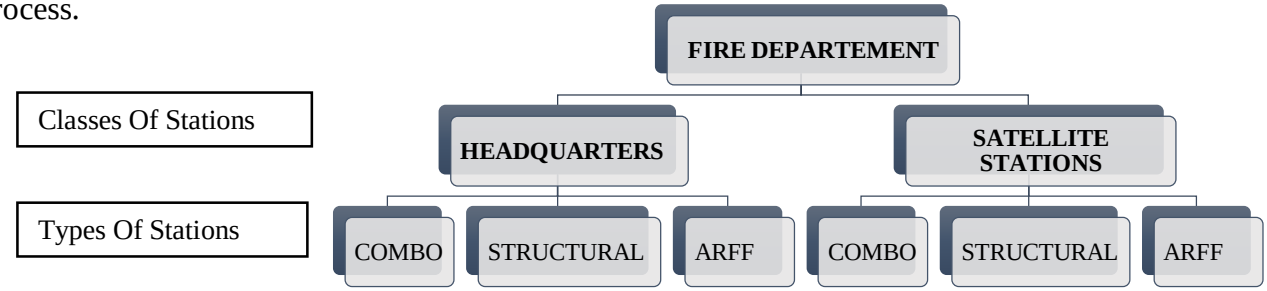


Figure 4: Classes and types of fire station
Source: U.S. Air force civil, 2013.

-Types of fire stations in Algeria

Table 1: The typology of units set by the provisions of decree n° 70-167 of November 10, 1970
Source: Author 2022

Units	Mission and Location	Intervention Equipment
Main Unit	Main Unit of Civil Defense whose establishment is fixed at the chief city of the Wilaya with the following mission: • Defend its sector of intervention (chief city of the Wilaya.) • To intervene in reinforcement to the Daïras and communes of the Wilaya. • To carry out specialized operations on the territory of the Wilaya. • To ensure operational coordination between the Civil Protection Units of the Wilaya. • To intervene as reinforcements in neighboring states.	2 Pump Trucks Ton 2 Forest Fire Trucks 2 Fire Tank Trucks 2 Automatic Ladder Trucks 2 Road Ambulances 2 Off-Road Ambulances 2 Modular Transport Trucks 1 Command Vehicle 3 Liaison Vehicles 3 Generators 3 Motor Pumps A Batch Of Operating Equipment

[13] Çğğdem Hacioğlu. (2010b, December). Spatial requirements of fire stations in urban areas: a case study of ankara (thesis). KTH Royal Institute of Technology. https://etd.lib.metu.edu.tr/upload/12612761/index.pdf

Secondary Unit	• Set up in Dairates, or in Municipalities with high popular density, or in high-risk areas. • Defend the capital of the municipality of establishment in first call, intervention in reinforcement to the bordering municipalities	2 Ambulances 1 Liaison Vehicle 1 Ton Pump Truck 1 Firefighting Vehicle 1 Fire Tank Truck 1 Forest Fire Tanker 2 Generators An operating lot
Sector Unit	• Established in the municipality, or in high-density working-class neighborhoods, or in high-risk areas. • Defend in first call, the capital of the municipality of establishment, intervention in reinforcement to the bordering municipalities.	1 Ambulance 1 Liaison Vehicle 1 Fire Fighting Vehicle

1.1.5 Fire stations services

National Fire Protection Association (NFPA) defines the primary functions of the fire station in the relevant code numbered 1201 as presented below:

- Fire prevention and risk reduction,
- Fire suppression,
- Rescue and emergency medical services,
- Hazardous materials response,
- Disaster planning.[14]

1.1.6 Site selection of fire stations

The location of fire and rescue stations is determined under a number of factors that should be considered when planning and constructing new stations including:

- Response time.
- Area of response coverage.
- Ability to concentrate department resources.

In addition, site selection should accommodate:

- Additional space for future growth or storage.
- Locating fuel sites in the event of disasters.
- Emergency power needs in the event of prolonged power outages.
- Apparatus response in more than two directions.
- Ample parking for personnel working at the facility.
- Training needs.
- Communications considerations (including line-of-sight), and
- Station distance from the curb to avoid potential pedestrian or vehicular accidents.[15]

[14] FEMA. (2018). Safety and Health Considerations for the Design of Fire and Emergency Medical Services Stations. . https://www.usfa.fema.gov/downloads/pdf/publications/design_of_fire_ems_stations.pdf

[15] FEMA. (1997). Safety and Health Considerations for the Design of Fire and Emergency Medical Services Stations. . Retrieved April 20, 2022, from https://www.usfa.fema.gov/downloads/pdf/publications/fa-168.pdf

-Fire station location planning must take into account a number of variables including

- The importance of time in responding to fire and medical emergencies
- Flashover
- Fire department total reflex time sequence.[16]

1.1.6.1 Flashover

Regardless of the speed of growth or length of burn time, all fires go through the same stages of growth. One particular stage emerges as very significant because it marks a critical change in conditions. It is called flashover.

Measuring the time to flashover is a function of time and temperature. Fire growth occurs exponentially; that is, fire doubles itself every second of free burn that is allowed. This can be plotted on what is known as the time and temperature curve.[17]

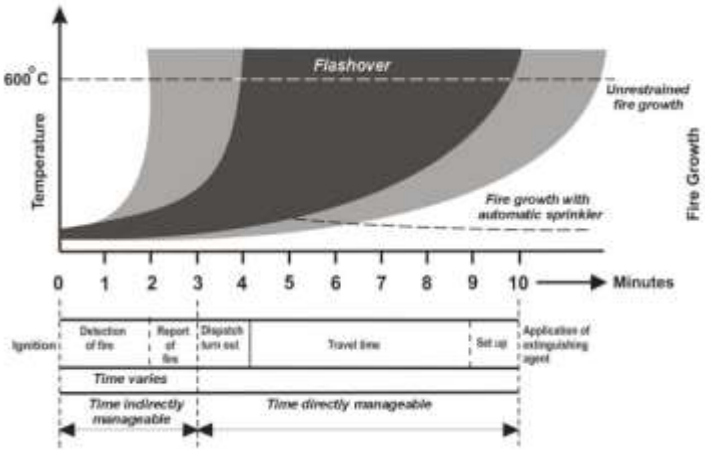


Figure 5: This diagram illustrates fire growth over time and the sequence of events that may occur from ignition to suppression.
Source: www.esri.com

1.1.6.2 Reflex Time Sequence

Time is the critical element when an emergency is reported. Fire growth can expand at a rate of many times its volume per minute. Time is the critical factor for the rescue of occupants and the application of extinguishing agents to minimize loss.

There are five steps in the fire department total reflex time sequence. Each of the five steps, after receiving the alarm, is defined below[18]:

1) **Dispatch time:** Amount of time that it takes to receive and process an emergency call. This includes:
    a. Receiving the call
    b. Determining what the emergency is.
    c. Verifying where the emergency is located.
    d. Determining what resources are required to handle the call.
    e. Notifying the units that are to respond.
2) **Turnout time:** The time from when units acknowledge notification of the emergency to the beginning point of response time.
3) **Response time:** The time that begins when units are en route to the emergency incident and ends when units arrive on the scene
4) **Access time:** Amount of time required for the crew to move from where the apparatus stops to where the emergency exists.
5) **Setup time:** The amount of time required for fire department units to set up, connect hose lines, position ladders, and so on, and prepare to extinguish the fire. This can include moving to the interior or upper stories of a large building and dealing with any barriers in the access to that area.

[16] ESRI. (2007, January). GIS for fire station locations and response protocol. . Retrieved march 15, 2022, from https://www.esri.com/content/dam/esrisites/sitecore-archive/Files/Pdfs/library/whitepapers/pdfs/gis-for-fire.pdf
[17] [16] ESRI. (2007, January). GIS for Fire Station Locations and Response Protocol. . Retrieved March 15, 2022, from https://www.esri.com/content/dam/esrisites/sitecore-archive/Files/Pdfs/library/whitepapers/pdfs/gis-for-fire.pdf

-National Standards

Table 2: National standards that contain time requirements that influence the delivery of fire and emergency medical services. Source: NFPA 1710, 2016.

Turnout time for fire responses	80 seconds
Turnout time for emergency medical responses	60 seconds
For the arrival of the first engine at a fire-suppression incident	240 seconds or less
For a high-rise response	480 seconds or less for the first full-alarm assignment for a fire-suppression incident.
For high-rise fire incidents	610 seconds or less for the first full-alarm assignment.
For a unit with an automatic external defibrillator (AED)	240 seconds or less.
For an advanced life support unit, provided the organization has a responder with an AED or a basic life support on the scene within 240 seconds	480 seconds or less.

- The number of personnel required to mitigate an incident is based on a task analysis as described in the standard.

1.1.7 Size of fire stations

Total size of fire stations is usually determined according to the population that will be under coverage.

-Size determinants:

- The number and types of vehicles housed

Table 3: Types & Minimum Number of Vehicles according to Population Groups.
Source: Çğğdem Hacioğlu, 2010.

Types & minimum number of vehicles	**Population**
1 fire extinguishing vehicle	less than 10.000
2 fire extinguishing vehicles, 1 vehicle with ladder and 1 emergent rescue vehicle	10.000-25.000
3 fire extinguishing vehicles, 1 vehicle with ladder, 1 double-cabin pickup, 1 service vehicle and 1 emergent rescue vehicle	25.000-50.000
4 fire extinguishing vehicles, 1 vehicle with ladder, 1 double-cabin pickup, 1 service vehicle, 1 ambulance and 1 emergent rescue vehicle	50.000-100.000
6 fire extinguishing vehicles, 2 vehicles with ladder, 2 double-cabin pickups, 1 service vehicle, 1 ambulance, 1 multi-functional rescue vehicle and 1 emergent rescue vehicle	100.000-200.000
8 fire extinguishing vehicles, 2 vehicles with ladder, 3 double-cabin pickups, 1 service vehicle, 2 ambulances, 1 multi-functional rescue vehicle and 1 emergent rescue vehicle	200.000-300.000
10 fire extinguishing vehicles, 3 vehicles with ladder, 3 double-cabin pickups, 2 service vehicles, 2 ambulances, 2 multi-functional rescue vehicles and 1 emergent rescue vehicle	300.000-400.000
14 fire extinguishing vehicles, 4 vehicles with ladder, 4 double-cabin pickups, 2 service vehicles, 3 ambulances, 2 multi-functional rescue vehicles and 2 emergent rescue vehicles	400.000-600.000

- Capacity In Terms Of Personnel

Table 4: The appointment of personnel in each type of civil defense unit.

Source: Decree 70-167 dated November 10, 1970 includes the classification of civil defense units and the determination of their framework and equipment.

Main unit					
Department	Rank				Total
	Non-commissioned officers	commissioned officers	Corporal	Firefighters	
Administration	2	3	7	4	16
Protection	2	2	/	/	4
Squad	1	3	/	/	4
Maintenance	/	3	2	11	16
Help	/	1	/	9	10
Total for each category	5	12	9	24	50
Secondary unit					
Department	Rank				Total
	Non-commissioned officers	commissioned officers	Corporal	Firefighters	
Administration	/	1	2	4	7
Protection	1	1	/	/	2
Maintenance	/	1	1	2	4
Help	/	/	1	2	3
Total for each category	1	3	4	8	16
Sector Unit					
Department	Rank				Total
	Non-commissioned officers	commissioned officers	Corporal	Firefighters	
Administration	/	/	1	1	2
Maintenance	/	/	1	2	3
Help	/	/	/	2	2
Total for each category	/	/	2	5	7

1.1.8 Types of Spaces

1.1.8.1 Apparatus and Maintenance

1.1.8.1.1 Apparatus Bay

The fire service response to a structure fire would normally involve a number of different units, also called companies. Fire service vehicles are called apparatus.[19]

The apparatus bay is not a just a garage; it is far more complex. It is a space like no other, that is vital to community safety. It is a space exclusively intended for storing and maintaining the most expensive and complicated vehicles on the road, ensuring that they can be quickly and safely deployed on time, every time for those who may need it most.[20]

[19] Occupational Safety and Health Administration. (2015). Fire Service Features of Buildings and Fire Protection Systems. Osha. Retrieved March 15, 2022, from https://www.osha.gov/sites/default/files/publications/OSHA3256.pdf

[20] Manns, R. (2017, August 1). Station Design: Anatomy of the Apparatus Bay. FIREHOUSE. Retrieved March 15, 2022, from https://www.firehouse.com/stations/building-components/article/12341699/anatomy-of-the-apparatus-bay

Table 5: Types Of Vehicles And Their Size Classes
Source: Author 2022

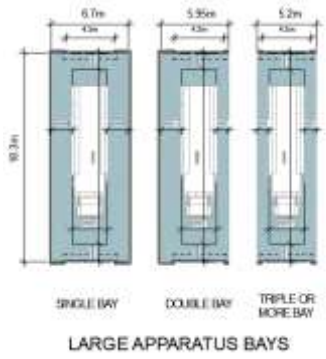
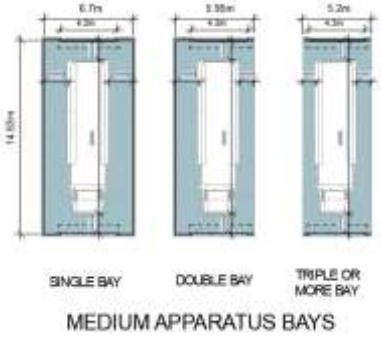
Large	The standardized footprint (floor space occupied by the truck, not considering the space around it) is 3.05 m by 15.24 m	
Medium	• Medium trucks have lengths between 9.14 and 11.58 m. • The standardized footprint is 3.05 m by 11.58 m • Small trucks have lengths less than 9.14 m	

Table 6: Types of vehicles and their size classes
Source: DOD, fire station, 2019.

Type of vehicle		Size class of vehicle
Structural	Pumpers	Medium
	Telesquirts	Medium
	Aerial/Ladders	Large
Tankers	Tankers	Medium or Large
Ambulance	Ambulances	Small
Rescue	Small/Light Rescue	Small
	Medium Rescue	Medium
HAZMAT	HAZMAT Support/Small	Small
	HAZMAT Squad	Medium
Brush	Small Brush	Small
	Large Brush	Medium

1.1.8.1.2 Apparatus Bay Support

Apparatus bay support functions include cleaning and maintenance areas for the firefighter's self-contained breathing apparatus (SCBA), protective clothing, fire extinguishers, and other equipment. It also includes storage areas for firefighting gear and equipment and secure storage for medical supplies.

A vehicle maintenance bay may also be included in a fire station. It is a dedicated maintenance area for the fire fighting apparatus and includes a heavy-duty lift and all utility connections required for large vehicle maintenance.[21]

Figure 6: Appararus Support.
Source: U.S. Air force civil engineer center. 2013

- **Vehicle Maintenance Bay / Equipment Storage**

This space is mainly used to service and repair firefighting vehicles. At times, this bay may be used as an additional Apparatus Bay as well. The bay is sized to accommodate the largest vehicle and the equipment required to service it. Similar to the Apparatus Bay, the Vehicle Maintenance Bay should be a drive-through

Equipment storage is tied to the vehicle maintenance bay and it is used to store spare parts and tools required for vehicle maintenance and service.[22]

Figure 7: PPE Gear Storage Lockers
Source: U.S. Air force civil engineer center.

- **Equipment Maintenance/Wash/Disinfection**

The maintenance area is used for the minor repair and maintenance of firefighters' equipment.

- The wash/disinfection area is located adjacent to the maintenance area.
- When fire trucks return from a fire or other event, equipment is brought into this area for cleaning and disinfection.
- The equipment is taken from the truck directly to the wash and disinfection area prior to the truck's entry into the Apparatus Bay.[23]

[21] G. Mion, E. (2017, March 22). Fire Station | WBDG - Whole Building Design Guide. Retrieved April 15, 2022, from https://www.wbdg.org/building-types/community-services/firestation#:%7E:text=Apparatus%20bay%20support%20functions%20include,secure%20storage%20for%20meical%20supplies.

[22] [21] DoD. (2019, May 8). Unified Facilities Criteria (Ufc); Fire Stations. Retrieved March 6, 2022, from https://www.wbdg.org/FFC/DOD/UFC/ufc_4_730_10_2019_c1.pdf

1.1.8.2 Administration and Training

-Offices

General administrative office spaces in the station include the following:

Assistant Chief/Shift Supervisor Office, Inspector's Office(s), Training Officer Office, Vehicle Maintenance Office, EMS Office, Dispatch Supervisor, Administrative Assistant, Assistant Chief of Fire Prevention, HAZMAT/Safety Officer , and Logistics Officer.[24]

Figure 8: Office Suite
Source: U.S. Air force civil engineer center.

-Station Officer's Office

The station officer's office provides space for the station officer and/or company officers to perform their administrative functions. For satellite stations the station officers office may serve to control public access to the station.[25]

Figure 9: Dispatch room
Source: www.fireapparatusmagazine.com

-Dispatch

This room functions to receive and dispatch emergency related calls.

The Dispatch Room includes workstations sized to accommodate the necessary equipment for each individual dispatcher.

Dispatch Rooms also include a dedicated toilet and kitchenette directly adjacent to and accessible from to the room for staff use.[26]

Figure 10: Classroom room
Source: id.pinterest.com

-Training Room/ Class room

Department training room is a classroom space used for the continuing education and training of the fire station staff and, occasionally, the public. It is typically sized to accommodate the entire on-duty population of the department—provide sufficient seating and desks.

A storage closet is located adjacent to the training room and used for storage of audiovisual equipment, media, additional equipment, and furnishings[27]

Figure 11: Training room
Source: www.fireapparatusmagazine.com

[24] [23] [24] [25] DoD. (2019, May 8). Unified Facilities Criteria (Ufc); Fire Stations. Retrieved March 6, 2022, from https://www.wbdg.org/FFC/DOD/UFC/ufc_4_730_10_2019_c1.pdf

-Training Tower

A training tower can be a nice architectural feature to a station, as well as a valuable space for on-site training.[28]

Examples of training evolutions that can be conducted in a tower:

- Rope rescue.
- Hose advancement.
- Sprinkler stoppage/change-out.
- Artificial smoke space for SCBA training.
- Rescue of personnel from upper floors

Figure 12: Textured Tower, 2012, training tower. **Source:** www.archdaily.com

1.1.8.3 Residential and Living

-Dorm Rooms

Dorm Rooms are the private quarters of the firefighters and are used for sleeping during 24- hour shift.

The room is shared between two firefighters of different crews/shifts so that the room is never occupied simultaneously.

Individual lockers are provided for each firefighter. A bed, nightstand, and desk are shared. A two-bed arrangement, giving each firefighter an individual bed and nightstand[29]

Figure 13: Fire Station, Birmingham Dorm Room **Source:** amberstudent.com

-Day Room (Including Kitchen)

The Day Room is configured and furnished like a very large residential kitchen/dining room/living room.

Provide plenty of adequate seating to accommodate all company members, both in the dining setting and comfortable seating for TV watching, reading, and relaxation in the living room area.

Directly adjacent to the dining area is a kitchen sized to provide ample preparation space for the entire overnight population of the station.[30]

Figure 14: Day Room - Kitchen/Dining **Source:** www.fireapparatusmagazine.com

-Fitness Room

The Fitness Room promotes health and physical fitness of fire department personnel.

The Fitness Room should accommodate the latest in fitness machines, as well as more traditional equipment. The room should be sized to provide free circulation between equipment while in use.[31]

Figure 15: Universal machines facilitate a variety of strength training options. **Source:** FEMA, 2018.

[28] FEMA. (2018, April). Safety and Health Considerations for the Design of Fire and Emergency Medical Services Stations. Retrieved March 6, 2022, from https://www.usfa.fema.gov/downloads/pdf/publications/design_of_fire_ems_stations.pdf

[29] [28] [29] Department of Defense. (2019, May 8). Unified Facilities Criteria (Ufc); Fire Stations. Retrieved March 6, 2022, from https://www.wbdg.org/FFC/DOD/UFC/ufc_4_730_10_2019_c1.pdf

-Recreation Room

This room provides space for the firefighters to engage in noisier recreational activities, such as table games (e.g., pool or table tennis) or video games and is in addition to the day room.[32]

Figure 16: Recreation Room
Source: stay-hub.com

1.1.9 Functional Relationship

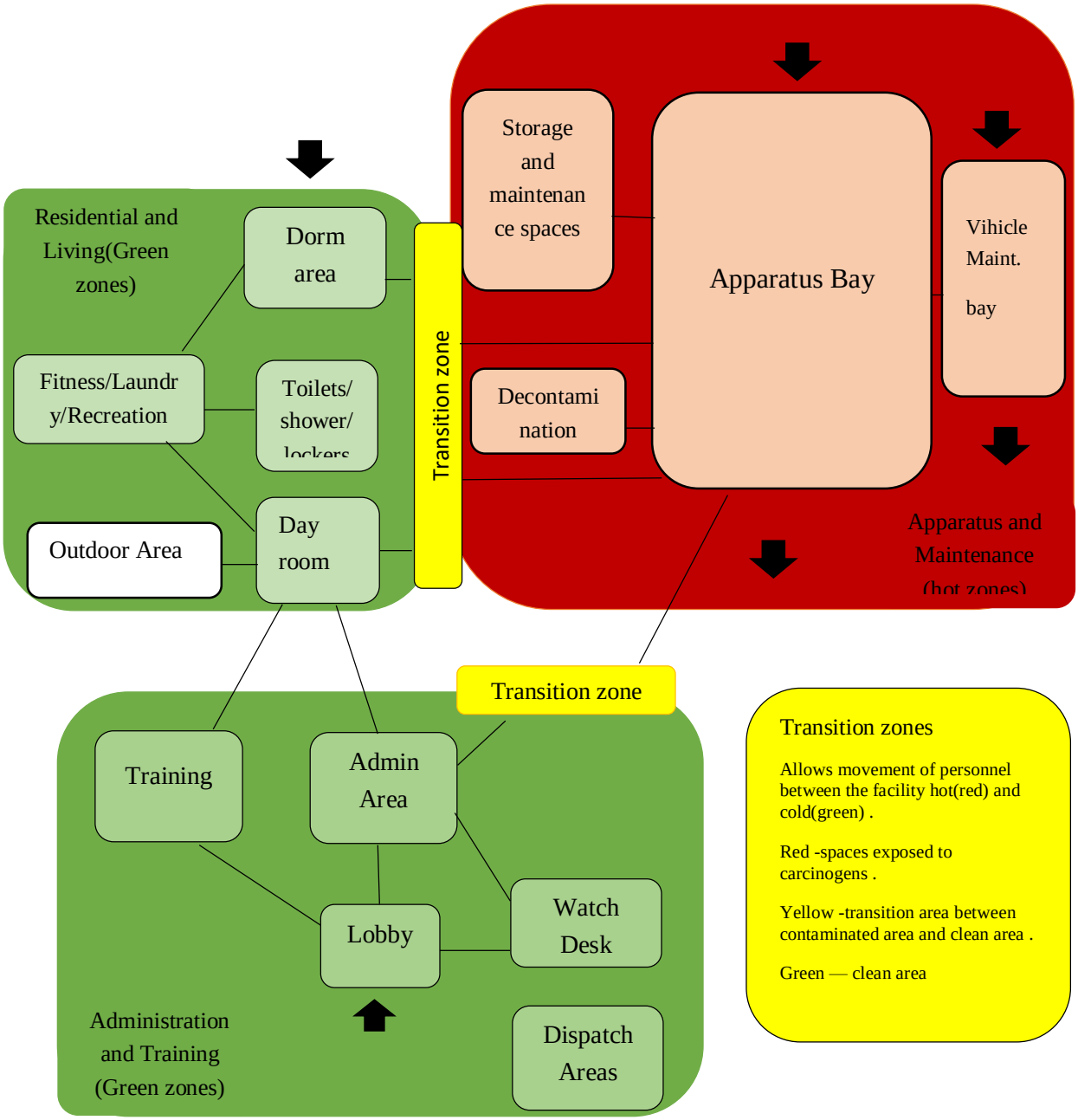


Figure 17: Basic Facility Functional Relationship Diagram
Source: Department of Defense. (2019, May 8). with the author's interpretatio

[32]Department of Defense. (2019, May 8). *Unified Facilities Criteria (Ufc); Fire Stations*. Retrieved March 6, 2022, from https://www.wbdg.org/FFC/DOD/UFC/ufc_4_730_10_2019_c1.pdf

1.2 Green-Tech

1.2.1 Definitions

The development and application of products, equipment and systems used to conserve the natural environment and resources, which minimizes and reduces the negative impact of human activities.[33]

Green-tech refers to a type of technology that is considered environmentally friendly based on its production process or its supply chain. Green tech—an abbreviation of "green technology"—can also refer to clean energy production, the use of alternative fuels, and technologies that are less harmful to the environment than fossil fuels.[34]

1.2.2 Green technologies in architecture

Green architecture is architecture that seeks to minimize the negative environmental impact of buildings by efficiency and moderation in the use of materials, energy, and development space.[35]

- Water efficiency technologies
- Low-energy house and zero-energy building design
- Cool roofs
- Passive solar systems
- Passive heating / Passive cooling
- Earth cooling tubes
- Green insulation
- Active heating / Active cooling
- greenery systems (GS)

1.2.2.1 The Green Building Design

The green building design process begins with an intimate understanding of the site in all its beauties and complexities. An ecological approach to design aims to integrate the systems being introduced with the existing on-site ecological functions performed by Mother Nature.

These ecological functions provide habitat, respond to the movements of the sun, purify the air as well as catch, filter and store water.

Creating new habitat on structures in urbanized areas is especially important to support bio-diversity and a healthy ecosystem.[36]

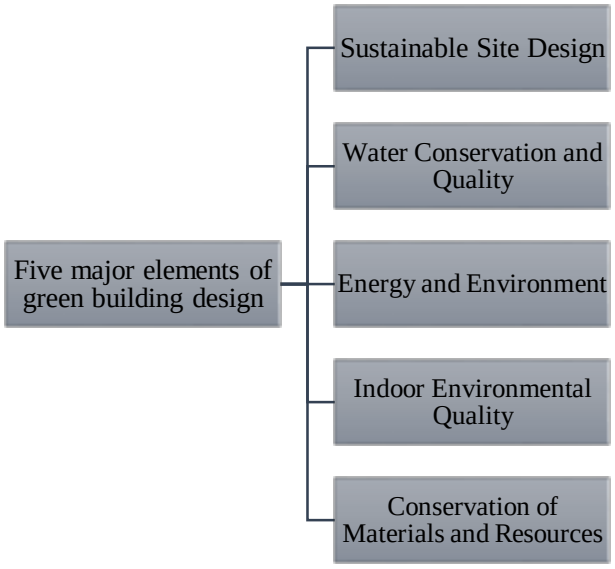


Figure 18: Elements of green building design
Source: Amany Ragheb, 2016.

[33] MC Editorial Team. (2013b, March 22). Ministry of Energy, Green Technology and Water Malaysia.
[34] United Nations. (1992, June 3). United Nations Conference on Environment & Development Rio de Janerio, Brazil. Sustainable Development
[35] Arch, B. (2014). Application of green technologies in architecture. Retrieved March 12, 2022, from https://updatepublishing.com/journal/index.php/rrst/article/view/1167/1152
[36] Ragheb, A. (2016b). GREEN ARCHITECTURE: A CONCEPT OF SUSTAINABILITY. Elsevier. Retrieved March 12, 2022, from https://reader.elsevier.com/reader/sd/pii/S1877042815062552?token=EB6026DE33740A6F3330CF3DB9CD1C6F21361C34CF8EAF685B6C110AEDC29077B1FA950BC703AB2F0377C1B8E7502066&originRegion=eu-west-1&originCreation=20220616205744

1.2.4 Greenery concepts

There are many forms by which Greenery can be integrated into buildings including horizontal and vertical, exterior and interior spaces (indoor plant).

Throughout history, greening of outside walls and roofs of buildings has taken place. Reasons for doing so were to increase insulation (keep cool in summer and keep cold out in winter), improved aesthetics, improved indoor and outdoor climate as well as increasing ecological values by creating habitats for birds and insects.[37]

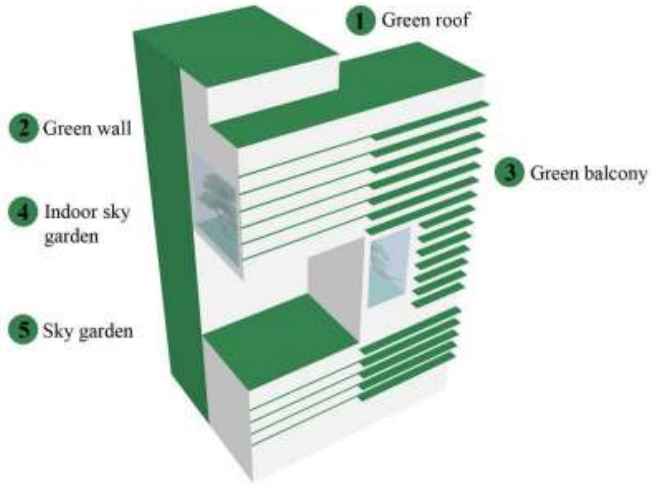


Figure 19: Different ways of integrating greenery systems on buildings **Source:** Babak Raji, 2015.

Green roofs	Vertical Greening	Indoor plants	Green landscaping
• Extensive Green Roof • Semi-Intensive • Intensive	• Green facade • Living wall	• Potted plants • Indoor vertical greenery	• Green spaces

Figure 20: Different ways of integrating greenery systems on buildings **Source:** Zeiler, W. (2022).

1.2.4.1 Green roofs

A green roof is a layer of vegetation planted over a waterproofing system that is installed on top of a flat or slightly sloped roof. Green roofs are also known as vegetative or Eco roofs.

New-style roof greening recognizes three main approaches, extensive, intensive and semi-intensive. On a green roof, vegetation is planted in a growing medium laid over a waterproof membrane separating the system from the roof and the building below.

The vegetation on a green roof can be composed of low groundcovers or may contain large trees and shrubs, depending upon the system`s construction[38]

Figure 21: Different ways of integrating greenery systems on buildings. **Source:** Building and Environment, 2018.

[37] Raji, B. (2015). The impact of greening systems on building energy performance: A literature review, Renewable and Sustainable Energy Reviews, Volume 45. Retrieved March 12, 2022, from https://www.sciencedirect.com/science/article/pii/S1364032115000994

[38] Seçkin, N. (2018, July). Environmental control in architecture by landscape design. Journalagent. Retrieved March 11, 2022, from https://www.journalagent.com/itujfa/pdfs/ITUJFA_15_2_197_211.pdf

1.2.4.1.1 Extensive roof greening

Extensive is loosely used to describe a system that typically has a very shallow depth between 2 and 15 cm of soil or growing medium and is primarily used for its environmental benefits such as storm water management and insulating properties. They can support relatively smaller-sized plant materials.

Extensive roofs are generally much cheaper than intensive roofs, both in construction and maintenance.[39]

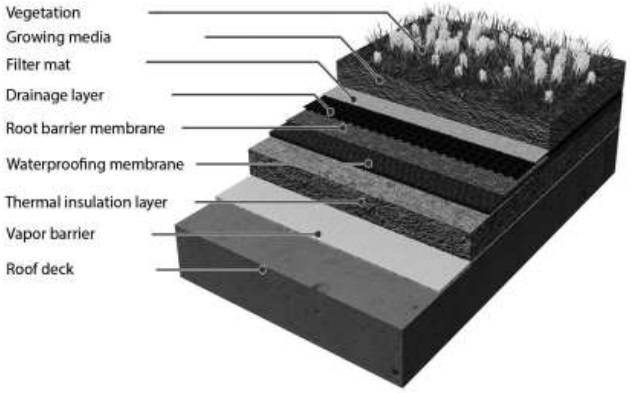


Figure 22: Extensive green roof.
Source: SEÇKİN, N. (2018, July).

1.2.4.1.2 Intensive roof greening

Intensive roof greening or landscape over structure is similar to the old-style roof gardens, where it is expected that people would use the area much as a conventional garden.

Intensive roofs can support the whole range vegetation types, from trees and shrubs through to herbaceous planting and lawns.

Substantial pools and water features are possible.

Such roofs are usually intended to be accessible to people, and certainly need to look good.[40]

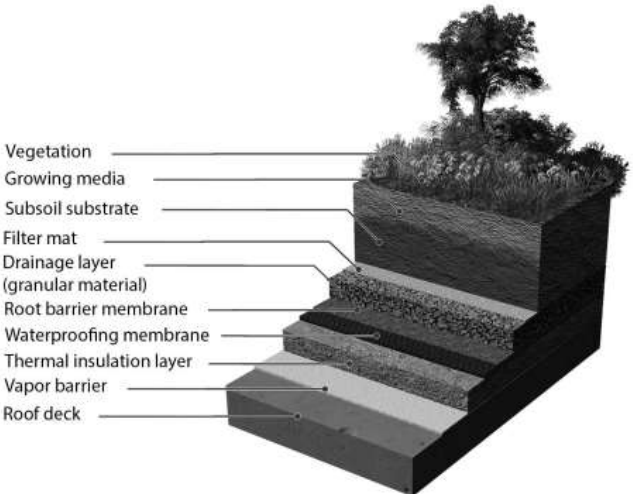


Figure 23: Intensive roof green roof.
Source: SEÇKİN, N. (2018, July)

1.2.4.1.3 Semi-intensive roof greening

The semi-intensive green roof has a great deal of potential for the creative extension of roof planting where the roof area is visible and intended for human use.

Semi-intensive roofs use lightweight substrates and modern green-roof construction technologies.

Substrate or growing medium depths are between 15-30 cm, which reduces the amount of extra loading that must be built into the roof construction.

Intensive and semi-intensive systems can accommodate larger plants species, including trees.[41]

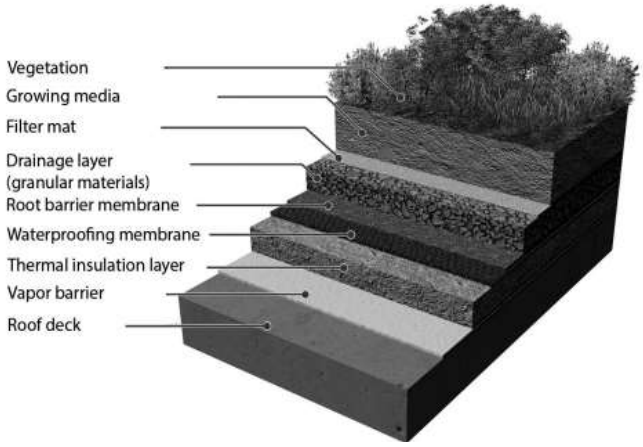


Figure 24: Semi-Intensive roof green roof.
Source: SEÇKİN, N. (2018, July)

[36] [37] [38] SEÇKİN, N. (2018, July). Environmental control in architecture by landscape design. Journalagent. Retrieved March 11, 2022, from https://www.journalagent.com/itujfa/pdfs/ITUJFA_15_2_197_211.pdf

1.2.4.1.4 Plants used in a green roof

Table 7: Typical plants for green roofs
Source: by author

Marsh mallow (Sekkoum)		Thapsie (Ederiess bounafaa)	
Mallow (Khobeiza)		Asphodel (Al berrouagh)	
European pennyroyal (Fliou)		Roman chamomile (Babounje)	
Honeysuckle (Chahmet elaatrous)		Peppermint (Naanaa)	
Shepherd'spurse (Kisset elrai)		Eglantier commun (Nessrin)	
Barberry (Aaneb eljebel)		Common chicory (Tilfef)	
Marigold / Calendula (Jemra)		Fringed rue (Elfijel)	

1.2.4.1.5 Examples

Figure 25: Renzo Piano Building Workshop, California Academy of Sciences, San Francisco, USA, 2008, exterior and roof
Source: Sayigh, A., & Trombadore, A. (2021).

Figure 26: Rooftop garden on a residential building in San Francisco—California, USA
Source: Sayigh, A., & Trombadore, A. (2021).

Figure 27: Large green roofs on Apple new office building in Silicon Valley, California, USA.
Source: Sayigh, A., & Trombadore, A. (2021).

Figure 28: Emilio Ambasz and Associates, ACROS Building, Fukuoka, Japan, 2000.
Source: Schröpfer, T. (2022).

Figure 29: The largest rooftop garden in Silicon Valley, San Francisco—California, USA.
Source: Sayigh, A., & Trombadore, A. (2021).

1.2.4.2 Vertical Greening

1.2.4.2.1 Green façade

One of the most unattractive features of much modern architecture is the presence of blank walls without windows or ornamentation. The idea of growing plants on a substrate attached to the surface of such walls is an attractive solution.

- **Direct façade greening**
  - This is counted as the traditional way of greening facades.
  - In this system climbing plants are directly connected to the façade and using building materials as a support.
  - Plants are mainly rooted in the ground or planter boxes.
- **Indirect façade greening**
  - In this system for providing a gap between the façade and the green layer, some structural supports e.g. wire, mesh or trellis are used.
  - Plants can root in the ground, on the roof or in substrates attached to the wall.[42]

1.2.4.2.2 Living wall

- **Living wall**

Living walls consist of modular pre-cultivated panels; each contains a growing medium and irrigation system to provide all of the nutrients for plants.

They have also a waterproof layer to isolate the façade from moisture penetration.

- **Indoor living wall (Bio-filters)**

Bio-walls are indoor vertical greening systems that are mostly used for filtration of the indoor air and enhancement of aesthetic values of the indoor environment especially in office spaces.

They can purify the air passively through natural convection or by using a fan to facilitate the circulation and improve its efficiency.[43]

1.2.4.2.3 Plant types to use for green walls/ indoor living wall

Green façades use climbing plants, which are divided into 'self-supporting plants' (root climbers and adhesive-suckers) and 'plants that need supporting structure' (twining vines, leaf-stem climbers, leaf climbers, and scrambling plants).

Plants used in vertical exterior applications are exposed to harsher climactic conditions than those at grade or indoors, and as a result, hardy species should be selected for projects that intend to reach great heights. Similarly, climbers with a tolerance for wind, frost, and heat should be selected for projects in less hospitable climates.[44]

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[42] [41] Raji, B. (2015). The impact of greening systems on building energy performance: A literature review, Renewable and Sustainable Energy Reviews, Volume 45. Retrieved March 12, 2022, from https://www.sciencedirect.com/science/article/pii/S1364032115000994

[41] Afrin, S. (2009, September). Green Skyscraper: Integration of Plants into Skyscrapers (Master's Thesis). KTH Royal Institute of Technology. https://www.diva-portal.org/smash/get/diva2:353678/fulltext01#:~:text=The%20provisions%20of%20integrate%20plants,savings%20and%20indoor%20environmental%20qualities.

Table 8: The typical varieties of plants that are commonly used in biofilters.
Source: Afrin, S. (2009, September).

Algerian ivy		Gardenia	
Birds nest		Hedera green vines	
Bromeliads		Hibiscus bush	
Schefflera		Dracaena ‘Janet Craig’	
Cissus grape ivy		Maidenhair	
Ficus starlight		Dracaena marginata	

1.2.4.2.4 Examples

Figure 30: Biodiverse green wall (Madrid, Spain).

Figure 31: SportPlaza Mercator, Amsterdam
Source: Sayigh, A., & Trombadore, A. (2021).

Figure 32: Vertical and verdant, living wall systems sprout on two buildings, in Paris and Vancouver
Source: Sayigh, A., & Trombadore, A. (2021).

Figure 33: Vertical greenery system (Thailand).
Source: Schröpfer, T. (2022).

1.2.4.3 Indoor Plants

Interior landscaping has become increasingly popular during the last 30 years. Plants are actually good for the building and its occupants in a number of subtle ways and are an important element in providing a pleasant, tranquil environment where people can work or relax.

The presence of plants in the office not only aesthetically pleasing but also helps increase workers productivity, reduce stress and improve air quality.

Indoor plants offer the building inhabitants some of the same benefits as the experience of outdoor nature.[45]

[45] Afrin, S. (2009, September). Green Skyscraper: Integration of Plants into Skyscrapers (Master's Thesis).

1.2.4.3.1 Types of Indoor Plants

- **Night time workers**

Epiphytic Bromeliads, orchids and succulents exchange Oxygen and Carbon Dioxide at night rather than as most other plants do during the daytime. This makes them perfect bedroom plants to refresh the air for breathe during sleep.[46]

- **Air Cleaning Flowering Plants**

According to the book Eco-Friendly Houseplants by Dr. Bill Wolverton (2009), the following are the best air cleaning flower plants that can be use in indoors.[47]

- Chrysanthemum – no 2 in the charts for ridding the air of Formaldehyde.
- Gerbera – no 3 in the same charts.
- Orchids – clean and refresh the air at night, so perfect for the bedroom.
- Anthurium.
- Potted Tulips.

1.2.4.3.2 Examples

Figure 34: Large plants can be used to improve indoor air quality (Hangzhou, China).
Source: Schröpfer, T. (2022).

Figure 35: Small plants such as bryophytes can be used to improve indoor air quality (Singapore).
Source: Schröpfer, T. (2022).

Figure 36: Plants can be used to improve indoor public space air quality (Singapore).
Source: Schröpfer, T. (2022).

Figure 37: Grant Associates/Wilkinson Eyre/CPG Consultants/Atelier Ten, Gardens by the Bay, Singapore, Flower Dome, interior
Source: Schröpfer, T. (2022).

[46] Wolverton, B. C. (1996, April). Interior Plants: Their Influence on Airborne Microbes Inside Energy-Efficient Buildings. Retrieved March 12, 2022, from https://www.wolvertonenvironmental.com/MsAcad-96.pdf
[47] Wolverton, B. C. (1996a). Eco-Friendly Houseplants: 50 Indoor Plants That Purify the Air in Houses and Offices. Weidenfeld & Nicolson Ltd.

1.2.5 The Benefits of Green in Buildings

"All plants remove the Carbon Dioxide we emit during breathing and release Oxygen into the air for us to breathe. This exchange takes place during photosynthesis, which most plants perform during daylight hours. All plants remove impurities from the air to a lesser or greater effect. They remove the impurities or Volatile Organic Compounds (VOCs) by absorbing them through their leaves or via their growing medium. The VOCs are moved (translocated) to the plant's roots where micro-organisms living in the root zone (rhizosphere), turn the VOCs into food for the plant."

Dr. B. Wolverton, (NASA).[48]

Plants can perform a key role in the context of architecture.[49]

- They can complement and reinforce the existing architectural features of the house, building, or structure, and they can contribute to creating outdoor spaces.
- Greenery can help to define a spatial development through the definition of space by introducing a sense of scale and by creating focal points for users indoors and outdoors.
- Trees, shrubs, and ground covers can be used to emphasize architectural lines and dimensions of the built environment
- Greenery in outdoor spaces around buildings acts as a natural air-conditioner through the process of evaporative cooling via plant transpiration.
- In seasonal countries, plants can be used as natural insulators during the winter months and coolers during summer months.

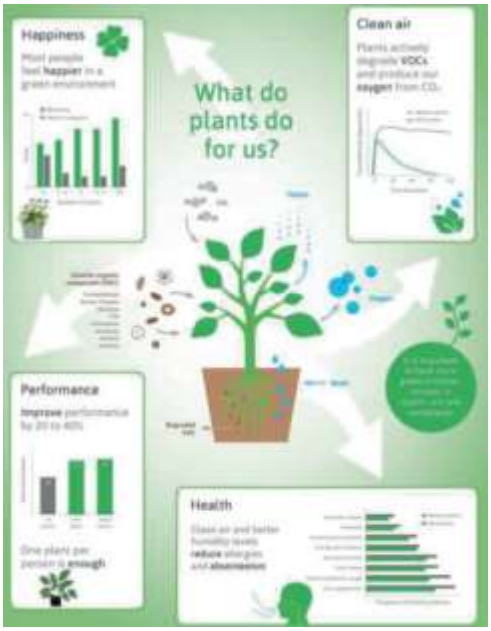


Figure 38: The benefits of plants for occupants
Soured: https://intogreen.nl/ 2019

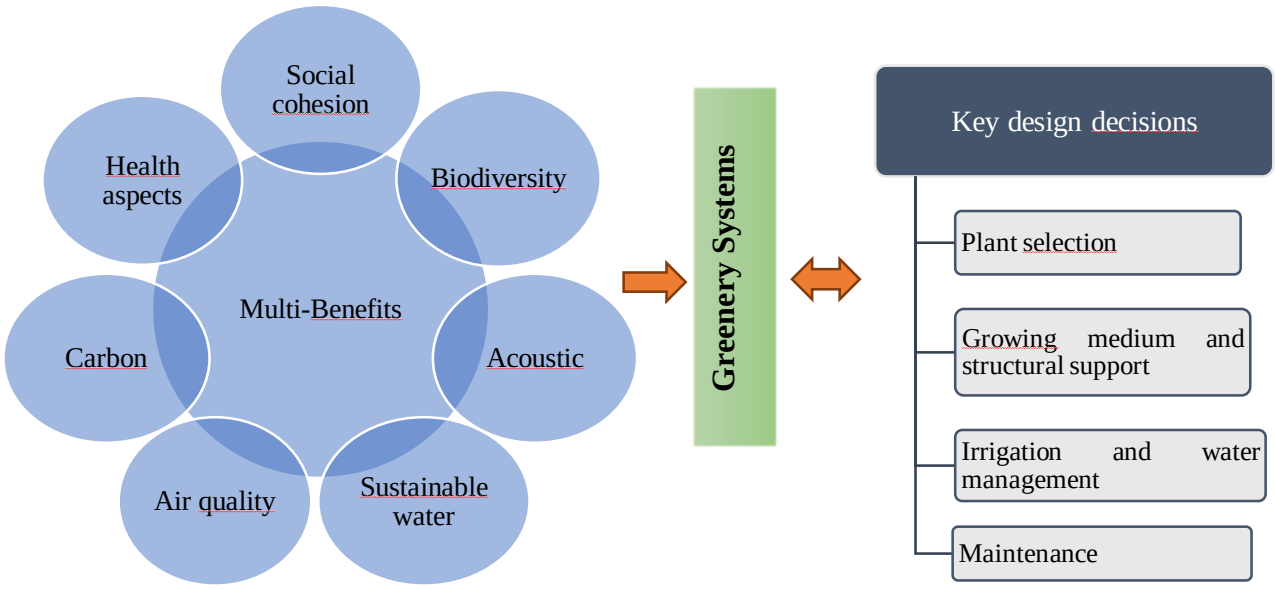


Figure 39: Multi-benefts of greenery and the related key design decisions
Source: Sayigh, A., & Trombadore, A. (2021).

[48] Wolverton, B. C. (1996, April). Interior Plants: Their Influence on Airborne Microbes Inside Energy-Efficient Buildings. Retrieved March 12, 2022, from https://www.wolvertonenvironmental.com/MsAcad-96.pdf
[49] Schröpfer, T. (2022b). Dense + Green: Innovative Building Types for Sustainable Urban Architecture (1st ed.).

1.2.5.1 Green Roof Benefits

Numerous benefits can result from the adoption of green roof technologies. Besides the obvious aesthetic and psychological benefits of being surrounded by garden-like settings, common ecological and economic benefits include the recovery of green space, moderation of the urban heat island effect, improved storm water management, water and air purification, and a reduction in energy consumption.[50]

Impacts of green roof that have been commonly cited are as follows:

- Effects on energy budgets of individual buildings.
- Effects on urban air quality.
- Effects on waste management from increase in roof material "life cycle".
- Promotion of biodiversity and wild life protection.
- Reduced heating due to fewer fluctuations in roof temperature and insulating properties of vegetation.
- Reduced cooling costs due to fewer fluctuations in roof temperature and heat loss due to evaporation in the summer.
- Noise insulation.

1.2.5.2 Green Wall Benefits

Installing green façades and living walls can result in many benefits to the environment, buildings and human welfare and reduce energy consumption[51]

- Reduce Heat Island Effect.
- Reduce Heat Gain.
- Sound Insulator.
- Ecological Preservation and beautification.
- Air purification.

1.2.5.3 Benefits Indoor Planting

Interior landscaping has become increasingly popular during the last 30 years. The main reason of indoor planting is, they look attractive, and they charmed people by their graceful arch like palm leaves or the exotic beauty of orchids.

Indoor plants offer the building inhabitants some of the same benefits as the experience of outdoor nature.

Improvement of comfort conditions is one among the numerous benefits indoor vegetation can provide for the tenants.

The importance of indoor air quality (IAQ) is growing due to its direct influence on human's health and productivity.[52]

- Removes Pollutants from Indoor Air
- Reduces HVAC Energy Consumption
- Provides Dramatic Aesthetic Amenity
- Improve indoor environment quality

[50] Ryerson University. (2005). Report on the Environmental Benefits and Costs of Green Roof Technology for the City of Toronto Munich Personal RePEc Archive. Retrieved April 12, 2022, from https://mpra.ub.uni-muenchen.de/70526/
[51] Benefits of green walls. (2017). Greenwallassociation. Retrieved April 16, 2022, from https://www.urbangreening.info/benefits-of-green-walls
[52] Schröpfer, T. (2022b). Dense + Green: Innovative Building Types for Sustainable Urban Architecture (1st ed.). Birkhauser.

1.2.6 Obstacles for integrating plants

A Green Roof is initially costly for its more demanding structural standards, water proofing system and long-term maintenance, but it is cost effective over the long run.

Green Walls often require maintenance. The excessive growth or dead wood may cause some problems of overloading so it needs to be trimmed down regularly.

Biofilters may generate some noise by the water circulation pump (which water the plants on its surface), 12 hours of natural or artificial light is preferred, and it requires regular maintenance and pest control.

Indoor Planting needs regular care for watering, pests and fertilization.[53]

1.3. Conclusions

For fire and medical emergencies, the basis for the placement of fire stations should be the amount of time that it takes to deliver adequate emergency resources to the point of demand from each fire station.
Indicators of fire stations influence the spatial requirements through the planning and design process.
The response time of each station is depended to its area of action, Response time targets are differentiated according to the character of coverage area.

Through an integrated design approach, which considers building location and orientation, site preparation, energy and water efficiency, material selection, and indoor environmental quality, green buildings will be part of building healthy, ecological communities for our future
Modern architecture and urban design is progressively exploring the integration of green spaces in buildings, producing new typologies that include public spaces, sky bridges, vertical parks, roof gardens and other 'green' components.
To analyze the benefits of integrating plants into the building design, for helping to reduce the energy use, and enhance living quality for the go-green.

[53] Afrin, S. (2009, September). Green Skyscraper: Integration of Plants into Skyscrapers (Master's Thesis). KTH Royal Institute of Technology. https://www.diva-portal.org/smash/get/diva2:353678/fulltext01#:~:text=The%20provisions%20of%20integrate%20plants,savings%20and%20indoor%20environmental%20qualities.

Chapter 2:

General Analytical Study of the Project

Introduction

Analysis is an essential step in the process of urban and architectural design. More than a simple reading of the site, the analysis makes it possible to clearly define the primary orientations of the project.

Case study is a process of research into a project and documenting through writing, sketches, diagrams and photos. Case studies are important to understand the various aspects that must be considered and to learn from other peoples mistakes.

Thereafter, we will highlight the ideas, the principles used in fire station and the deferent ways of integrating greenery and know there relationship with the fire prevention, we analyze four different projects.

2.1 Case studies

2.1.1 Case Study 01: Waterford Fire Station

2.1.1.1 The selection criteria:

The importance of this project in its urban fabric and architectural "A Pole Of Attraction"

Form is folded around - Origami-Like - where function is paramount

Figure 40: Aerial view, Waterford fire station
Source: www.archdaily.com

2.1.1.2 Introduction to Project

Table 9: Technical sheet, Waterford fire station
Source: www.archdaily.com

Location	WATERFORD, IRELAND
Architects	Mccullough Mulvin Architects
Area	3500 m²
Year	2015
Manufacturers	VM

- The new Waterford fire station will become the regional center for firefighting, river rescue, public consultation and training for the whole of the south east of Ireland; it provides a 24-hour response unit for the region.

2.1.1.3 Site Analysis

The site sits within a predominantly residential area consisting of medium density, **Single-Family houses**.

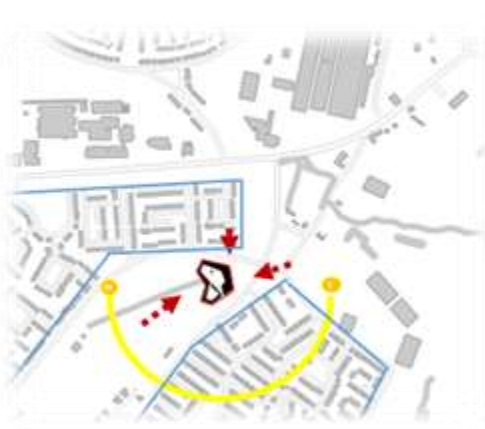


Figure 41: Site Analysis – Environment
Source: www.archdaily.com with the author's interpretation

Figure 42: Site Analysis - Accessibility
Source: www.archdaily.com with the author's interpretation

2.1.1.4 Concept and Design Strategy

The building form is derived from the tracking movements of the fire tenders leaving their appliance bays.

The Station has been thought of like a large house

Shaped around the active service it delivers where function is paramount[54]

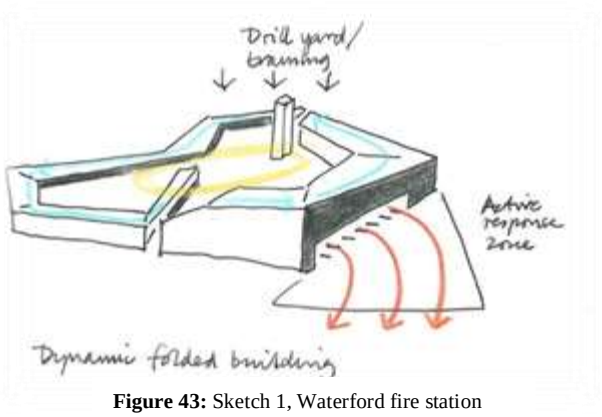


Figure 43: Sketch 1, Waterford fire station
Source: www.archdaily.com

2.1.1.5 Massing Design

- The building is three storeys high on eastern and part southern elevation sloping to two storeys high along the northeastern boundary, and sloping to single storey high along western boundary and part of the southern boundary.
- A strong but simple enclosing form wrapped in zinc is folded around - **origami-like** - to enclose a large drill yard
- The **drill tower** acts like an **urban beacon** in a new public space[55]

Figure 44: Aerial View, Waterford station
Source: www.archdaily.com

2.1.1.6 Structure

- A **Structural Steel** was selected, supported on an in situ concrete slab on **strip foundations.**
- Intermediate floors were also in situ slabs on **steel beams**[56]

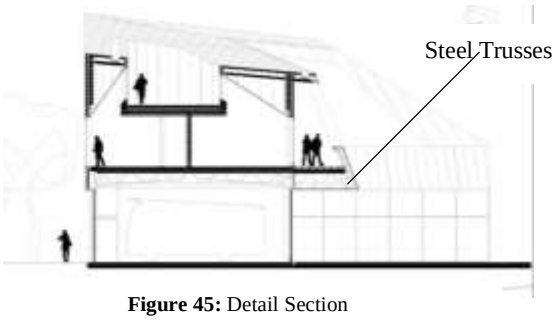


Figure 45: Detail Section
Source : www.archdaily.com

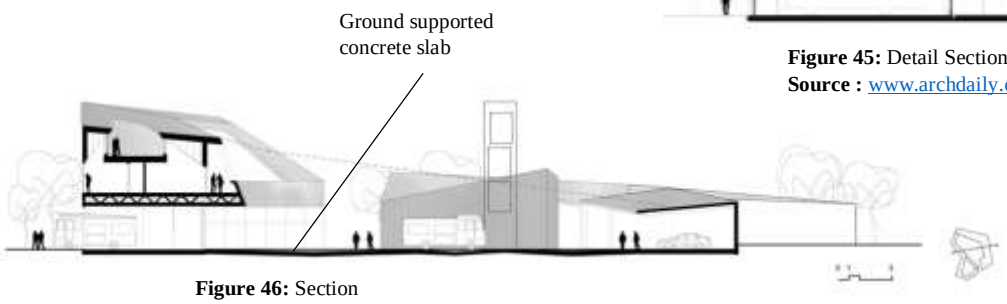


Figure 46: Section
Source: www.archdaily.com

2.1.1.7 Materials and Construction

- The main public elevations are composed of significant areas of **curtain wall** glazing, interspersed with plastered and painted blockwork

[54] [3] [4] McCullough Mulvin Architects Ltd. (2016, March 30). Waterford Fire Station. . https://www.theplan.it/eng/award-2016-education/waterford-fire-station-1

- The main material of the external envelope is **zinc sheeting** on a timber substrate of plywood sheeting.[57]

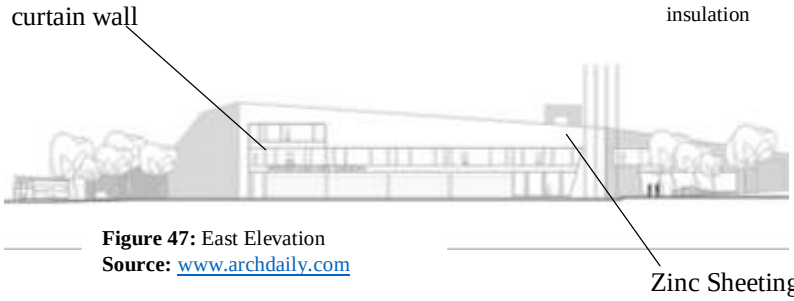


Figure 47: East Elevation
Source: www.archdaily.com

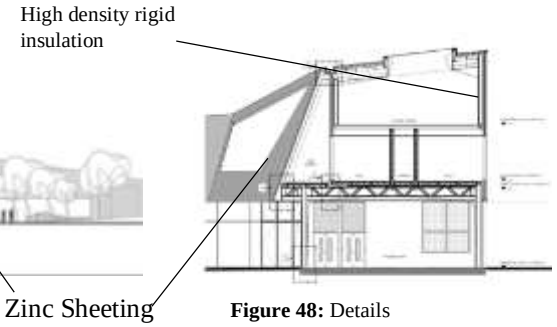


Figure 48: Details
Source: www.archdaily.com

2.1.1.8 Organization Spatial

The building house 10 fire appliance bays, watch room, muster bays, training rooms, dormitories, offices, canteen, and recreational rooms, lecture theatre, drill tower, external training areas, underground pipe for confined space training.

The building encloses staff car parking and Civil Defence vehicle spaces with visitor car parking spaces on Ballybeg drive and Kilbarry road.[58]

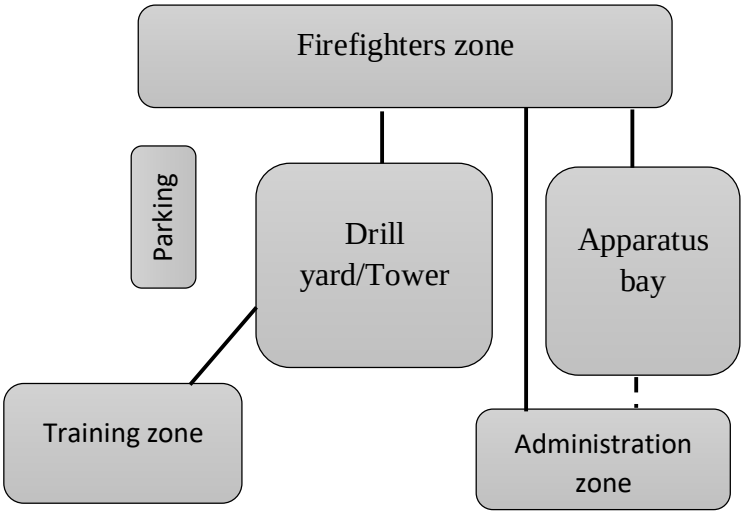


Figure 49: schema represent the organization of the project
Source: Author

2.1.1.9 Zoning

Organised in a sort of spiral, rising from single storey vehicle parking, workshops and dormitories

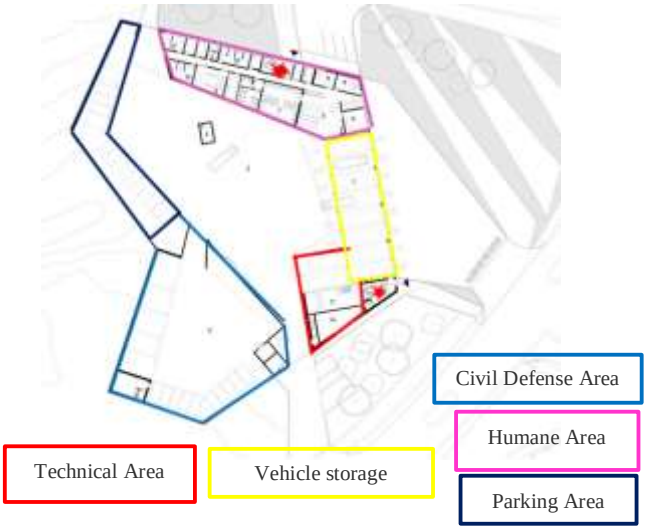


Figure 50: first floor spatial flowchart
Source: www.archdaily.com with the author's interpretation

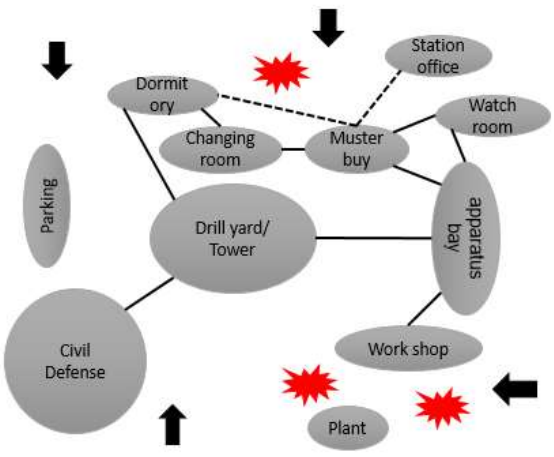


Figure 51: Schema first floor
Source: Author

[57] [6]Cardenas, D. (2019, October 24). Waterford Fire Station / Mccullough Mulvin Architects. ArchDaily. https://www.archdaily.com/786984/waterford-fire-station-mccullough-mulvin-architects

-First floor

To a first floor of offices, canteen, leisure and study facilities

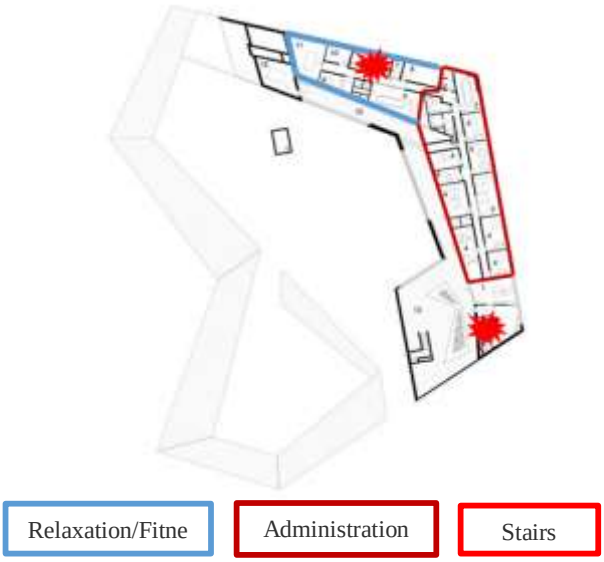


Figure 52: Second floor spatial flowchart
Source: www.archdaily.com with the author's interpretation

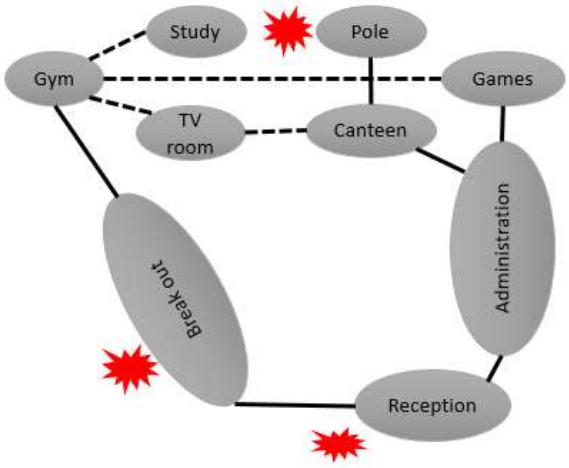


Figure 53: schema second floor
Source: Author

-Second floor

Terminating at a third floor lecture theatre.

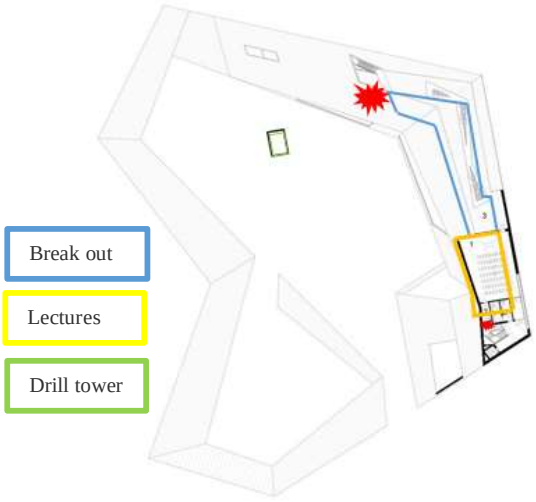


Figure 54: Third floor spatial flowchart
Source: www.archdaily.com with the author's interpretation

Program spatial

Table 10: Program spatial
Source: Author

Programm	**Area m²**	**Programm**	**Area m²**
Apparatus bay	487	Reception	37
Drill yard	1755	Conference	27
Civil Defense	12	Filing	31
Drill tower	1225	Office	157
Muster buy	129	Tea station	23
Watch room	27	Canteen	56
Changing room	80	Pole	7
Dirty Training	69	Games	24
Station Office	38	TV room	21
Dormitory	104	Study	15
Workshop	65	Gym	48
Public entrance	32	Lectures	105
Firefighters entrance	26	Break out	422+223
Plant	47+35	Parking	482
Total			**5809**

The zinc roof is angled and cut away to provide a series of sheltered inside-outside spaces overlooking the yard[59]

[59] Waterford City Fire Station – Duggan Brothers Ltd. (1 C.E.). . https://dugganbrothers.ie/project/waterford-city-fire-station/

2.1.1.10 Interior views

Figure 55: Vehicle Storage Area
Source: www.archdaily.com

Figure 56: Training Yard
Source: www.archdaily.com

Figure 57: Equipment Area
Source: www.archdaily.com

2.1.1.11 Sustainability & Energy

From the outset, the design team used the "Lean, Clean and Green" approach to the design of Waterford Fire Station;[60]

Lean Design:

- This reduces the building's requirement for energy to make the building as Lean as possible.
- The idea is to reduce the buildings requirement for heat, mechanical ventilation, water and power.
- The building is predominantly naturally ventilated except for the lecture theatre.
- Insulation levels greatly exceed compliance levels.

Clean:

- At this stage, we looked at ways to maximize the use of natural resources on site and maximize the efficiency of equipment and technologies proposed for the site.

Green:

- Concrete with fly ash aggregate (Ecocem) has been utilised throughout all concrete structures.
- Space has been allocated for future renewables, rainwater harvesting and a wood pellet boiler.

2.1.1.12 Conclusion

- Waterford fire station introduces a new group of process-driven buildings that make dramatic forms in the landscape from constructed volumes with large-scale industrial character spaces.
- Space has been allocated for future renewables, rainwater harvesting and a wood pellet boiler.
- The station has been thought of like a large house, with people coming and going at different hours, some sleeping, some wakeful
- It creates its own artificial landscape, a new geography of enclosure.

[60] McCullough Mulvin Architects Ltd. (2016, March 30). Waterford Fire Station. . https://www.theplan.it/eng/award-2016-education/waterford-fire-station-1

2.1.2 Case Study 02: Fire Station of Tianfu New District

2.1.2.1 Introduction to Project

Table 11: Technical sheet, Tianfu New District, fire station.
Source: www.archdaily.com

Location	Chengdu Shi, China
Architects	China Southwest Architectural Design and Research Institute
Area	8620 m²
Year	2016

Figure 58: side view, Fire Station of Tianfu New District
Source: www.archdaily.com

2.1.2.2 Site Analysis

The site sits within a predominantly residential area consisting of high density, **Single-Family houses**.

Tianfu new district is a new urban area As the first fire station in Tianfu new district, it integrates office, fire control, rescue, training

Therefore the new design adopted centralized layout[61]

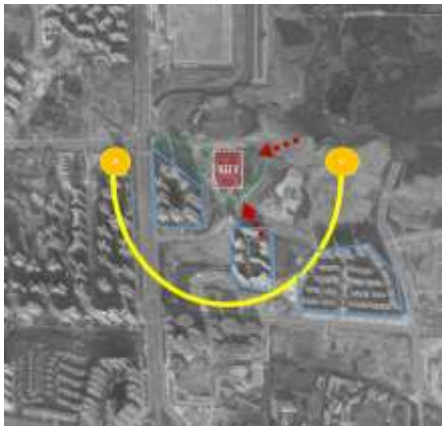


Figure 59: Site Analysis – Environment
Source: www.archdaily.com with the author's interpretation

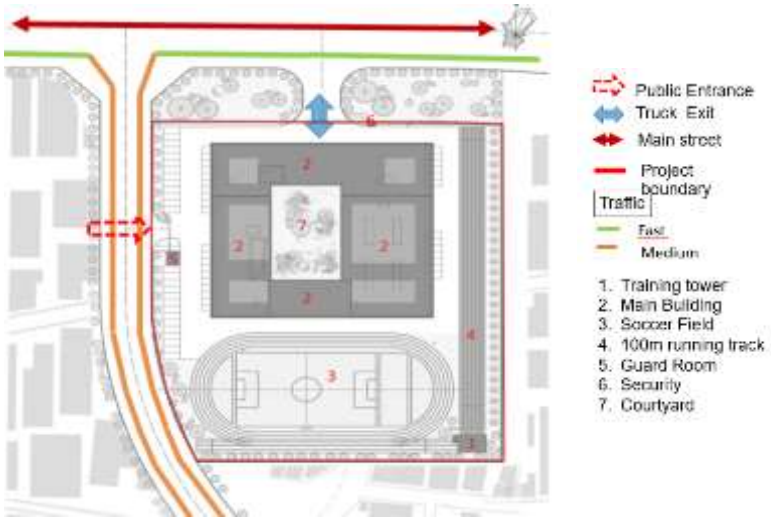


Figure 60: Site Analysis - Accessibility
Source: www.archdaily.com with the author's interpretation

2.1.2.3 Concept and Design Strategy

The new design adopted centralized layout,

The function becomes compact and efficient, and creates sufficient training ground.

The main building is arranged in "U" shape, introducing the sunlight and natural air into the green environment.[62]

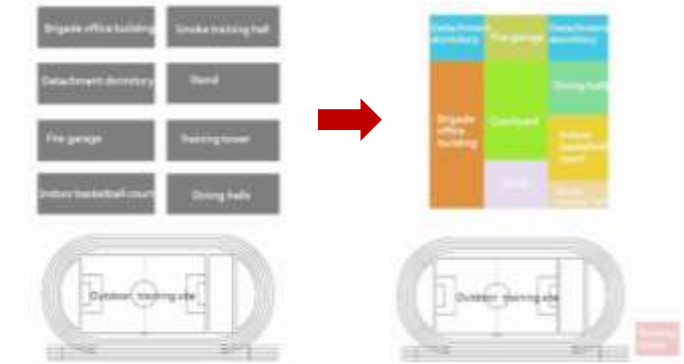


Figure 61: Diagram, represent the development of the design idea
Source: www.archdaily.com

[61] [9] Hernández, D. (2019, October 24). Fire Station of Tianfu New District / CSWADI. ArchDaily. https://www.archdaily.com/879439/fire-station-of-tianfu-new-district-cswadi

2.1.2.4 Massing Design

The overhead layer is inserted by four red square boxes,

The entire ground floor is elevated.

Upper massing has large-scale overhangs that produce tension for the massing.[63]

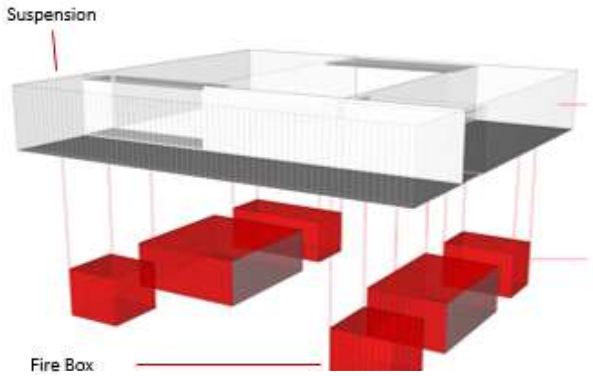


Figure 62: Diagram, represent the massing design.
Source: www.archdaily.com

2.1.2.5 Structure

The building consists of a hybrid supporting structure with a central staircase.

Concrete in The ground floor with garage due to its functionality.[64]

Figure 63: Section.
Source: www.archdaily.com

2.1.2.6 Facade design

Facade design breakthrough stereotyped conservative army's building, and adopted concise and modern style

The upper cantilevered massing fitted with long wing-shaped shadings,

Unify different internal function under a complete skin texture, highlighting army's culture of uniformity.[65]

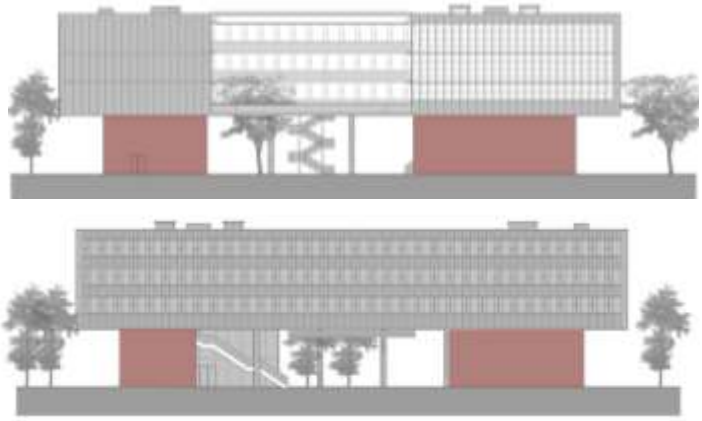


Figure 64: North Elevation.
Source: www.archdaily.com

2.1.2.7 Public Interaction

The fire station values public education, and by creating an independent touring circulation, the flow of visitors does not interfere with the fire department's daily operation:

1. The publics visit the fire fighting vehicles under the overhead space.
2. Go through the outdoor stairway to visit the gallery on the second floor.
3. Access to the multi-purpose training hall for firefighting training.
4. Arrived in the south edge-viewing platform on the second floor, the platform is in front of the training ground, easy for army review and public viewing.

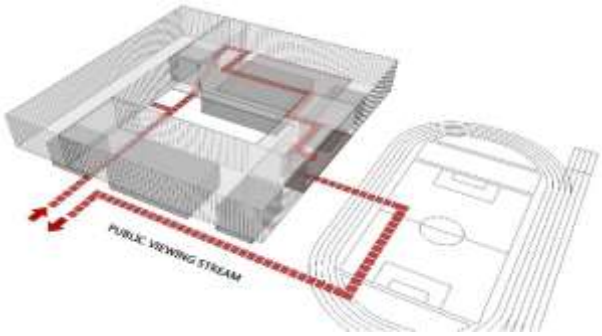


Figure 65: Diagram, public viewing stream.
Source: www.archdaily.com

63 11 12 Hernández, D. (2019, October 24). Fire Station of Tianfu New District / CSWADI. ArchDaily. https://www.archdaily.com/879439/fire-station-of-tianfu-new-district-cswadi

5. The steel stair in the central round opening can lead visitors to the training ground, completes the independent touring circulation. This convenient strategy for public will become a function highlight for the next generation of fire station.[66]

2.1.2.8 Organization Spatial

Design adopted centralized layout, making different function such as office building, dormitory, dining halls, multi-purpose training facility, and the public visitation gallery into an integrated **arrangement** as well as creating a circular layout.[67]

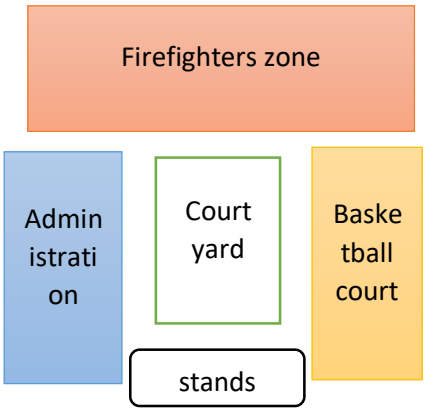


Figure 66: Schema represent the organization of the project
Source: Author 2022

2.1.2.9 Zoning

Four red square boxes, accommodates the functions of the Battalion foyer, Detachment foyer, cafeteria and the smoke & heat training hall, forming the concept of "fire box".

Two delicate outdoor steel stairs are interspersed between the overhead spaces, creating a focal point on the outdoor circulation.[68]

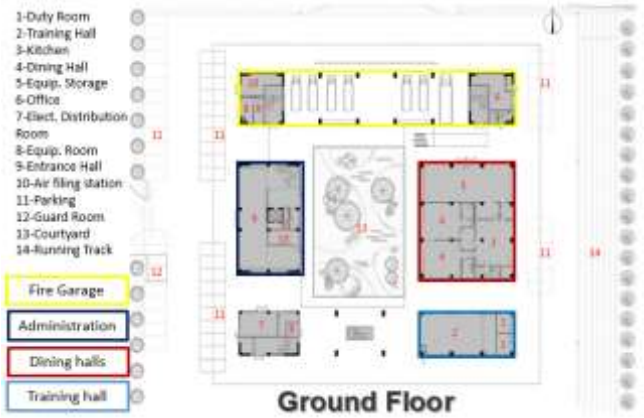


Figure 67: Diagram, ground floor
Source: www.archdaily.com with the author's interpretation

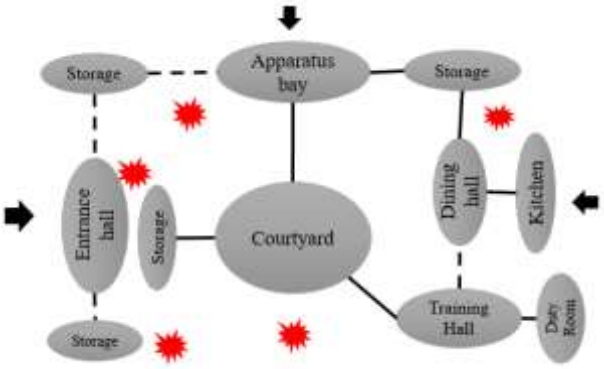


Figure 68: Diagram, Relation Spatial ground floor
Source: Author 2022

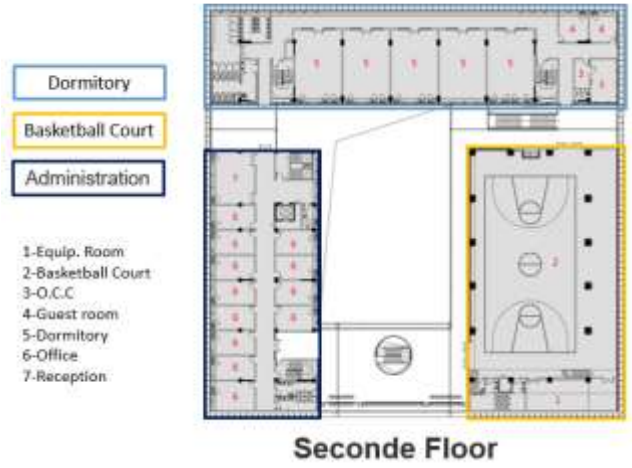


Figure 69: Diagram, Second floor
Source: www.archdaily.com with the author's interpretation

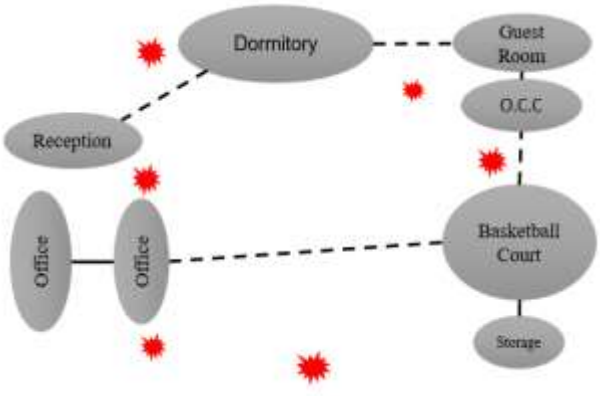


Figure 70: Diagram, Relation Spatial second floor
Source: Author 2022

66 14 15 Hernández, D. (2019, October 24). Fire Station of Tianfu New District / CSWADI. ArchDaily. https://www.archdaily.com/879439/fire-station-of-tianfu-new-district-cswadi

Figure 71: Diagram, third floor
Source: www.archdailv.com with the author's interpretation

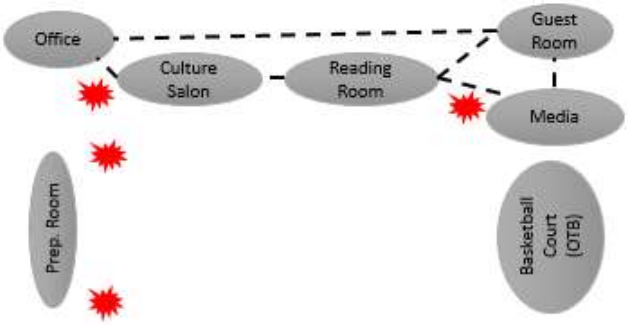


Figure 72: Diagram, Relation Spatial third floor
Source: Author 2022

Figure 73: Diagram, four floor
Source: www.archdaily.com with the author's interpretation

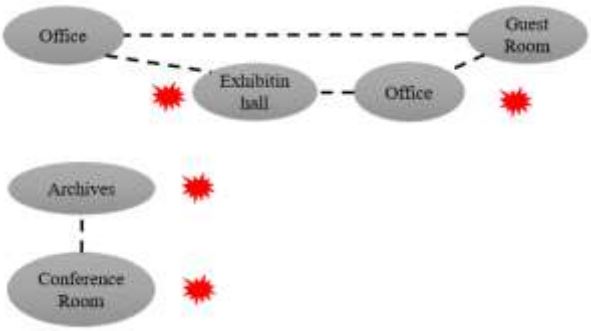


Figure 74: Diagram, Relation Spatial fourth floor
Source: Author 2022

2.1.2.10 Program spatial

Table 12: Program spatial
Source: Author 2022

Programme	Area m²	Programme	Area m²	Programme	Area m²
apparatus bay	505	Guard Room	26	Rest Platforme	175
Duty Room	34	Courtyard	700	Media Room	164
Smoke Training Hall	162	Machine Equipment	52	Detachment Media	27
Kitchen	116	Basketball Court	1084	Prep. Room	459
Dining hall	440	Communication room	62	Reading Room	187
Training Equipment Storage	60	Guest Room	117	Cultur Salon	282
Electricity Distribution Room	48	Dormitory	556	Exhibition Hall	214
Equipment Room	65	Office	604	Locker Room	161
Entrance Hall	144	Reception	70	Laundry Room	33
Air Filling Station	65	Shower	52	Conference Room	302
45*Parking	743	Bathrooms	236	Archives	68
Total					**8013**

2.1.2.11 Interior views

Figure 75: Basketball Court
Source: www.archdaily.com

Figure 76: Fire Truck Parking Space
Source: www.archdaily.com

Figure 77: Stands
Source: www.archdaily.com

2.1.2.12 Sustainable Design

- The station is an environmental friendly demonstrative project for the army.
- Courtyard greenery is a tradition for army dormitory.
- The main building is arranged in "U" shape, introducing the sunlight and natural air into the green environment.
- The building uses technical strategies such as
- ground level elevated ventilation,
- rain water recycle,
- training hall celling level side-window ventilation,
- green roof,
- vertical façade sun shades,
- permeable concrete paving to improve the architectural micro climate.[69]

Figure 78: Courtyard
Source: www.archdaily.com

Figure 79: View On Courtyard
Source: www.archdaily.com

2.1.2.13 Conclusion

The fire station in Tianfu new district, it integrates office, fire control, rescue, training and publicity. It will become a high standard fire station for the future.

The original station has limited building volume, scattered construction covered too much area, make it difficult to form an overall strong image. Therefore the new design adopted centralized layout

Facade design breakthrough stereotyped conservative army's building, and adopted concise and modern style.

The fire station values public education, and by creating an independent touring circulation

The station is an environmental friendly.

[69] Hernández, D. (2019, October 24). Fire Station of Tianfu New District / CSWADI. ArchDaily. https://www.archdaily.com/879439/fire-station-of-tianfu-new-district-cswadi

2.1.3 Case Study 03: Da-Yo Fire Station

2.1.3.1 Introduction to Project

K-Architect designed the Da-Yo Fire Station in Taoyuan City in Taiwan as an energy-efficient building topped with a **green roof**. The project blends the boundaries between architecture and landscape, and it consists of a **fire station** and a small public open space.[70]

Figure 80: Arial view, Da-Yo Fire Station
Source: www.archdaily.com

Table 13: Technical sheet, Da-Yo fire station.
Source: www.archdaily.com

Location	Taoyuan City, Taiwan
Architects	K-Architect
Area	2544 m²
Year	2013

2.1.3.2 Site Analysis

This project was located in an existing park. Due to the lack of public facilities land, many parks were planned to be multiuse for better efficiency by the increasing of population in Taiwan.

The original landscape of the site was mainly a 10-meter-high slope, with an existing temple in the north.[71]

Figure 81: Site Analysis – Environment
Source: earth.google.com with the author's interpretation

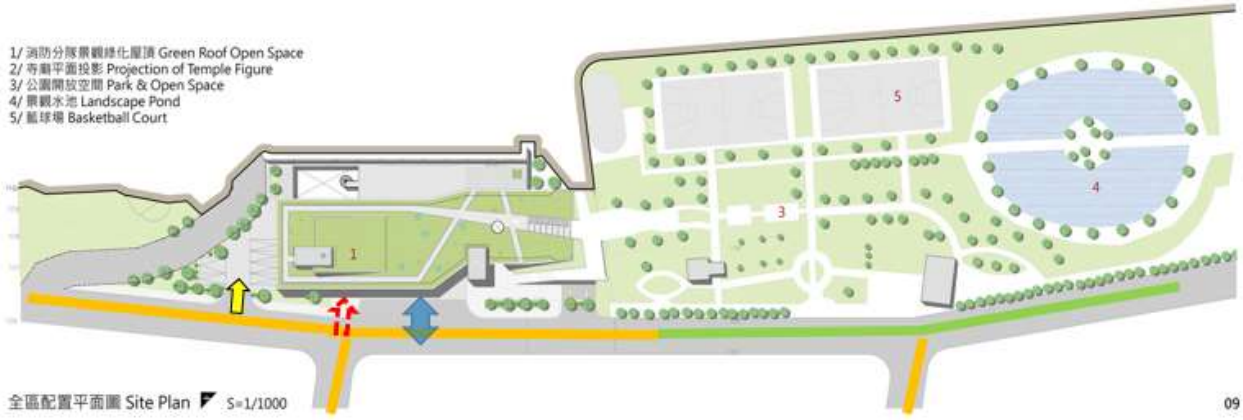


Figure 82: Site Analysis - Accessibility
Source: www.archdaily.com with the author's interpretation

[70] [17] Grozdanic, L. (2014, March 1). K-Architect Unveils Scorching Hot Green-Roofed Da-Yo Fire Station in Taiwan. Inhabitat - Green Design, Innovation, Architecture, Green Building | Green Design & Innovation for a Better World. https://inhabitat.com/k-architect-unveils-scorching-hot-green-roofed-da-yo-fire-station-in-taiwan/

2.1.3.3 Concept and Design Strategy

Tried to combine a friendly environment with a fire station

The main design issue was to coordinate both the existing slope and temple as a complete plan and at the same time keep a good front view for the temple[72]

Figure 83: Diagram, Buildings Components
Source: www.archdaily.com

2.1.3.4 Massing Design

According to the regulations, the building height is only 7 meters

Made the fire station inevitably to be a long building with low height and a big roof.

The fire station divided into two volumes and connecting by the bridge,[73]

2.1.3.5 The Façades

After serious studies of different elevation strategies,[74]

- Concrete Sto tile
- Random openings create an interesting and intimate atmosphere for the fire station.,
- The sculpture, represented the concept of the fire fighters,

Figure 84: front view
Source: www.archdaily.com

Figure 85: front facade, left
Source: www.archdaily.com

Figure 86: front facade , right
Source: www.archdaily.com

[72] [19] [20] Valenzuela, K. (2021, October 15). Da-Yo Fire Station / K-Architect. ArchDaily. https://www.archdaily.com/477531/da-yo-fire-station-k-architect

2.1.3.6 Organization Spatial

-Ground Floor

Figure 87: Diagram ground floor
Source: www.archdaily.com

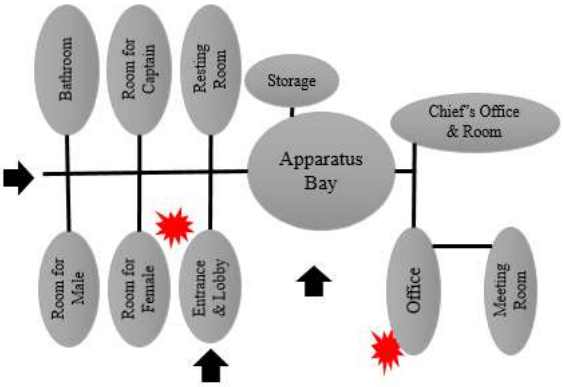


Figure 88: Diagram, Relation Spatial grond floor
Source: Author

-First Floor

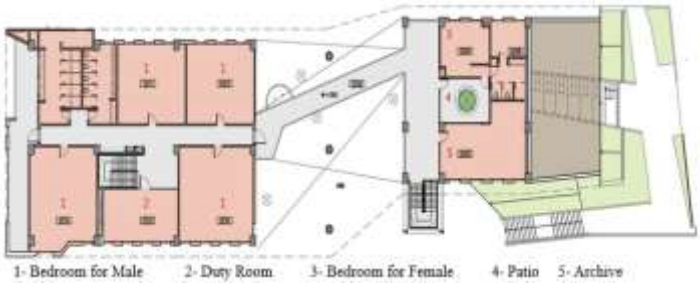


Figure 89: Diagram, first floor
Source: www.archdaily.com

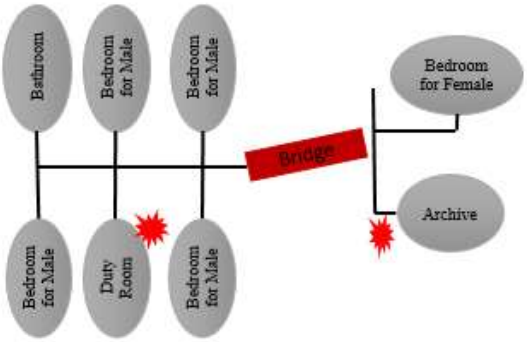


Figure 90: Diagram, Relation Spatial first floor
Source: Author

2.1.3.7 Interior views

Figure 91: Sliding Pole To Save The Time
Source: www.archdaily.com

Figure 92: Parking Area And bridge
Source: www.archdaily.com

Figure 93: Entrance & Lobby
Source: www.archdaily.com

2.1.3.8 Program

Table 14: Program spatial
Source: Author

Program	Area m²				
Room for Captain	45	Entrance & Lobby	70	Mechanical	47
Resting Room	43	apparatus bay	416	Bathrooms	103
Storage	52	Chief's Office & Room	61	Bedroom for Male	239
Room for Male	47	Office	38	Duty Room	40
Room for Female	39	Meeting Room	28	Bedroom for Female	59
Total					**1656**

2.1.3.9 Sustainable Design (greenery)

The thin Green Roof can lighten the loading of the roof and the water reservoir plate works as the inter-layer between substrate and roof deck to prevent typical water problem of green roof.

Make the big roof green as a friendly public open space for the citizens, which connects to the existing park and achieves the goal of a green-sustainable-architecture.

Trying to create an quiet and Green courtyard, offers good natural light and ventilation for working space.[75]

Figure 94: Da-Yo Fire Station 3D Rendering
Source: www.archdaily.com

Figure 95: Green Court-Yard
Source: www.archdaily.com

Figure 96: View On Green Roof
Source: www.archdaily.com

[75] Grozdanic, L. (2014, March 1). K-Architect Unveils Scorching Hot Green-Roofed Da-Yo Fire Station in Taiwan. Inhabitat - Green Design, Innovation, Architecture, Green Building | Green Design & Innovation for a Better World. https://inhabitat.com/k-architect-unveils-scorching-hot-green-roofed-da-yo-fire-station-in-taiwan/

2.1.3.10 Conclusion

The architects decided to elevate part of the greenery and nestle the building underneath, In order to maintain its natural environment without excluding the possibility of building the fire station.

- The semi-outdoor space allows for a fast reaction to emergencies and easy coordination of vehicles
- The landscaped roof keeps the field of view from the adjacent temple on the north side of the site.
- Follows the modern architectural style and also the concept of greenery which is used in the roof (big green roof), court-yard (green courtyard), trying to extend the greenery of the area, which connects to the existing park and achieves the goal of a green-sustainable Architecture.

2.1.4. Case Study 04: The main civil defense unit of Biskra

2.1.4.1 Introduction to Project

The new main unit of civil defense will become the regional centre for firefighting, public consultation and training.[76]

Table 15: Technical sheet, main unit of civil protection
Source: Directorate of civil defense

Location	Biskra, Algeria
Architects	M.Mokeddem
Area	35,134 m²
Year	2020

Figure 97: front view, main unit civil defense biskra
Source: Author 2022

The unit is responsible for:

- Defend area of intervention
- Carry out specialized operations on the territory of the wilaya
- Ensure operational coordination between the civil defense units of the wilaya

2.1.4.2 Site Analysis

The unit is located in the northwest of the city of Biskra on National Road No. 3 towards Batna

The site sits within a predominantly residential area consisting of medium density, Multi-Family housing.

Figure 98: Site Analysis – Environment
Source: Earth.google.com with the author's interpretation

[76] Directorate of Civil Protection

Figure 99: Site Analysis - Accessibility
Source: Earth.google.com with the author's interpretation

2.1.4.3 Massing Design

The unit consists of several separate cubes distributed on the site in relation to the various functions of administration, gymnasium, dining hall, dormitory and different storage

Integration through the resemblance of the volumetric with the environment of the shape and height

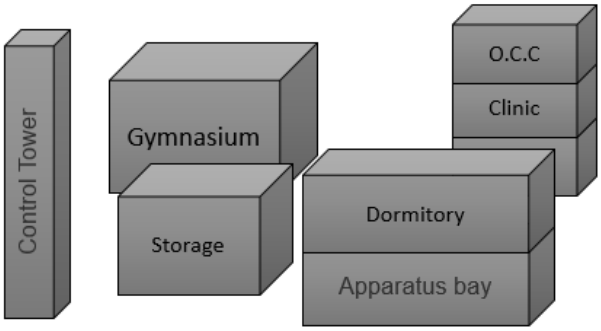


Figure 100: Diagram, massing design
Source: Author

2.1.4.4 Structure

Concrete structure was selected

A **Structural Steel** was selected in the Gymnasium for wide span

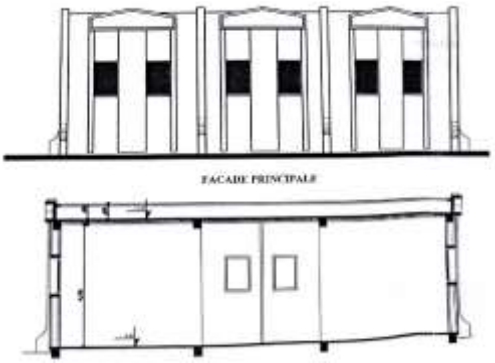


Figure 101: Façade And Section Of Workshops Bloc
Source: civil defense Directorate Biskra

2.1.4.5 Building Materials

The main materials used are:

- Reinforced concrete for structure
- The concrete and the hinge for the texture
- Glass to create openings
- Metal for the protection of the openings

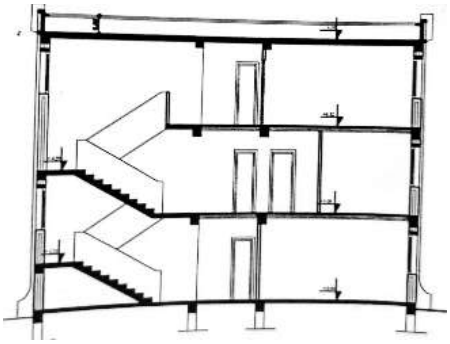


Figure 102: Section Of OCC Bloc
Source: civil defense Directorate Biskra

2.1.4.6 Organization Spatial

The unit adopted 14 fire trucks garages, administration bloc, OCC bloc, workshops, dormitories, gymnasium, control tower, and dining area, water tank, house for chief, external training areas.[77]

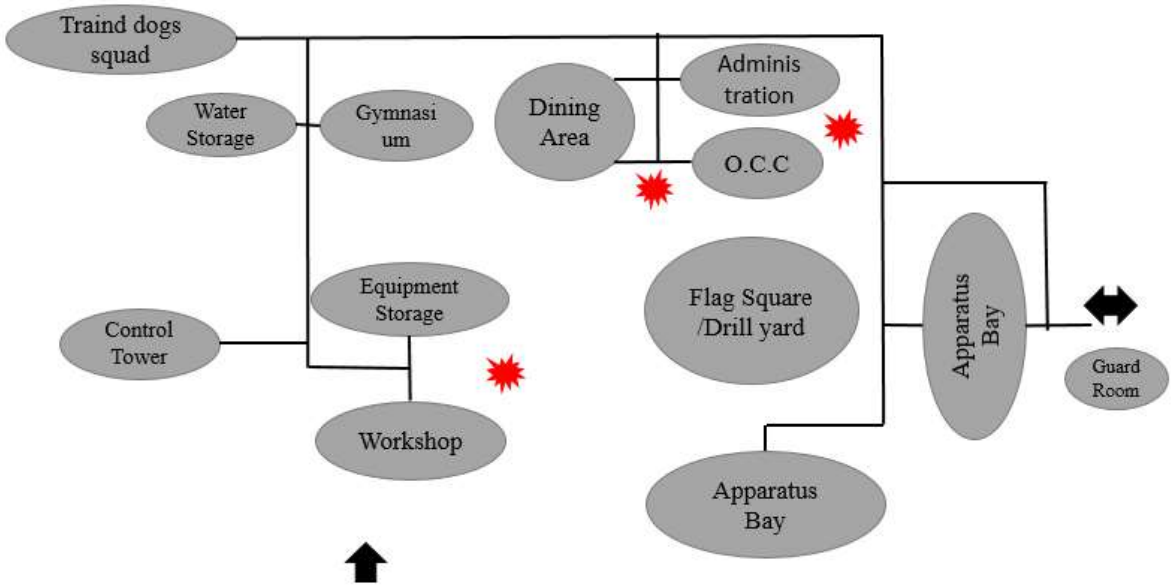


Figure 103: Diagram, organization spatial of the project
Source: Author 2022

2.1.4.7 Zoning

-Administration

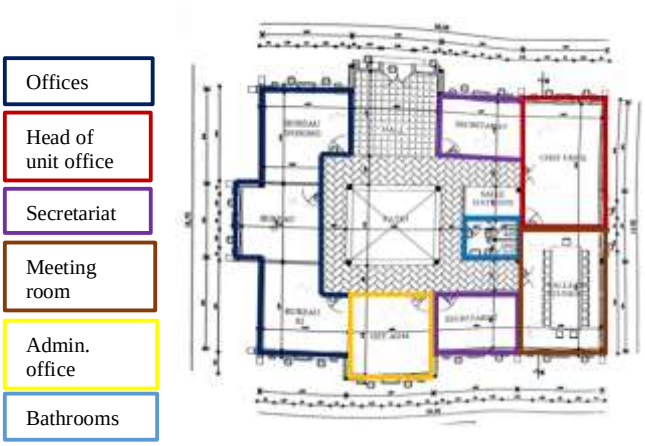


Figure 104: zoning administration, ground floor
Source: civil defense Directorate Biskra

-Mechanical Workshops

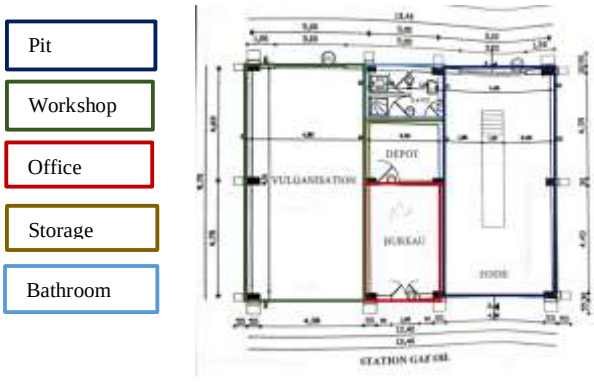


Figure 105: zoning mechanical workshops
Source: civil defense Directorate Biskra

[77] Administration and Logistics Department, Civil Protection Directorate Biskra

-Operational Coordination Center

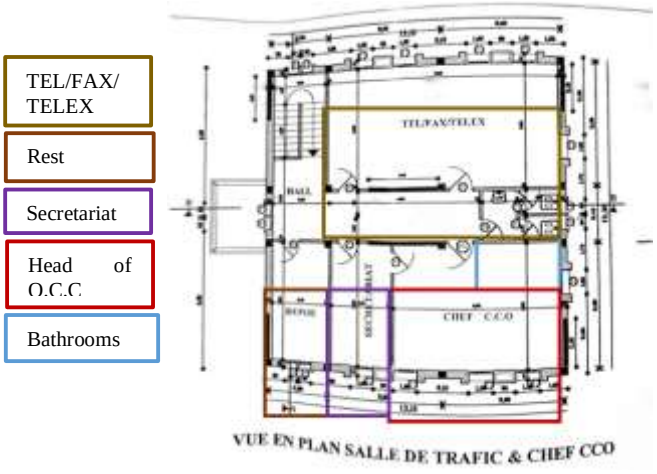


Figure 106: Zoning OCC, ground floor
Source: civil defense Directorate, Biskra

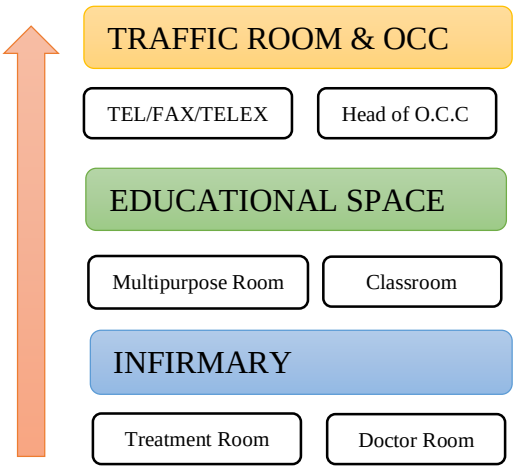


Figure 107: Diagram, organization spatial, OCC
Source: civil defense Directorate,Biskra

-Dormitory/Apparatus bay

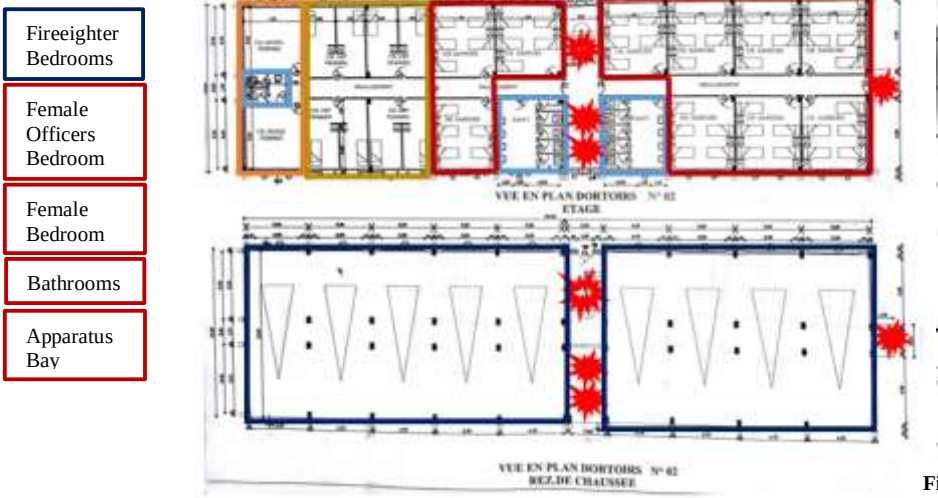


Figure 108: Zoning Apparatus bays, ground floor/first floor
Source: civil defense Directorate, Biskra

- Control Tower

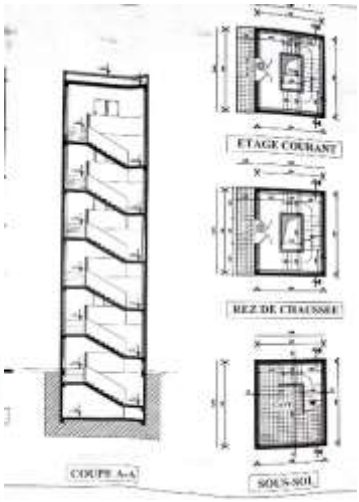


Figure 109: training tower,
Source: civil defense Directorate, Biskra

2.1.4.8 Program Spatial

Table 16: Program spatial
Source: Author

Programm	Area m²	Programm	Area m²
Apparatus bay	957	Workshop	260
Control tower	25	Administration	265
Drill yard	1995	O.C.C	174
Equipment Storage	483	Clinic	174
Kitchen	87	Lectures	174
Storage	77	Sports hall	370
Dining hall	227	Trained dogs squad	180
Dormitory	645	Parking	377
Total			6738

2.1.4.9 Indoor/Outdoor Views

Figure 110: O.C.C
Source: Author, 2022

Figure 111: Apparatus bay/Equipment Storage

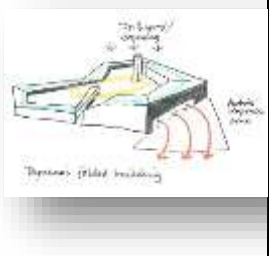
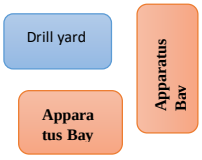
Figure 112: General Storage
Source: Author, 2022

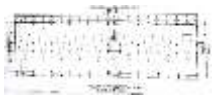
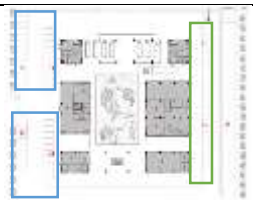
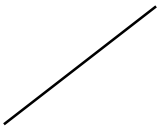
Figure 113: Slide Pole
Source: Author, 2022

II.1.5. Comparison Between case studies

Table 17: Presents the comparison between the four fire stations

Source: Author 2022

Project	Waterford Fire Station 	Fire Station of Tianfu New District 	Main civil defense unit of biskra 	Da-Yo Fire Station 
Concept	The building form is derived from the tracking movements of the fire tenders 	Design Adopted Centralized Layout 	Creates two separate volumes by a drill yard 	combine a friendly environment with a fire station 
Situation	In an inhospitable environment on the ring road around the city 	Tianfu new district is a new urban area 	Located in the northwest of the city of Biskra on National Road No. 3 	The landscape of the site was mainly a 10-meter-high slope 

Accessibility				
Apparatus Bay	Drive through Bays 	Parking Space For Fire Truck 	Vehicle garages 	Parking Area 
Massing Design	Form Wrapped In Zinc Is Folded Around - Origami-Like - To Enclose A Large Drill Yard 	U shaped for overhangs Four Red Square Boxes 	Several Separate Boxes Distributed 	Into Two Volumes And Connecting By The Bridge 
parking				
Sustainability	"Lean, Clean and Green"	Courtyard greenery, rain water recycle, green roof 		Green roof, Green open space, green court-yard. 
Common points	The Drive-through bays allows for a fast reaction to emergencies and easy coordination of vehicles			

II.1.6. General Conclusion

1. Establish a link between the projects and the external environment through a public space, drive through garages, gardens... most of the projects being located near a main road in residential and accessible to road networks.

2. Multiple entrances, various and ease of permeability to projects, we give importance to exits of the fire truck emphasizing one of the key points in the design: speed. and to the main entrance to facilitate access for visitors

3. Accessibility obtained by the presence of different means of transport and the development of public transport (pedestrians, bicycles and trains).
4. Integration of projects into the environment through construction materials, form, structure and the architectural envelope.
5. The fire stations introduces a new group of process-driven buildings that make dramatic forms in the landscape from constructed volumes with large-scale industrial character spaces.
6. The separation of the Three main areas: (reception administration area - humane area, training area
7. Diversity of circulation routes (free, vertical, horizontal...) in the projects and methods of project permeability
8. Diversity in spaces and function: meeting, gallery, public education and enriching the relationship between the fire station and the public.
9. The combination between the two types of natural and artificial lighting is made according to the nature of the spaces and the quality of the works of art.
10. Follows the modern architectural style and also the concept of greenery which is used in the roof (big green roof), court-yard (green courtyard), trying to extend the greenery of the area
11. The projects The projects focusing on sustainability through the integration of greenery.
12. The stations are an environmental friendly adopting green-tech that will include green roofs, courtyards, gardens and vertical gardens, rain water recycle, “Lean, Clean and Green” approach.
13. The projects implemented elements of LEED, WELL and SITES standards for passive design elements and high-quality lifestyle.

2.2 Criteria for choosing a site

2.2.1 Major Risks in Algeria

1. Earthquakes and geological hazards.
2. Floods.
3. Climate risks.
4. Forest fires.
5. Industrial and energy risks.
6. Radiological and nuclear risks.
7. Risks relating to human health.
8. Risks relating to animal and plant health.
9. Atmospheric, telluric, marine or water pollution.
10. Disasters due to large human gatherings.[25]

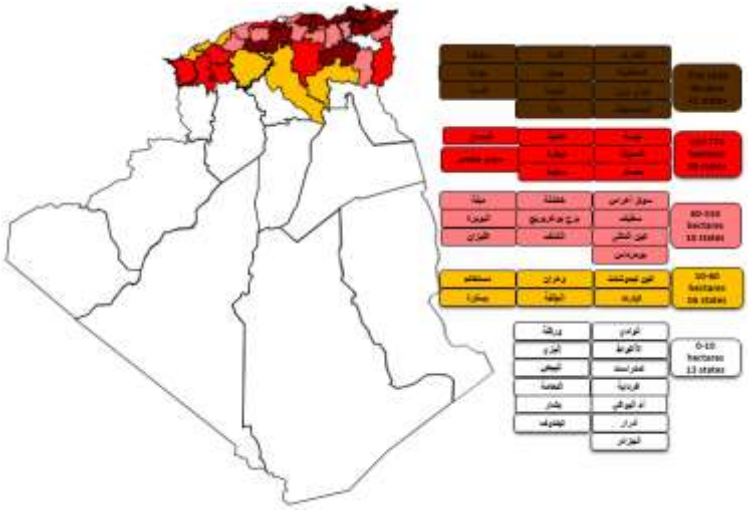


Figure 114: Map Of Areas Prone To Forest Fires
Source: سبتي, بن شعبان . (2013, May).

2.2.2 The State Of Batna

Why chose the state of Batna for its need for civil protection services,

- Ranked among the highest areas prone to forest fires
- Ranked among the highest areas prone to floods
- Ranked among the highest areas prone to Industrial Hazards

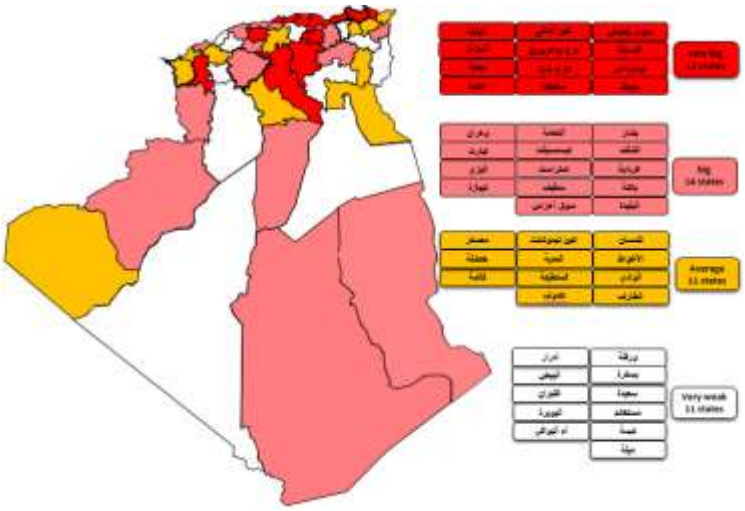


Figure 115: Floods Map
Source: سبتي, بن شعبان . (2013, May).

Figure 116: Flooding, Batna
Source: Civil Protection Directorate, Batna.

Figure 117: Forest fires.
Source: Civil Protection Directorate, Batna.

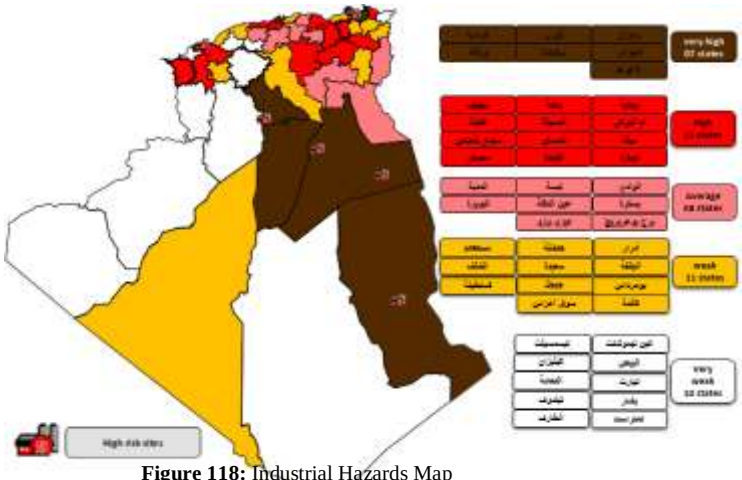


Figure 118: Industrial Hazards Map
Source: سبتي, بن شعبان . (2013, May).

[25] العقيد سبتي, بن شعبان. (2013, May). الأخطار الكبرى بالجزائر[Slides]. https://slideplayer.fr/slide/15016118/

Batna's Civil Defense

There are 19 units, including a main unit, 14 secondary units, 2 sector units, an advanced center and a road ambulance center.

The City of Tazoult

Why chose the city of Tazoult, because it is already nominated by the Directorate of Civil Protection of the state of Batna to establish a civil protection unit in the vicinity in the near future, and according to the statistics (by the DCPB) the most common hazards are:

- Traffic accidents, fires and floods.
- Close to fire-prone forests.

It is also in the proximity to the city of Batna, in order to reduce the response time in the region.

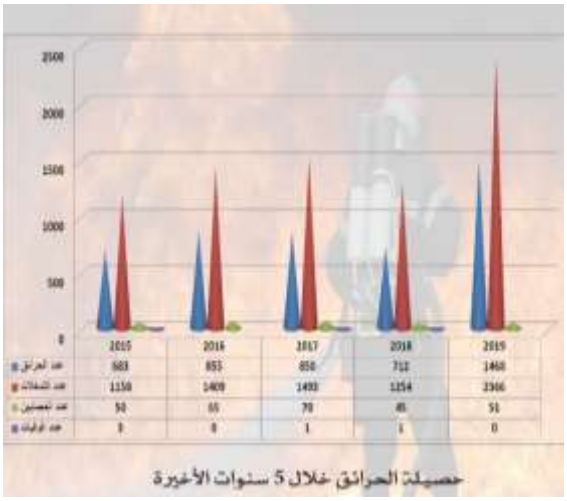


Figure 119: The number of fires in the last five years
Source: 1st Lt. Nekaa, Zohir, Information Office 2022

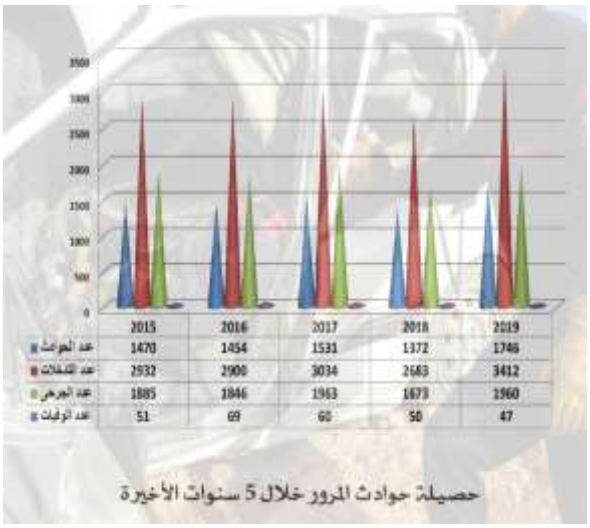


Figure 120: The number of traffic accidents in the last five years
Source: 1st Lt. Nekaa, Zohir, Information Office 2022

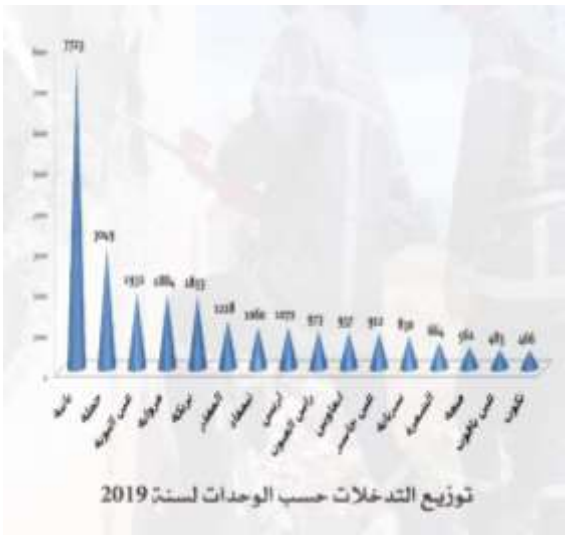


Figure 121: Distribution of interventions by units for the year 2019
Source: 1st Lt. Nekaa, Zohir, Information Office 2022 2022

Why chose the site

- The location is on the edge of the city near the intersection of roads, which allows reaching the accident as soon as possible.
- The site is in an agricultural area, allowing the project to be integrated into the area and the application of green space concepts.
- Its location is close to the main roads and public transportation, which makes it easier to reach from various points on the site.
- Connection to utilities (electricity, gas, drinking water, etc.) and service.

2.3 SITE ANALYSIS

2.3.1 Location

Tazoult is a Roman military city located in the north-east of Algeria, 10 km from the city of Batna, on National Road No. 31 between Batna and Khenchela.

Tazoult is considered one of the most important archaeological cities in Algeria in terms of its heritage stock[26]

Figure 122: Situation
Source: en.wikipedia.org

2.3.2 SITE DETAILS

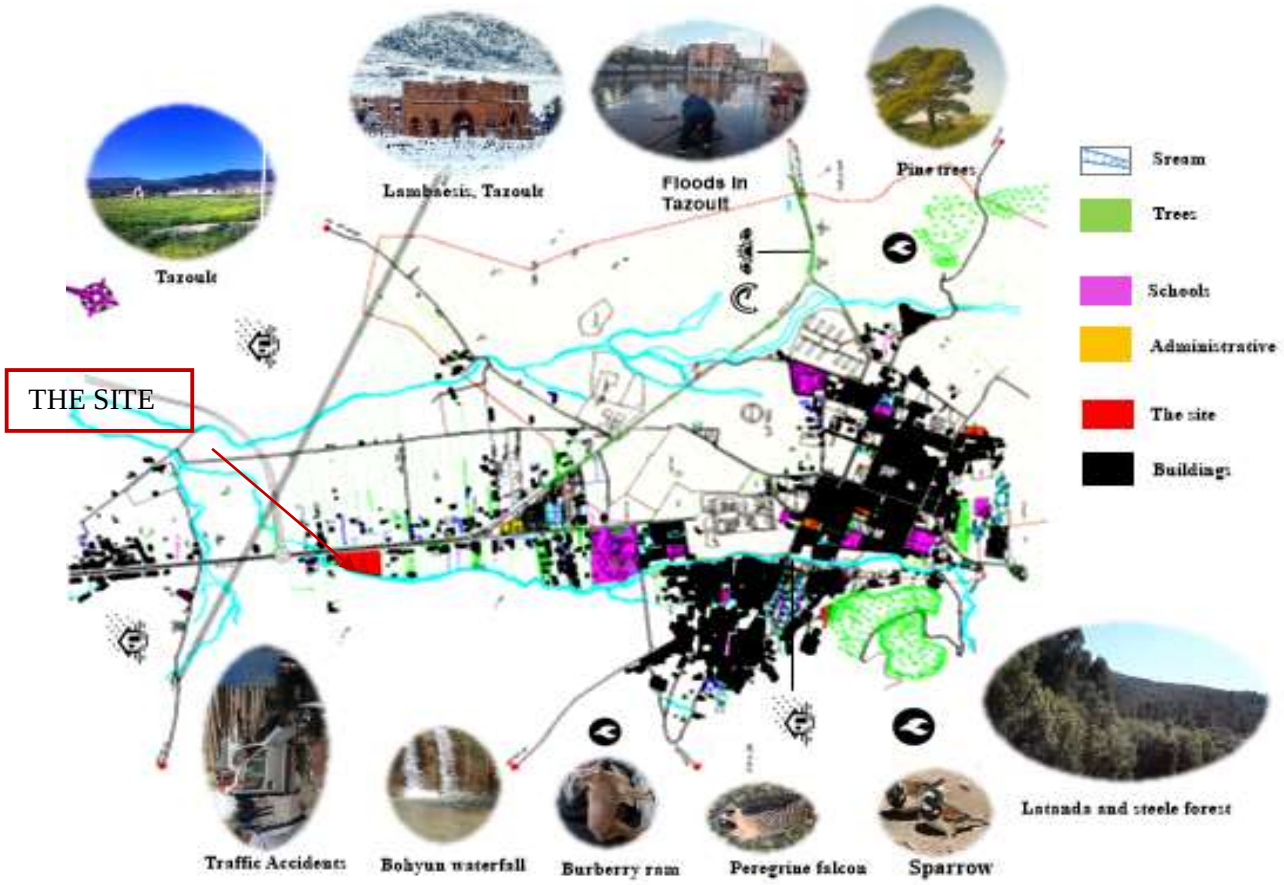


Figure 123: City of Tazoult, land use, street network, natural features
Source: Author

[26] Dahmani, M. (1 C.E.). PRESENTATION GEOGRAPHIQUE ET HISTORIQUE DE LA VILLE ANTIQUE DE TAZOULT (LAMBESE). . https://www.asjp.cerist.dz/en/downArticle/210/9/1/71383

2.3.2.1 Sun Path / Wind Direction

- The brighter period of the year lasts for 3.6 months, from May 1 to August 21, with an average daily incident shortwave energy per square meter above 6.9 kWh.
- The wind is most often from the south for 7.1 months, from April 21 to November 25.[27]

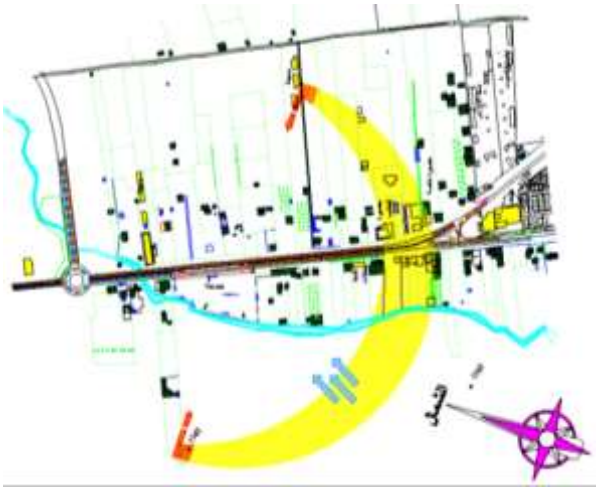


Figure 124: Diagram, sun path/ wind
Source: Author

2.3.2.2 Dimensions

- Area : 21396.6 m²
- With the longest side of 219.5 meters, in front of the National Road 31

2.3.2.3 Accessibility

- The site is accessible by vehicles from one road with nearby nodes
- Public transport nearst bus stop 700 m

2.3.2.4 Noise

- The site is subject to noise from the road(traffic)

Figure 125: Diagram, site Dimention/Accessbility
Source: Author

2.3.2.5 Typography

The site is flat and the soil is alluvial

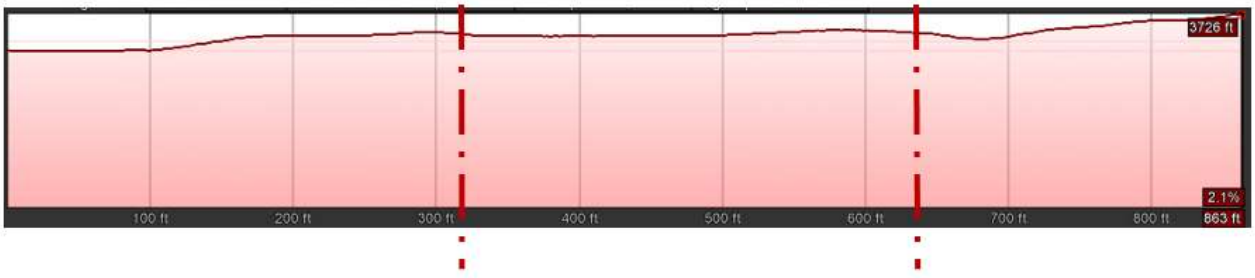


Figure 126: Site Typography.
Source: earth.google.com

[27] Tazoult-Lambese Climate, Weather By Month, Average Temperature (Algeria) - Weather Spark. (2022). https://weatherspark.com/y/53034/Average-Weather-in-Tazoult-Lambese-Algeria-Year-Round#Sections-Clouds

2.3.2.6 Views

Figure 127: View 1, from site front to the south.
Source: Author

Figure 128: View 2, from site front to the north.
Source: Author

Figure 129: View 3, from within site to the south.
Source: Author

Figure 130: View 4, from site front to the west.
Source: Author

Figure 131: View 5, from site front to road..
Source: Author

Figure 132: View 6, from the site front to the east.
Source: Author

2.3.3 Street Network

The site is well connected through roads, the red are the major roads with major traffic, green are the divergens from major road and have less traffic, main road have footpath on both sides

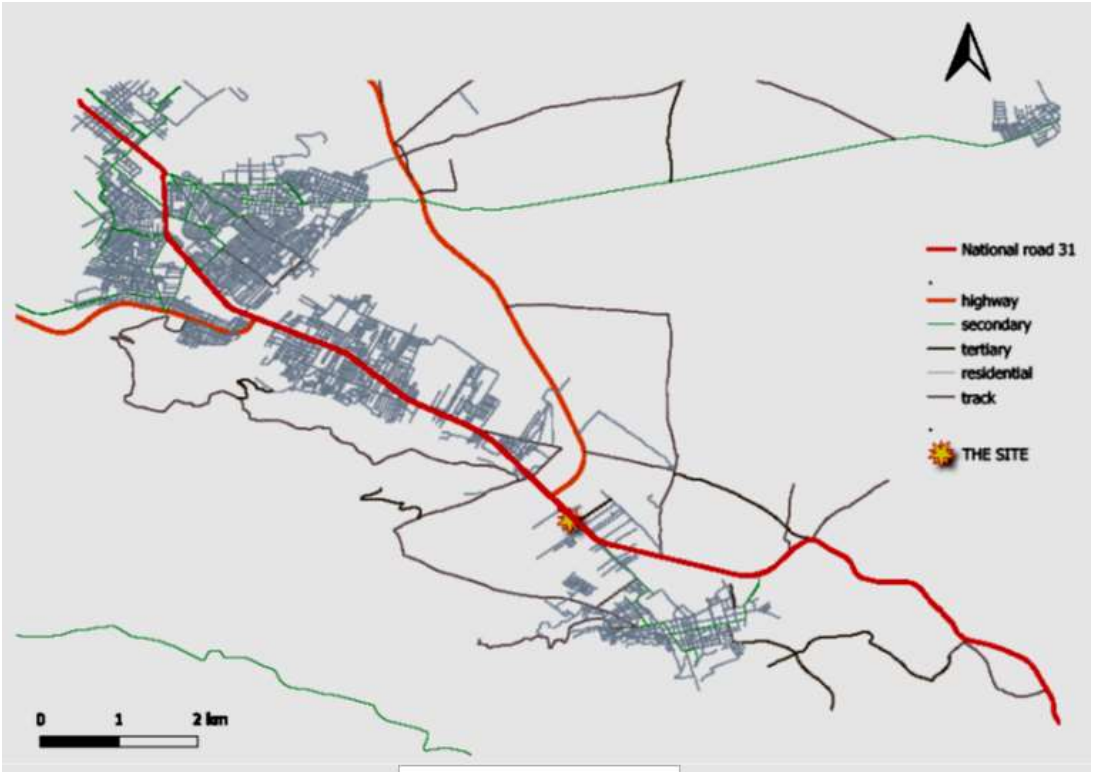


Figure 133: Street network map
Source: www.openstreetmap.org with the author's interpretation

2.3.4 Land Uses

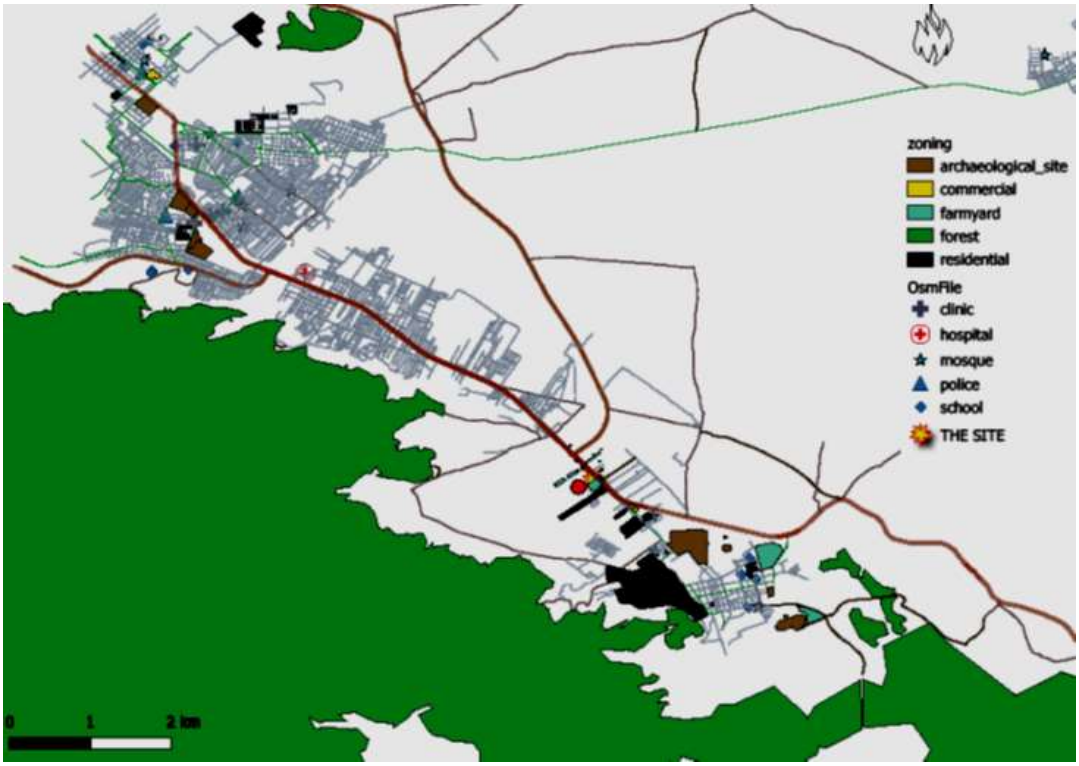


Figure 134: Land uses map
Source: www.openstreetmap.org with the author's interpretation

2.3.5 Response Time

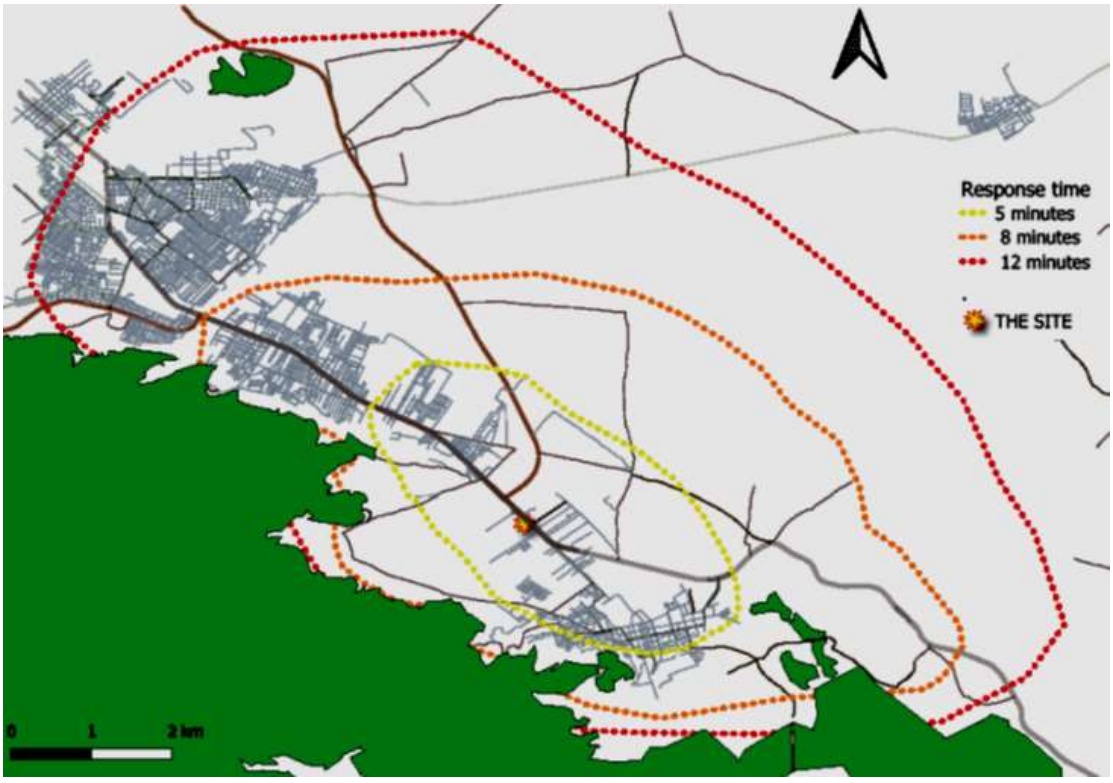


Figure 135: Map represent the response time
Source: www.openstreetmap.org with the author's interpretation

2.3.6 Climate

In Tazoult-Lambese, the summers are short, hot, dry, and mostly clear and the winters are long, very cold, snowy, and partly cloudy. Over the course of the year, the temperature typically varies from -1°C to 32°C and is rarely below -4°C or above 36°C.[28]

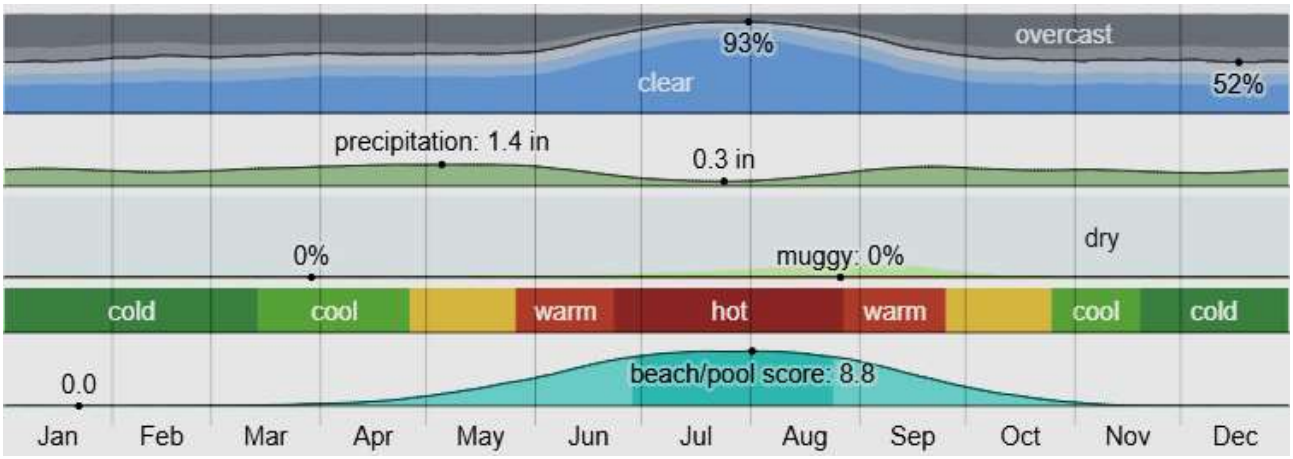


Figure 136: Climate in Tazoult-Lambese
Source: weatherspark.com

2.3.7 S.W.A.T

Strengths: These are the plus points or advantages of the site

- The Site near to national road good Accessibility
- Entrance opportunities
- A very wide space is available in back of site

Weaknesses: These are the minus points or disadvantages of the site.

- The Site near to national road wich causes noise and traffic
- A Stream passes back to site
- Crossroads far from the site

Opportunities: These are the factors or conditions on the sites which can be used to enhance the design of the building.

- Greenery around the side can be used for Landscaping
- Well connected to all kinds of public spaces

Threats: These are the limitations or dangers on the site which need to be overcome through the design.

- The site in rural area may cause noise to neighbors
- A Stream passes back to site may cause Flooding
- Interruption

[28] Tazoult-Lambese Climate, Weather By Month, Average Temperature (Algeria) - Weather Spark. (2022). https://weatherspark.com/y/53034/Average-Weather-in-Tazoult-Lambese-Algeria-Year-Round#Sections-Clouds

2.4 The End Result Of The Proposed Program

The proposed program is a combination result between the official program of the Algerian civil protection units (source: Infrastructure Office, Civil Protection Directorate, Batna), case studies(table), and Fire Station Program Spaces(U.S Department of Defense 2019).

Table 18: Fire Station Program Spaces.
Source: DoD, 2019.

Functional Component	**Space Allocation Standard**		**Note**
	M²	**Standard**	
Apparatus, Equip and Maintenance			
Apparatus Bay – Large			
PPE Gear Storage	86	Per truck	Station
Hose Storage	1	Per Person	Station
SCBA Maintenance Room	5	Per 52-HOSE Storage unit	Department
SCBA Compressor Room	13.5	Per four staffed vehicles	Department
Protective Clothing Laundry	4.7	Per four staffed vehicles	Department
Equipment Wash/Disinfection	9.5	Per staffed vehicle	Station
Work Room/Equipment Maintenance	14	Per room	Station
Vehicle Maintenance Equipment Storage	11.2	Per room	Station
EMT Storage (basic first aid supplies)	37.5	Per station	As dictated by installation mission requirements
HAZMAT/CBRNE Equipment Storage	1.2	Per station	Station
Spare PPE Gear Storage	11.2	Tech level	Department
Fire Extinguisher inspection	6	Per room	Department – storage for 30% total crew gear
Fire Extinguisher Maintenance and Storage	2.5	Per inspection station	Department - dictated by installation mission requirements
Vehicle Maitenance/Storage Bay	11.2	Per room	Department - dictated by instalation mission requirements
Vehicle Maintenance Office	112	Per station	Dpertment – AF only
Administrative and Training			
Station Officer Office/Watch	**11.2**	**Per office**	**Station**
Fire Chief Office	32	Per office	Dpertment
Chief's Conference Room	11.2	Per room	Department – tied to Chief's and deputy chief
Deputy Chief Office	11.2	Per office	Dpertment
Lobby Area	9.5	Per lobby	Department – tied to Chief's and deputy chief
Administrative assistant	6	Per office	Department – tied to Chief's and deputy chief
Assistant Chief Shift Supervisor	11.2	Per office	Dpertment
Assistant Chief of Fire Prevention	11.2	Per office	Dpertment
Inspection Offices	4.5	Per Workstation	Dpertment
EMS Office	7.5	Per office	station
HAZMAT/Safety Office	11.2	Per office	Dpertment
Logistics Office	7.5	Per office	Dpertment
Department Training Room	2.6	Per Person	Dpertment
Training Room Storage	7.5	Per Training Room	Tied to Department Training Room
Training Officer Office	9.5	Per office	Dpertment
Computer Training/Testing Room	13	Per four testing stations	station
General/Admin Storage	7.5	Per station	station
Dispatch	18	Per dispatcher	Dpertment
Dispatch Supervisor	6	Per Workstation	Dpertment
Dispatch Bathroom	4.5	Per fixture	Dpertment
Dispatch Kitchenette	2	Per kitchenette	Dpertment
Residential and Livig			
Day/Training Room	**60.2**	**Per staffed vehicle**	**Station = kitchen + dining/training**
Dorm Rooms with one bed	10	Per room	Station = staffed vehicle count + f/company
Dorm Rooms with Tow bed	13	Per room	Station = staffed vehicle count + f/company
Dorm Rooms with Tow fold-up bed	9.5	Per room	Station = staffed vehicle count + f/company
Bathrooms/shower /changing	23.5	Per staffed vehicle	station
Fitness Room	41	Per station	station

Laundry Room	7.5	Per staffed vehicle	Station accommodate 4 working out at one time
Physical Therapy/sauna	19	Per station	Station 1 washer 2 dryers sink folding table
Recreation Room	33.5	Per station	Station

Table 19: Main unit (civil protection) spaces program
Source: Infrastructure Office, Civil Protection Directorat, Batna. Feb. 09. 2011.

TECHNICAL PROGRAM 5671m²			
l- ADMINISTRATIVE BLOCK: (165 M2)		VI/ Accommodation: (1080M2)	
A/Head of unit: (80 M2)		Female/male officer rooms (6x15 m)	130m²
Head of Unit Office.	25m²	Chambers S/women/men officers (6x15 m2)	130m²
Secretariat	13m²	Chambers for sappers (30 m2x8elemx3equi)	720m²
Meeting room	30m²	Bathrooms	100m²
Waiting room	06m²	VII/ multipurpose space: (996m?)	
bathrooms	06m²	Amphitheater with control room for 120 people (30x20)	600m²
B/Administration : (85 m²)		VIP lounge	70m²
Office of the off in charge of the ADM.	18m²	Dining room.	120m²
Secretariat Office (1) training.	13m²	office and outbuildings	70m²
Office 2	18m²	guest rooms (03 double bedrooms and 03 individual bedrooms).	120m²
Office order	18m²	bathrooms	16m²
II- GUARD ROOM: (29 M2)		VIII/ Vehicle shed: (1080 M2)	
Reception	09m²	06 Frames of (12.00x5.00x4.5h)	360m²
Waiting room	10m²	09 Frames of (12.00x5.00x4.5h)	540m²
bathrooms	04m²	03 Discounts for other materials	180m²
rest room	06m²		
III/ TRAFFIC ROOM AND C.C.O: (136 M)		1./ Mechanical and sheet metal workshops: (302 M2)	
Office of the Chief of the C.C.O.	20m²	workshop manager office	12m²
staff room	50m²	General Storage.	60m²
Engine room	15m²	Mechanical, sheet metal and painting workshop.	140m²
radio room	15m²	Pit	40m²
Telex / fax / tel room	15m²	Vulcanization room	40m²
rest room	15m²	toilets and showers.	10m²
bathrooms	06m²	2./ General stores: (256 M²)	
IV/INFIRMARY: (85 M²)		Bureau magasinier.	16m²
Waiting	08m²	Fire equipment stores	100m²
Treatment room	18m²	Safety stock warehouse	140m²
Consultation room.	18m²	3. / Technical rooms: (78 M²)	
Pharmacy..	18m²	Local sonelgaz	06m²
bathrooms	05m²	Generator room	12m²
Nurse's room (doctor).	18m²	Transformer room	06m²
V / CATERING:(484.00 M2)		Boiler room Water cover 120M.	24m²/30m²
Stores.	30m²	X/ Sports areas: (630 M²)	
two (02) cold room (positive and negative)	40m²	Sports hall (gymnasium).	360m²
Commissary office (2 offices of 15.00 M²/office)	30m²	dressing-room	20m²
Refectory	180m²	Toilets and showers.	20m²
Foyer	30m²	Training pool (10x05x5.50)	50m²
Officers Mess	30m²	Maneuvering tower of 06 levels with cellar and balconies on the facades	180m²
Mess S/officers	30m²	XI/ ON-CALL HOUSING: (400 M²)	
bathrooms	18m²	4 F4 (100 M2x04)	400m²
dressing-room	06m²	XII/ TRAFFIC 10% OF THE TOTAL BUILT AREA: (567.10 M²)	
kitchen	90m²	IVX/ Maneuvering areas: (2500 M2)	

Table 20: The proposed program
Source: Author

MAINTENANCE & APPARATUS AREA		**M²**
Apparatus Bays	**Apparatus Bays**	**1038**
	Small Vehicle	2
	Medium Structural	7
	Large Structural	4
	Apparatus Bays (Vehicle Maitenance)	120
	Mechanical, sheet metal and painting workshop.	80
	Pit	40
Apparatus Support	EMT Storage (basic first aid supplies)	3.5
	Equipment Wash/Disinfection	14
	Hose Storage	5
	PPE Gear Storage	21.5
	Protective Clothing Laundry	9.5
	SCBA Maintenance Room	13.5
	SCBA Compressor Room	4.7
	Fire Extinguisher Maintenance and Storage	11.2
	Work Room/Equipment Maintenance	11.2
	General Storage.	100
	Pool machine room	38
	Vehicle Maintenance Office	14
	SUBTOTAL MAINTENANCE & APPARATUS AREA	**1392**

DAY ROOM AND RESIDENTIAL AREA		**M²**
Day	**Living Room**	**120**
	Dining	70
	Kitchen	40
	Pantry	25
Dorm Rooms	Dorm Rooms	375
	Dorm Rooms with one bed	10
	Dorm Rooms with Tow bed	15
Restrooms	**Bathrooms / Showers / Changing – Female Responders**	22
	Lavatories	2
	Water closets	2
	Showers	2
	Lookers	7
	Bathrooms / Showers / Changing – Male Responders	39
	Lavatories	3
	Water closets/Urinals	4
	Showers	3
	Lookers	16
Laundry	Laundry Room	30
Fitness	Fitness Room	245
library	Reading room	100
Recreation Room	Recreation Room	33.5

SUBTOTAL DAY ROOM AND RESIDENTIAL AREA	**1124.5**

TRAINING AND ADMINISTRATIVE AREA		**M²**
	Lobby Area	**9.5**
	Main Entry Vestibule	6
Admin and Offices	Admin & Training Restrooms	27
	Female Lavatories	1
	Female Water Closets	2
	Male Lavatories	2
	Male Water Closets / Urinals	3
	Administration & Training Break Room	10
	Administration Assistant	6
	Head of Unit Office.	32
	Secretariat	13
	Meeting room	30
	Waiting room	06
	Office 1	13
	Office 2	18
	Office order	18
	Station Officer Office/Watch Desk	11.2
	General/Admin. Storage	7.5
Presentation	Presentation room	95
	reserooms	9
Training	Training Room	105
	Training Room Storage	15
	Training Officer Office	9.5
Simulation	Smoke training room	60
SUBTOTAL TRAINING AND ADMINISTRATIVE AREA		**500.7**

Sports area		**M²**
Sports hall	Gymnasium	1120
	Dressing-room	40
	Toilets and Showers	70
	storage	80
Training Pool	Training Pool (10x05x5.50)	645
Control Tower	Maneuvering tower of 06 levels with balconies on the facades	36
SUBTOTAL SPORTS AREA		**1991**

Operational Coordination Center (O.C.C)		**M²**
	OCC Dispatcher	35
	OCC Kitchenette	3
	OCC Restroom	6
	OCC Supervisor	6
SUBTOTAL OPERATIONAL COORDINATION CENTER (O.C.C)		**50**

INFRASTRUCTURE		**M²**
Mechanical / Electrical	Electrical rooms	47
	Mechanical room – Admin area	24
	Mechanical Room – Responders area	40
Local sonelgaz	Local sonelgaz	06
Generator room	Generator room	12
Water tank	Water tank 24 m^3	30
	SUBTOTAL INFRASTRUCTURE	**159**

OUTDOOR AREA		**M²**
Outdoor training	Football filed	884
	Running truck	150
Drill yard/ maneuver	Drill yard/ maneuver	2096
Green spaces	Court yard	670
	Landscaped bridge	2572
	Green spaces	3284
Parking	Public parking	862
	Staff parking	432
	SUBTOTAL INFRASTRUCTURE	**10948**

THE TOTAL BUILT AREA 5217 m²

CIRCULATION 10% OF THE TOTAL BUILT AREA 521.7 m²

DRILL YARD & OUTDOOR SPORTS FILED AREA 10948 m²

THE TOTAL FIRE STATION AREA 16686.7 m²

Chapter 3:

Design Process

Introduction

This chapter is the design process of the final project that combines between the chapters with certain steps mentioned in this chapter to arrive at the final design of the Project,
The design of a fire station, located in the northern zone of the city of Tazoult.
On the basis of theoretical research on the theme of the green-tech and the analysis of the various examples of fire stations, we were able to identify elements of passages because of the use of them as a base for the design of our project entitled fire station. .
These elements are:

- Take into consideration the requirements of fire station spaces in terms of fire prevention, routes, public education....
- The different greenery concepts and their use according to the space and the lighting atmospheres.

3.1 Passage elements

- Take into consideration the requirements of fire station spaces in terms of functional relationship(like a large house) and it's connection, circulation paths, apparatus bays (fast reaction to emergencies),
- The different types of greenery concepts and their use according to the project space (inner, outer) and their benefits.

3.1.1 First the Concept

The arranging of the different functions such as office building, dormitory, dining rooms, multi-purpose training facility, on the site.

Figure 138: diagram, Project different functions

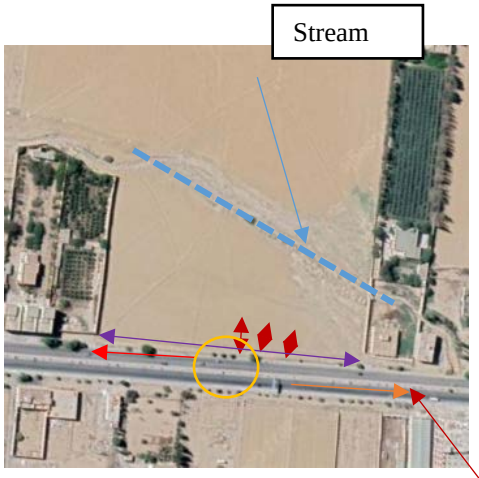


Figure 137: site environment
Source: author

Accessibility

Through documentary study and ground analysis
We focused on Accessibility where time is paramount.
Longest side of the site direct to the highway.
Where the idea came to distribute apparatus bays along the road, allowing the quick exit of trucks and reduce response time

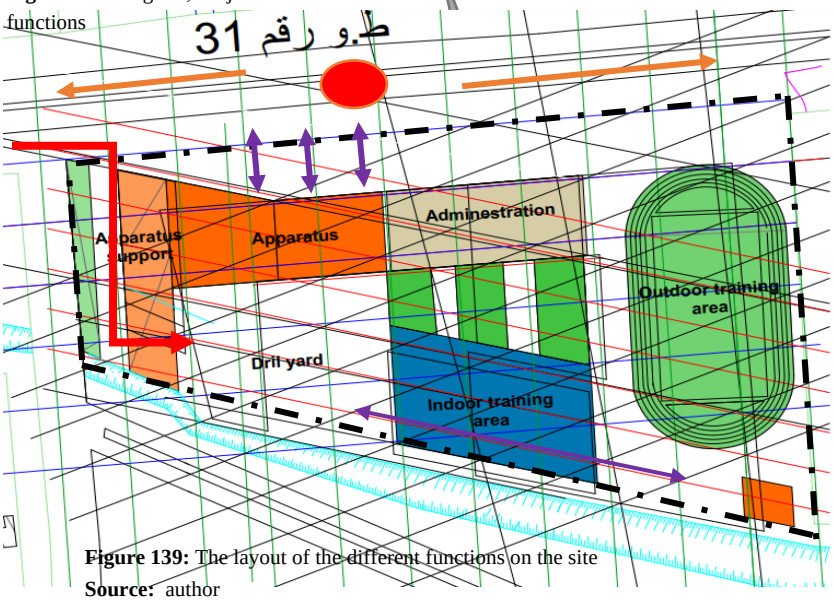


Figure 139: The layout of the different functions on the site
Source: author

Zoning

We have identified the basic functions of the fire station (indoor and outdoor training) office building, dormitory, dining rooms, and multi-purpose training facility
We created a **grid** on the site from the surrounding area, and divided the site according to the relationship of functions, movement paths (trucks and staff), exits and entrances, parking, the shape of the site (site dimensions).

3.1.2 The form devolepment

For the model development, first we tried to give the first functions zoning in the site plan a height into a 3D model

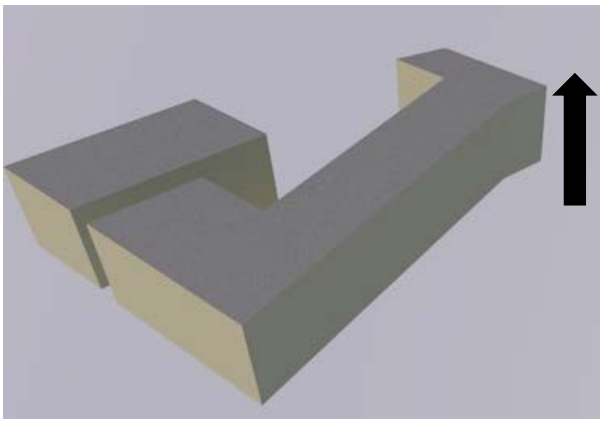


Figure 140: first model made
Source : author

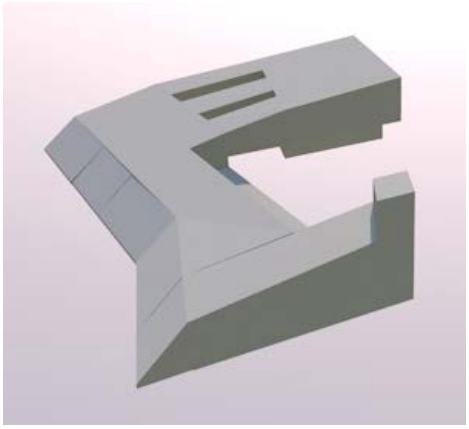


Figure 141: second model made
Source : author

The nature of the surrounding area (mountains) give us the idea to mimic it by making a gradation of levels, to integrate greenery in the building, by making different levels of green spaces

Figure 142: Third model made
Source: author

Figure 143: the mountains in the area .
Source: author

Figure 144: forth model made gradation of levels
Source: author

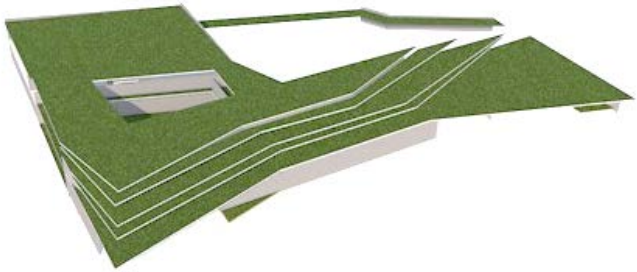


Figure 145: Forth model made, gradation of levels greenery
Source: author

The idea is to create a fragmented volume to offer a central courtyard (green space) with a Landscape bridge connection for fragmented green areas; therefore two simple and geometric volumes.

3.1.3 Interior layout

Divided in 3 zones: apparatus bay/vehicle storage /technical area / fire corps representation.

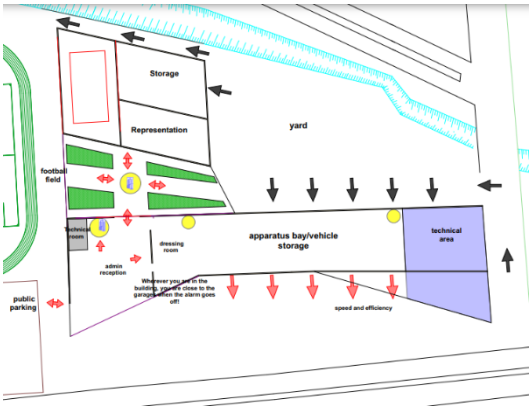


Figure 146: Ground floor, interior layout.
Source: author

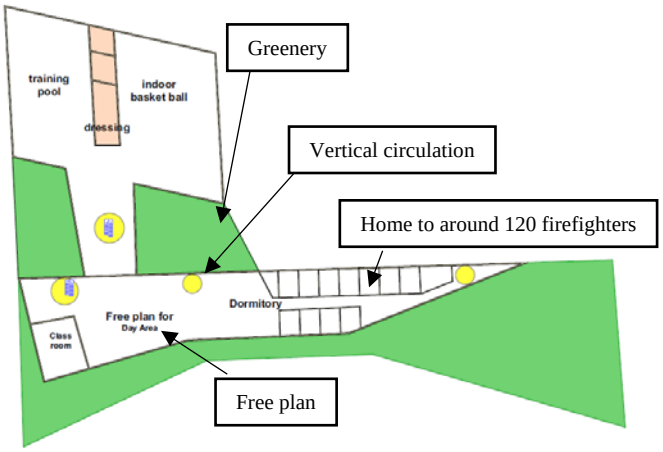


Figure 147: First floor, interior layout.
Source: author

Divided in 3 levels: apparatus bay/vehicle storage /humane area/ indoor training.

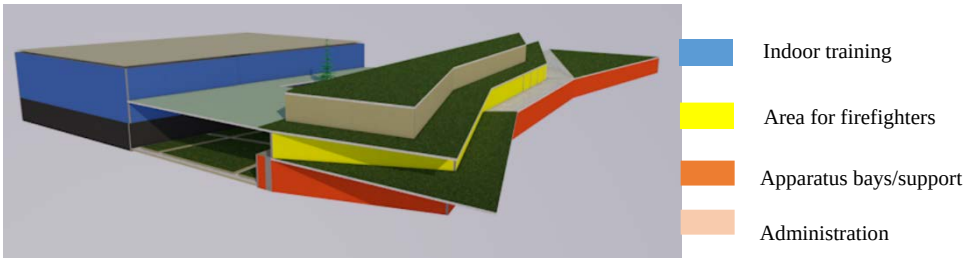


Figure 148: Diagram, form divided in 3 levels.
Source: author

3.1.4 Circulation

Efficacy in circulation system is emphasizes the design. Drive through apparatus bay to reduce response time. All vertical and horizontal circulation with clear visibility and connection

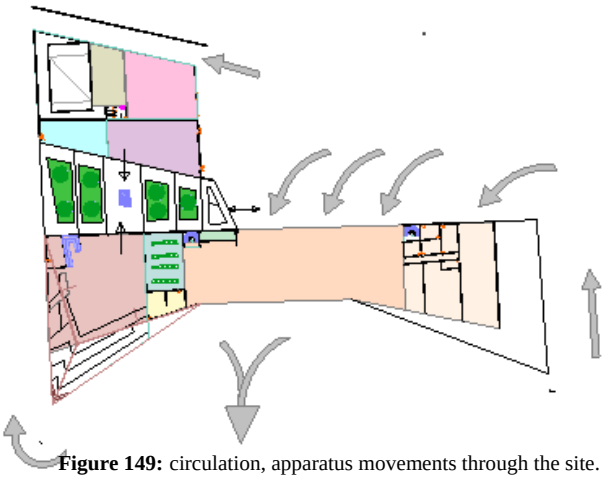


Figure 149: circulation, apparatus movements through the site.
Source: author

3.1.5 The Transparency

Simultaneous visual perception of different spatial areas in two virtual and apparent types better air circulation and light, microclimate, ecological….

Figure 150: Transparency, see through apparatus bays to connect with community.
Source: author

3.1.4 Greenery concepts

The project indicate that it will include green roofs, courtyards, gardens and vertical gardens.

Landscape Bridge/ courtyard

Creation of a central courtyard. (a jungle courtyard)

Figure 151: creating new habitat for animals
Source: author

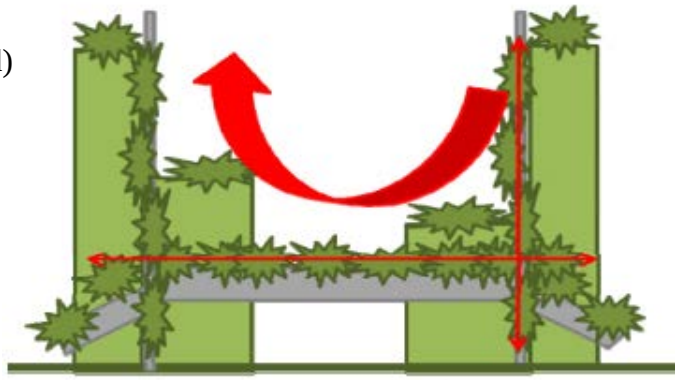


Figure 152: Landscape bridge connection for fragmented green areas
Source: Shahrina Afrin, 2009.

Figure 153: creating new habitat for animals
Source: author

The project is sustainably focused through the integration of native plants, which require less water and maintenance.

Figure 154: creating new habitat for animals
Source: www.archdaily.com

The green space also creates a natural habitat, attracting a diverse range of wildlife.

- **Green roofs**

a stepped green roofs that blends with the landscape.

Figure 155: creating new habitat for animals
Source: author

Multiple levels green roofs
Semi intensive green roof

Figure 156: creating new habitat for animals
Source: author

The project is sustainably focused through the integration of native plants, which require less water and maintenance.

▪ Landscaping

The landscape concept is “Interaction with Nature” which embraces three objectives: planting the future of relationship with nature, immersing the wilderness, and balancing human activities and the growth of rural forest

Figure 157: creating new habitat for animals
Source: author

The southern part of the site has a outdoor training site with a landscaped green space above a parking that will be required to remain as public green space.

Figure 158: creating new habitat for animals
Source: author

The layout to encourage an effortless relationship with nature, balancing the needs of the environment with the needs of humans.

▪ Indoor gardens

Indoor gardens can contribute important benefits to home living, ranging from aesthetic beauty to improved health and productivity

Figure 159: creating new habitat for animals
Source: author

▪ Plant selection

Figure 160: Thapsie
Source: www.wikipedia.org

Figure 161: Globulaire
Source: www.wikipedia.org

Figure 162: Rosemary
Source: www.wikipedia.org

Figure 163: Eglantier commun
Source: www.wikipedia.org

Figure 164: Holly oak
Source: www.wikipedia.org

Figure 165: Atlas cedar
Source: www.wikipedia.org

Figure 166: Aleppo pine
Source: www.wikipedia.org

Figure 167: Prickly juniper
Source: www.wikipedia.org

Figure 168: Marigold
Source: www.wikipedia.org

Figure 169: Artemisia
Source: www.wikipedia.org

Figure 170: Mauritanian grass
Source: www.wikipedia.org

3.2 Project representation

3.2.1The plans

A series of green technologies are proposed in this project, such as storm water management, green roof, permeable landscape, passive ventilation, maximized natural daylight, etc…

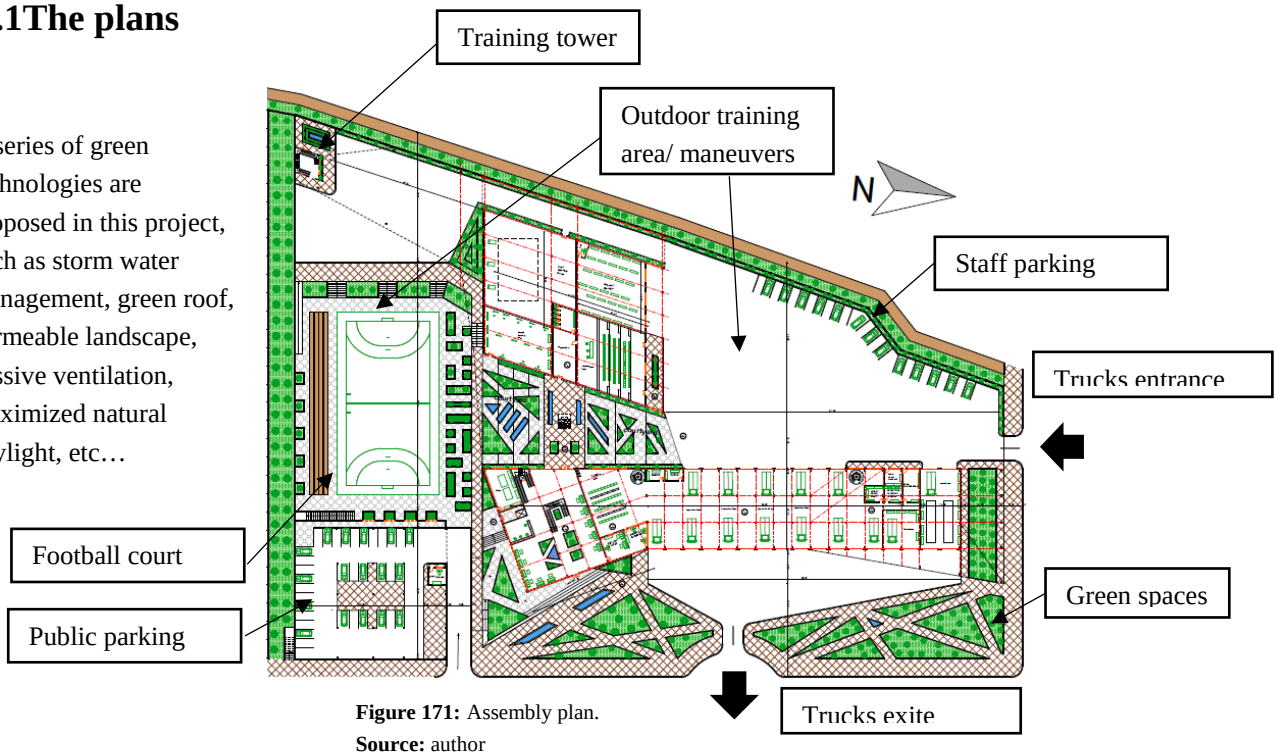


Figure 171: Assembly plan.
Source: author

The project hope to set an example for a community-based urban design that puts people and the environment at the center of the discussion

Figure 172: Mass plan
Source: author

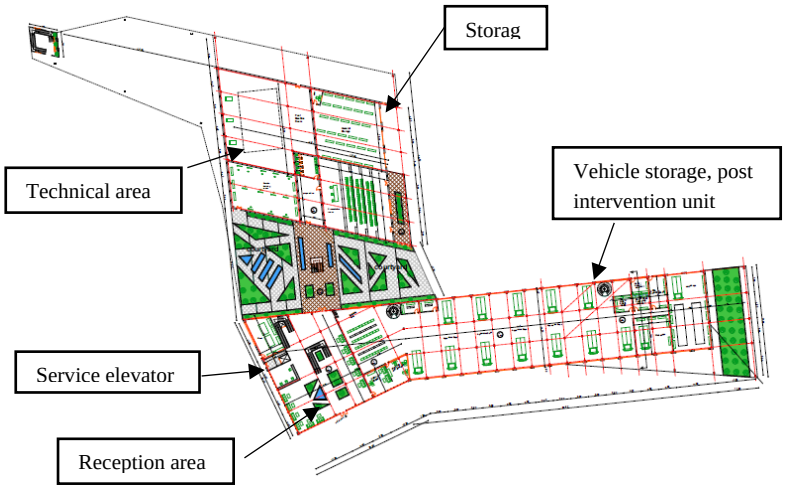


Figure 173: Ground floor plan.
Source: author

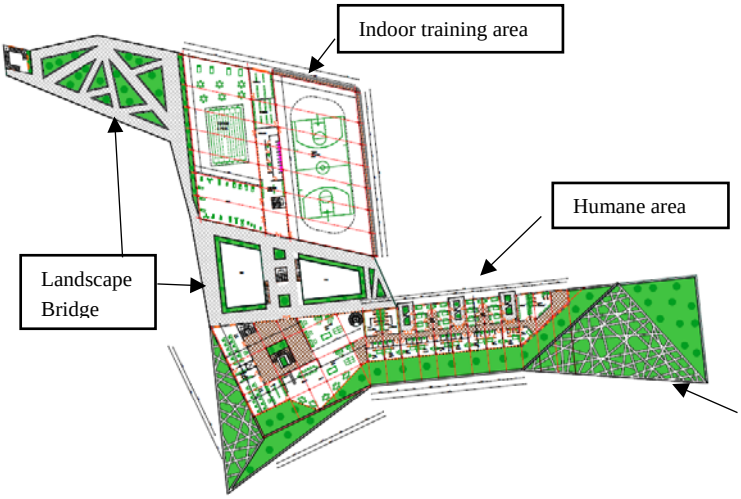


Figure 174: First floor plan.
Source: author

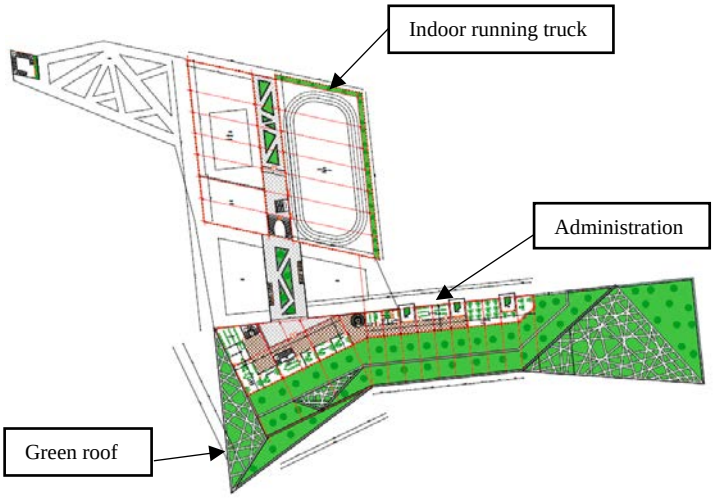


Figure 175: Second floor plan.
Source: author

3.2.2 Sections

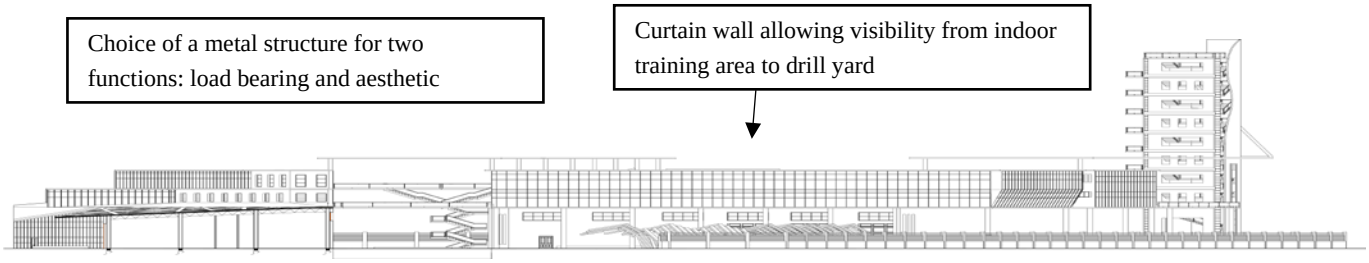


Figure 176: Section
Source: author

3.2.3 Facades

Figure 177: Southern façade
Source: author

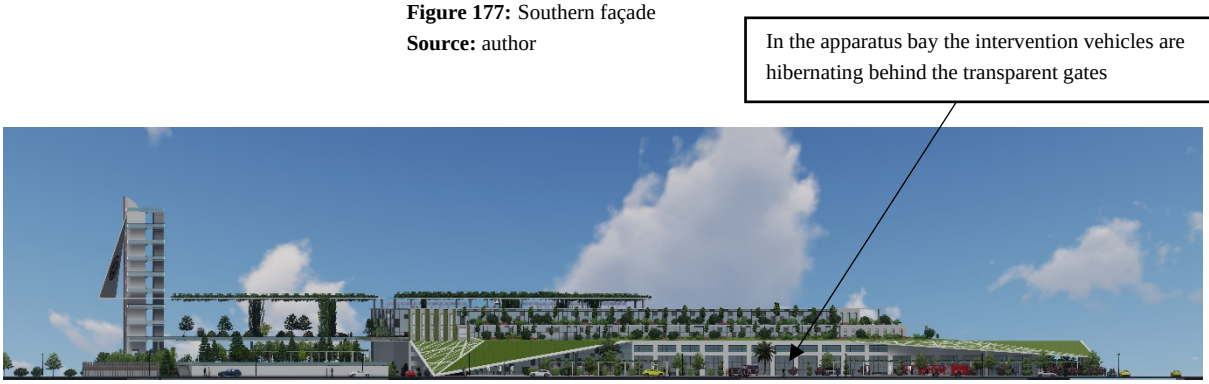


Figure 178: Eastern façade.
Source: author

Transparency and visibility in the interior is emphasized in order to ensure overview and outlook at all times.

The southern part and features large panoramic window overlooking the valey.

Figure 179: Northern façade.
Source: author

Figure 180: Western facade
Source: author

3.2.4 Exterior perspectives

Photovoltaic Panels

Perspectives show the atmosphere of the colors and materials used.

Roof gardens

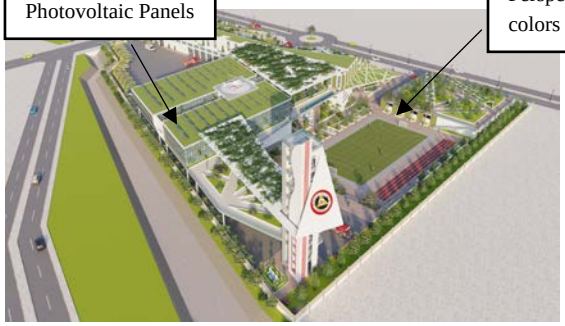


Figure 181: Arial view, showing training tower
Source: author

Figure 182: Arial view
Source: author

Perspectives show the atmosphere of outdoor space in terms of green space, outdoor area, façade treatment.

Figure 183: southern view
Source: author

Figure 184: northern view
Source: author

The importance of vegetation, water space at the central space level which give an atmosphere and an aesthetic vision with visual continuity with the other surrounded spaces.

Figure 185: view on central courtyard.
Source: author

Trying to extend the greenery of the area..

Figure 186: view on connection bridge, green spaces
Source: author

Perspectives on a landscaped bridge with green spaces.

Figure 187: view on central courtyard.
Source: author

Figure 188: view on southern part of the project
Source: author

Perspectives on a drill yard /truck movements / Transparence.

Figure 189: view on drill yard/ stuff parking.
Source: author

Figure 190: view on southern side of the project
Source: author

3.2.5 Interior perspectives

Reception areas are reached trough main entrance in the building's eastern part and features large panoramic curtain wall overlooking the city, with quick access to the emergency units dressing room.

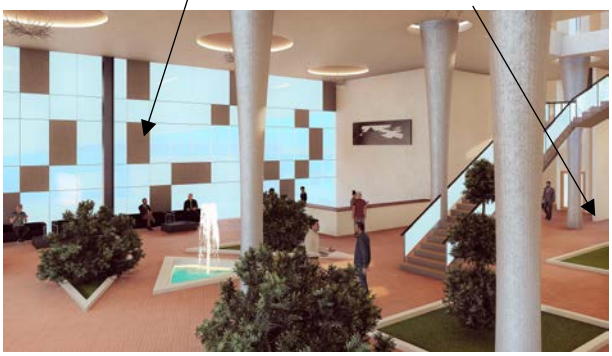


Figure 191: view on reception area.
Source: author

Perspectives on apparatus bay/vehicle storage
Metallic structure for long span

Figure 192: view on apparatus bays.
Source: author

3.3 Project recommendations

- ✓ The location of a fire station is determined under a number of factors such as accessibility to road networks area to reduce response time
- ✓ Design of a multifunctional fire station (rescue, public education, training) to meet user needs.
  - Create common public spaces between the fire station and the Urban context for project urbanity.
  - The main entrances, truck parking access a must be moved away from each other to avoid mechanical and pedestrian traffic.
  - The main entrance must be clear and attractive and must offer several entrances.
- ✓ It is necessary to create interior atmospheres by:
  - water areas and green spaces,
  - The apparatus bay must be wide to support the maximum of the vehicle.
  - The use of transparency concept to display the fire trucks.
- ✓ The use of transparent facades to reinforce the relationship between the exterior and the interior.
- ✓ The needs of disabled people must be taken into account at all levels (toilets, vertical circulation, public spaces, etc.)

3.4 General conclusion

Our research was based on the deferent ways of integrating plants in the design of the buildings in general and fire stations in particular. We also deal with fire stations, their types, the foundations of their design, the introduction of the green-tech and the greenery concept as a basic principle in its design technology, with particular emphasis on the architectural, functional, urban environments, and on the aesthetic qualities.

We have tried to show and explain the benefits of the greenery concepts in various fields with the concentration of how to exploit these benefits in fire stations.

The relationship that exists between the greenery and fire station is above all aesthetic; it's all a question of appearance, of the image you want to give to your architecture, environment friendly architecture. To develop what we call a poetic identity; this is a jungle courtyard, the identity approach makes the project more understandable, more local, easier to be accepted, understood and finally appropriated by the people.

Today, the difficulty of designing a fire station becomes a challenge for architects, it is no longer simply a place to host fire vehicles; but the fusion of a whole series of function, service and aesthetics and the greenery concepts is the element that can be established to link between architecture and the aesthetic vision reflected by the fire station. Gives the choice to highlight the aesthetics and function of our architecture and our ideas, it can be made communicative, even talkative; it makes itself accessible, understandable to the greatest number, and to reveal anything about its function. It is a functional and aesthetic bias, a game between shadows, colors and textures.

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