POLITECNICO
MILANO 1863

SCUOLA DI INGEGNERIA EDILE / ARCHITETTURA
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ANNO ACCADEMICO 2020 / 2021

@The Times of Israel

SCUOLA AL-NURI

Riabilitazione del complesso Al-Nuri nella Città Vecchia di Mosul
Scuola secondaria in terra cruda

RELATORE Prof. Arch. TRABATTONI Luca

AUTORE GNAGNE AGNERO Cécile | 913943

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Rehabilitation of the Al-Nuri complex in the Old City of Mosul
Raw earth secondary school

TUTOR Prof. Arch. TRABATTONI Luca

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RINGRAZIAMENTI

Questi ultimi mesi di formazione sono stati un periodo unico e decisivo nella mia vita personale e professionale. Aver completato questo lavoro di tesi è di grande importanza personale. Dimenticando il fatto che è stato un lavoro solitario, voglio ringraziare cordialmente tutte le persone che mi hanno accompagnato fino alla fine del mio lavoro.

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ABSTRACT

Il 10 luglio 2017 la città di Mosul in Iraq è stata liberata dall'occupazione jihadista dello Stato Islamico che controllava la città da tre anni. I conflitti armati si lasciano dietro una città distrutta. Da allora, la terza città più potente del paese ha lottato per ricostruire. Agenzie umanitarie e governi di tutto il mondo sono coinvolti nel processo di ricostruzione delle aree irachene colpite dalla guerra passata.

In questo contesto, UN Habitat e il governo degli Emirati Arabi Uniti lanciano un concorso aperto per la riabilitazione del complesso che circonda la Moschea Al Nuri come parte dell'iniziativa Revive the Spirit of Mosul. Nel cuore della Città vecchia, l'obiettivo è quello di ripristinare e rivitalizzare la zona intorno a quella che una volta era la seconda moschea più importante della città. Il progetto prevede la riabilitazione dell'identità degli edifici religiosi e la costruzione di nuovi elementi pubblici. Tra queste nuove implementazioni, una scuola secondaria per ragazze e ragazzi è l'argomento di questa tesi.

L'intervento ipotetico prevede la realizzazione di una scuola mista per 300 studenti recuperando i resti di vecchie case. L'edificio risultante combina le funzioni di una scuola per bambini e adulti, un luogo per lo sport e la cultura personale. Dietro le facciate apparentemente chiuse, la struttura sociale della scuola è intense come un quartiere dove alcuni dei vuoti creati dai cortili interni riuniscono diversi individui all'interno della loro comunità e altri sono centri sociali per incontri inter-comunitari. Si prendono delle libertà rispetto alle vincoli ufficiali del concorso per strutturare meglio il vuoto urbano e offrire nuove opportunità alla popolazione attraverso un'apertura funzionale e sociale degli edifici.

L'iniziativa mira a ripristinare il tessuto urbano e sociale del distretto e a dare potere alla popolazione attraverso la comunità e la riconciliazione. Per raggiungere questo obiettivo, il progetto intende creare un vivace centro sociale per la comunità all'interno del complesso, affrontando la mancanza di mezzi costruttivi e il fallimento dei servizi. L'integrazione in questo contesto unico e divisivo si ottiene attraverso scelte semplici e pratiche. Le sfide della progettazione passiva permettono l'indipendenza tecnologica e il comfort. Il ritorno alla terra cruda ha lo scopo di offrire prospettive di costruzione accessibili alla popolazione. All'interno delle parete dell'edificio, il progetto cerca di utilizzare il sapere tradizionale come vettore di identità. Il lavoro cerca di acquisire le basi della costruzione in terra cruda e le caratteristiche dell'architettura vernacolare araba. Si tratta di progettare con i legami di una popolazione con il suo passato.

On 10 July 2017 the city of Mosul in Iraq was liberated from the jihadist occupation of the Islamic State which had controlled the city for three years. The armed conflicts leave behind a destroyed city. Since then, the third most powerful city in the country has struggled to rebuild. Humanitarian agencies and governments from all over the world are involved in the reconstruction process of the Iraqi areas affected by the past war.

In this context, UNHabitat and the UAE government are launching an open design project competition for the rehabilitation of the complex surrounding the Al Nuri Mosque as part of the Revive the Spirit of Mosul initiative. In the heart of the Old city, the aim is to restore and revitalise the area around what was once the second most important mosque in the city. The project foresees the rehabilitation of the identity of religious buildings and the construction of new public features. Among these new implementations, a secondary school for girls and boys is the subject of this thesis.

The intervention foresees the realization of a mixed school for 300 students by recovering the remains of old houses. The resulting building combines the functions of a school for children and adults, a place for sports and personal culture. Behind the seemingly closed walls, the social structure of the school is intended to be a neighbourhood where some of the voids created by the inner courtyards bring together different individuals within their community and others are social centres for inter-community gatherings. Freedoms are taken from the official restrictions of the competition in order to better structure the urban void and offer new opportunities to the population through a functional and social opening of the buildings.

The initiative aims to restore the urban and social fabric of the district and empower the population through community and reconciliation. To achieve this goal, the project aims to create a vibrant social centre for the community within the complex by addressing the lack of constructive means and the failure of services. Integration into this unique and divisive context is achieved through simple and practical choices. The challenges of passive design allow for technological independence and comfort. A return to raw earth is aimed at to offer accessible construction perspectives to the population. Within the walls of the building, the design attempts to use traditional knowledge as a vector of identity. The work attempts to master the basics of raw earth construction and the characteristics of Arab vernacular architecture. It is about building with the links of people with their past.

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I. CONTEXTUAL STUDY

INDICE DEL CAPITOLO

REPUBLIC OF IRAQ

جمهورية العراق
كۆمارا عێراقێ

1. GENERALITY

In the sixth century, muslim conquerors drew lower Mesopotamia from ''Iraq el-Arabi''. In 1921, this territory became a state named Iraq by the British. The territory has one of the largest oil and gas reserves in the world.

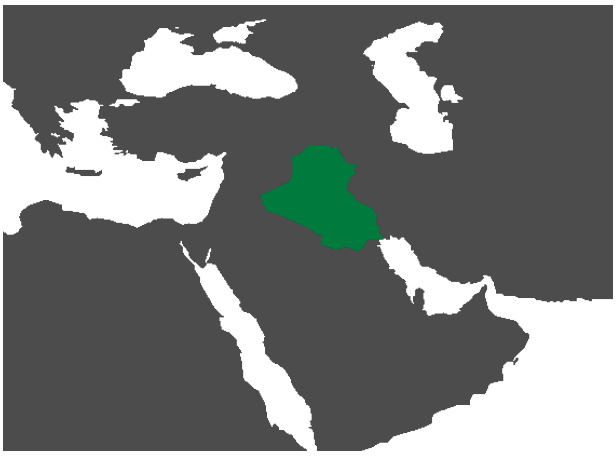

Fig. I-01. Localizzazione dell'Iraq

Government.	Federal Parliamentary Republic
National motto.	God is the greatest
Capital city.	Baghdad
Official languages.	Arabic and Kurdish
Surface area.	438 417 km2
Population.	38 872 600 (2020)
Density.	89 inhabitants/km2
Currency.	Iraqi Dinar
GDP.	US$166 (2020)
Poverty rate.	22.5% (2012)
HDI.	0.689 (2018)
Gini.	29% (2012)
Literacy.	51% over 15 years
Life expectancy.	70.5 years
Fertility.	3.7

2. ECONOMIC PROFILE

The Iraqi economy is focused on oil production as a privileged industrial sector. Oil covers 99% of Iraqi exports and the main purchasing countries are China (25.4%), India (17.3%), the United States (14.3%), South Korea (12%). The other sectors concern chemicals, textiles, leather, building materials, food processing, fertilizers, metal manufacturing and processing.

Agriculture accounts for a minimal part of GDP, 4.8%. The territory is dedicated to agriculture for 18%. The main vegetable crops are wheat, barley, rice, vegetables, dates, cotton. In addition, there are animal farms: cattle, sheep, poultry. Unfortunately, agricultural production does not cover the food needs of the Iraqi population. Iraq remains one of the largest importers of food. The other main imports are medicines and manufactured products from China 23.5%, Turkey 23%, Iran 20%. (Moody's Analytics, 2017)

3. GEOGRAPHY

3.1. The territory

The Republic of Iraq is a state of West Asia surrounded by Iran to the East, Turkey to the North, Syria and Jordan to the West, Saudi Arabia and Kuwait to the south. Geographically it is known thanks to the Tigris and Euphrates rivers that formed Mesopotamia.

The approximately 438 417 km2 are mostly occupied by desert landscapes. The shore of the Persian Gulf is swampy, unfavorable for the development of economic activities. However, between Baghdad and Basra the rivers frame fertile plains where rice can be grown. Further north, along the rivers, the territory is covered with semi-desert steppe where agriculture is difficult and cattle breeding prevails. In the far north, there are the mountains of Kurdistan up to 3 607m high where Mount Halgurd is located.

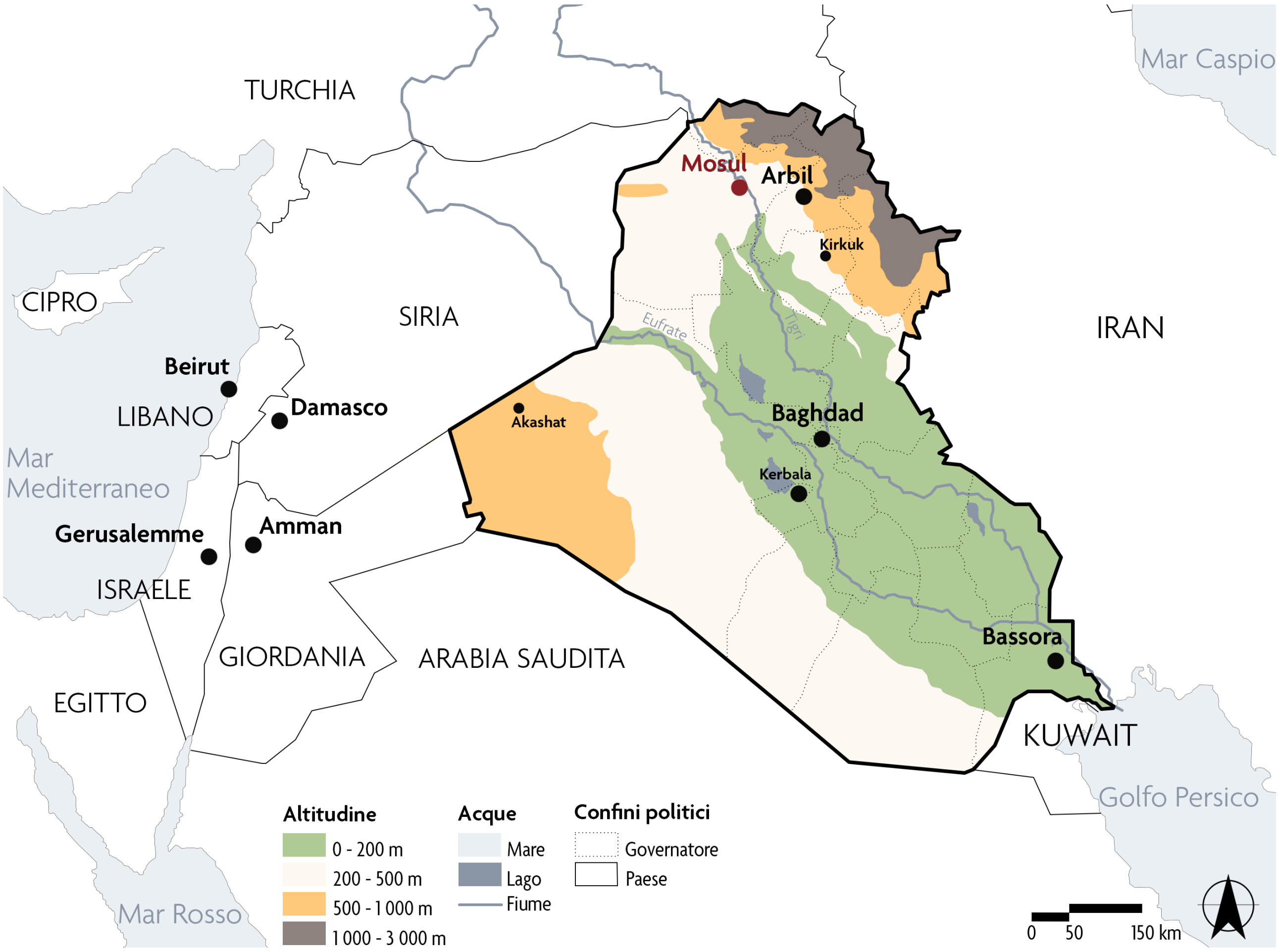

Fig. I-02.Geografia dell'Iraq

Fig. I-03.Kurdistan iracheno ©Matthieu Tordeur

Fig. I-05.Deserto iracheno ©Jon Kerstetter

Fig. I-04.Palude del Sud ©Agata Skowronek

Fig. I-06.Barzan, Kurdistan © Roxane photo

4. CLIMATOLOGY

4.1. General climate

According to the Koppen-Geiger classification, the Iraqi climate has four different profiles.

Bwh, the warm desert climate dominates the western desert. Bsh, the hot semi-arid climate between the two rivers. Bsk, cold semi-arid climate covers the steppe region. Finally, the DSB, is temperate continental climate on the northern part of Kurdistan. It constitutes the wettest part of the country with an annual total of rain up to 1000mm. In areas over 1500m above sea level it snows in winter.

The climate year can be divided into two, with the cold semester from November to April and the warm semester from May to October. During the cold semester, clouds cover about 50% of the sky.

Fig. I-07.Climi di Koppen-Geiger presenti in Iraq

1.4.a. Temperatures

In the cold season, the minimum temperature is about 0°C in the mountains, 3°C in the deserts and 5°C in the plains. The lowest temperature recorded is about -14 ° C, in the desert to Syriac confinement. However, everywhere except in the mountains at high altitudes, the average temperature exceeds 15°C in winter.

In summer, temperatures are in the order of 22°C and 29°C. It is not surprising to reach temperatures up to 40°C in this semester. The maximum punctually recorded exceeded 50 ° C.

1.4.b. Rainfall

The rains tend to occur exclusively in the cold semester. In desert regions they are between 100 mm and 170mm. In the center of the country and in the southern steppes the rains are between 300mm and 570mm.

1.4.c. Winds

In the warm semester, there are two types of winds. The Sharqi blows between April and June and from September to November from the south or southeast. It is a very strong wind up to 80 km/h that triggers sandstorms. The Shamal, less dangerous, blows between June and September from the north or from the northeast. It is responsible for temperature jumps in this period. In winter, cold winds sometimes blow from the North.

4.2. Threats

1.4.a. Seismic risk

As the periodic earthquakes in Turkey and Iran show, the Middle East is hit by a seismic risk. The Arabian Peninsula where Iraq is located defines the Arab tectonic plate. Two of the six borders, therefore most seismically active places, are close to Iraq's territorial borders with Iran and Turkey.

1.4.b. Sandstorms

From June to September, especially the Shargi wind carries sand and dust, creating sandstorms. In Iraq, it can be up to 24 days of storms each year. In the province of Nineveh, the risk is lower with a maximum of four days in Mosul. The frequency of sandstorms is constantly increasing, due to climate change and military operation

Fig. I-08.Tempesta di sabbia @Munir Irak

1.4.c. Floods

Historically, since antiquity, the control and power of Mesopotamia depended on the control of its rivers. The Tigris and Euphrates have hit Iraq annually with massive floods. It happened that cities were destroyed.

Demography

Fig. I-09.Innondazione @Lalibre.be

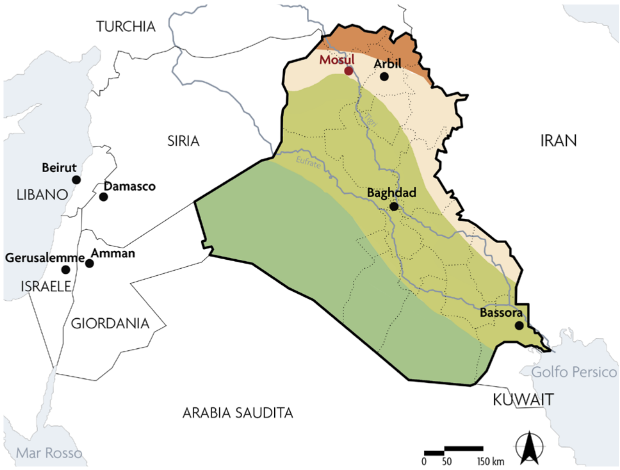

Fig. I-10.Rischio sismico in Iraq

In addition, the melting of snow in the northern mountains occasionally affects the center of the country flooding it and filling Iraqi rivers. The risk is greater between Baghdad and Basra where the distance between the two rivers is low from 20-100km.

The risk of flooding has been decreasing in recent years. After 2018, periods of severe drought led the government to ban the culture of rice and corn. The impact of climate change is double. The rains are more sparse, leaving the Middle Eastern country without enough water. Faced with this phenomenon, governments build dams to collect water. Turkish Dams Upstream Reduce Iraq's Water Supply Downstream

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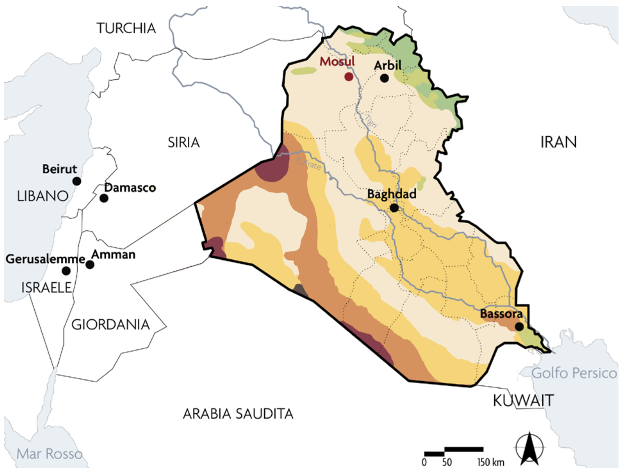


Fig. I-11.Rischio di tempesta di sabbia in Iraq

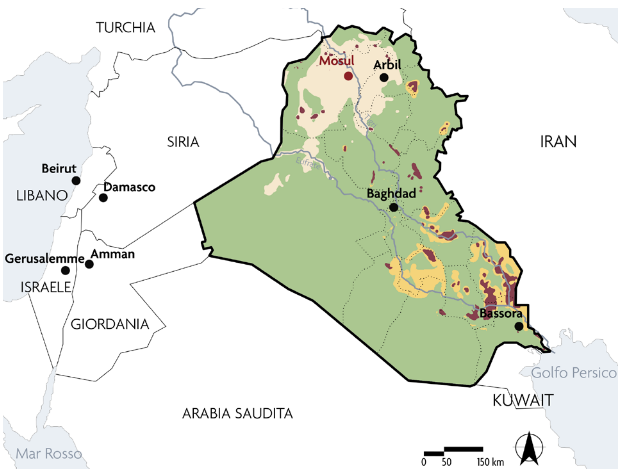


Fig. I-12.Rischio d'inondazioni in Iraq

DEMOGRAPHIA

1. DEMOGRAPHIC PROFILE

In 2020, the Iraqi population was estimated at around 38 872 600 inhabitants. During the last fifteen years, population growth has been between 2.5% and 3.3%.

Despite the wars, life expectancy in Iraq is seventy years and 60% of Iraqis are under twenty-five years old.

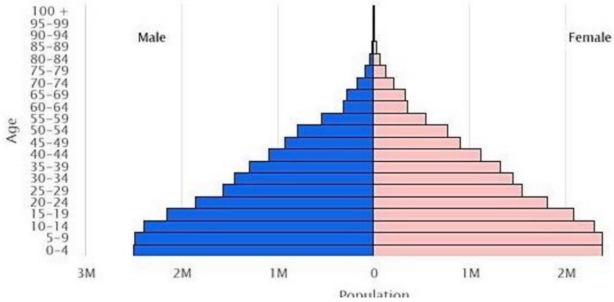


Fig. I-14.Profilo della popolazione @CIA

2. CONNECTION

2.1. City

The most important cities are the capital of Baghdad with about 13 million inhabitants, Basra with 3.8 million and Arbil with 1.7 million. Recent conflicts in the country have made the population census complex, in fact until now the values have been obtained statistically.

In addition, the population has been forced to move to refugee camps, neutral zones in conflicts. These temporary installations have become real villages. The refugees have not yet all returned to their cities, due to the impossibility of finding a habitable home. In September 2020, an estimated 252,000 refugees were

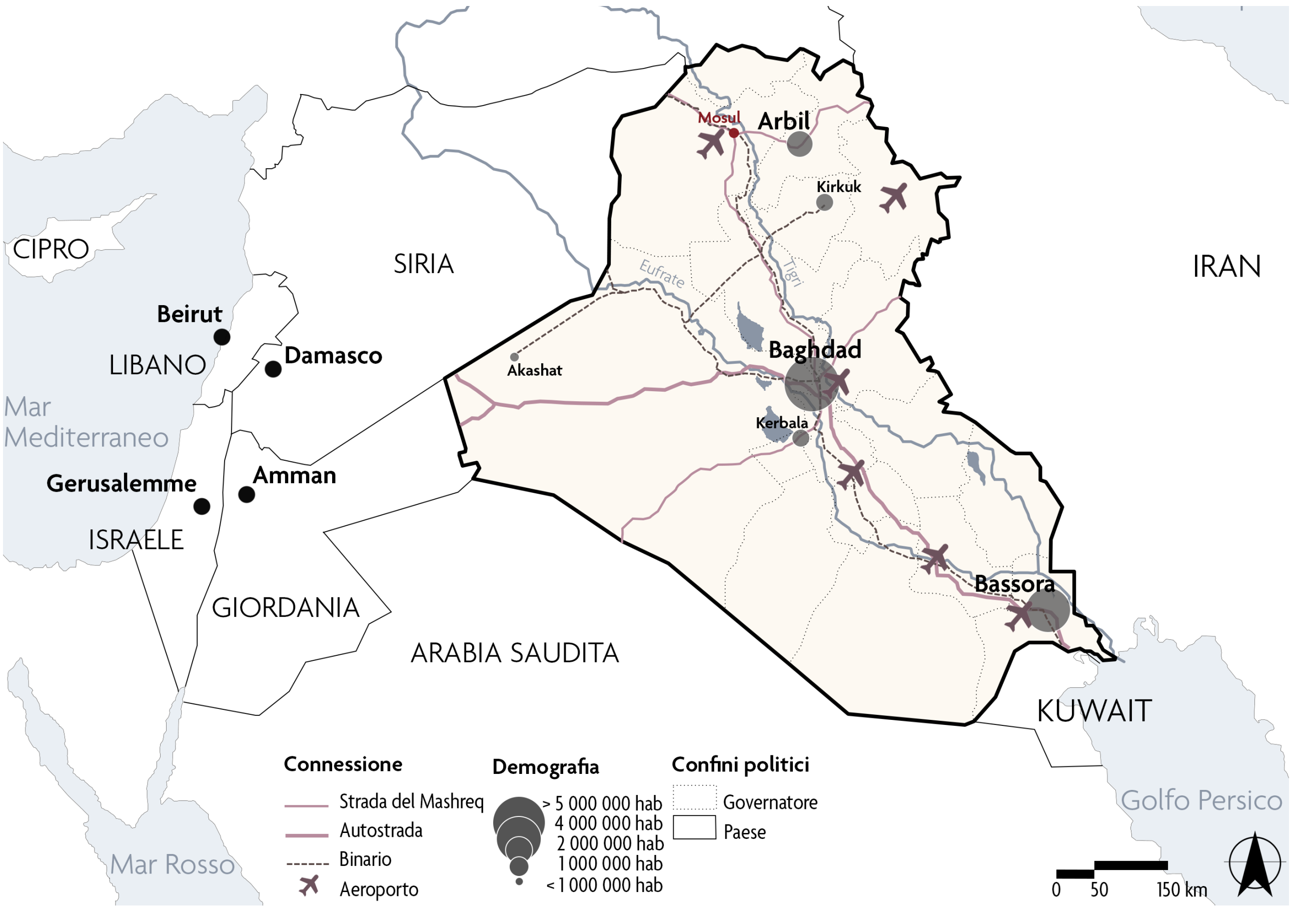


Fig. I-13.Principale citte d'Iraq e loro connessione still present in official camps.

2.2. Airports

There are four international airports: Baghdad, Arbil, Mosul, Basra, Sulaymaniyya and Al-Najaf.

2.3. Rail networks

Through the road network, there are 6 railway tracks that form a network of about 2 000km that crosses the country. Today, not all infrastructure is fully operational. So many stations have been destroyed by conflicts.

2.4. Roads

Iraqi cities are connected to each other mainly by roads. In 2001, it was decided to create a road network throughout the peninsula, the Roads of the Arab Mashreq connecting Iraq to Syria, Jordan, Palestine, Israel, Lebanon, Kuwait, Egypt, Saudi Arabia, Bahrain, Qatar, the United Arab Emirates, Oman and Yemen. With the exception of the express roads defined by this project, there is only one highway connecting Basra to Ramadi.

3. ETHNICITIES

Being a young country, it is not the history of the Eastern peoples that drew the borders of Iraq. For this reason, like so many colonized countries, Iraq is made up of numerous ethnic groups that do not speak the same language. The peoples' princes are the Arabs and the Kurds.

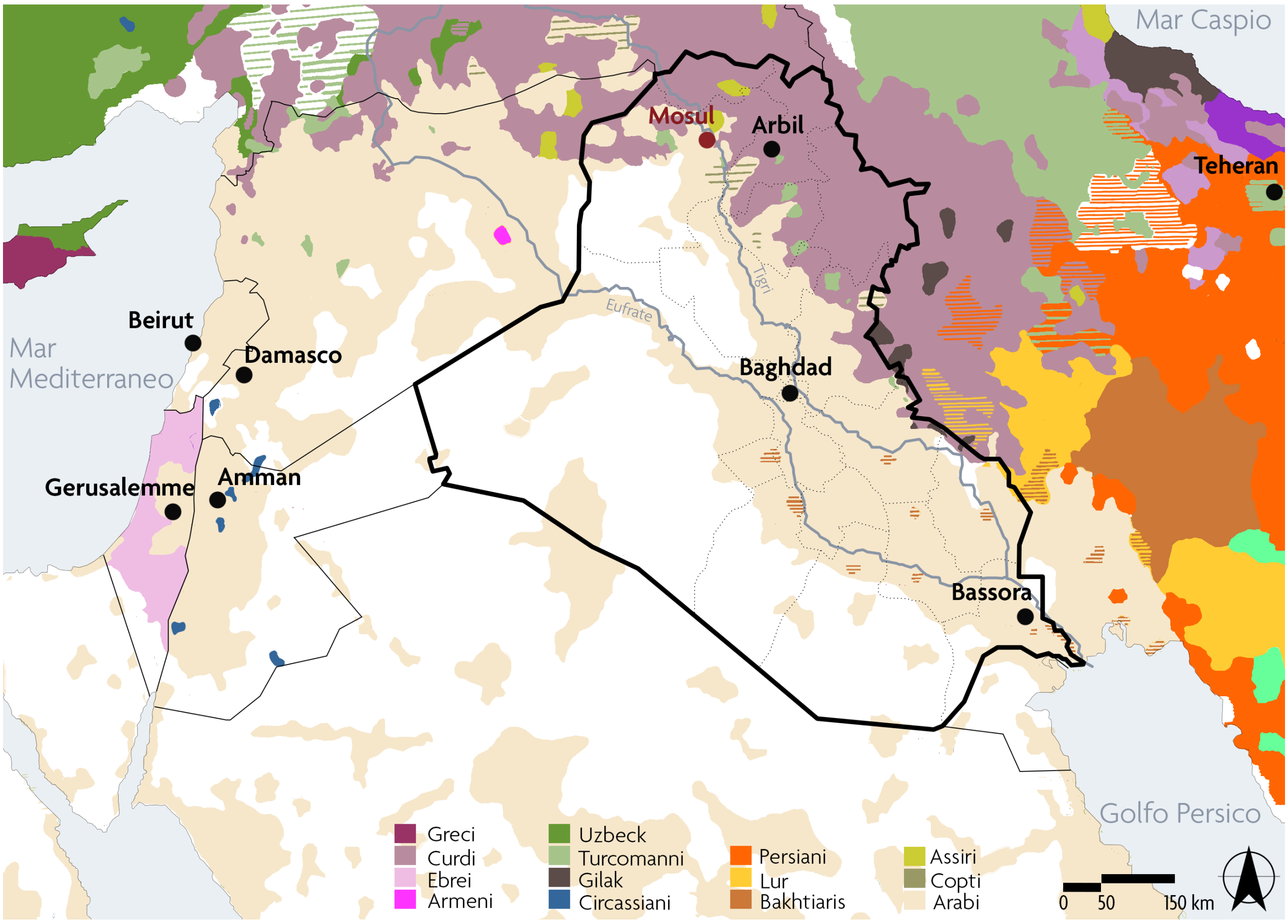


Fig. I-15.Mappa delle etnie del Medio Oriente

3.1. Arab

Brought by the invasions of the Muslim Empire in the fifth century in Mesopotamia, the Arabs today correspond to about 67% of Iraqis. They direct the political and social aspects of the country.

3.2. Kurds

The Kurds are the most important people in the Middle East. They live in Turkey, Iraq, Iran and Syria. That's about 33 million. The inhabited area of the Kurds is called Kurdistan. For decades, the Kurds have been campaigning to make this 530 000 km2 region a real country. In Iraq, Iraqi Kurdistan is recognized as an autonomous region where the capital is Arbil. On September 25, 2017, through a referendum, the Kurds are agreed to demand the independence of this party. The political identity of this country has always been contested by Arab governments. Their history is characterized by discrimination.

In Iraq, the Kurdish state is nationally recognized. Considering that they represent about 20% of the population, the Kurdish language is the official language of the country.

3.3. Other minorities

There are many other ethnic minorities in Iraq, some officially recognized. There are Azerbaijanis 4%, Assyrians 1%, Farsi, Turkmen...

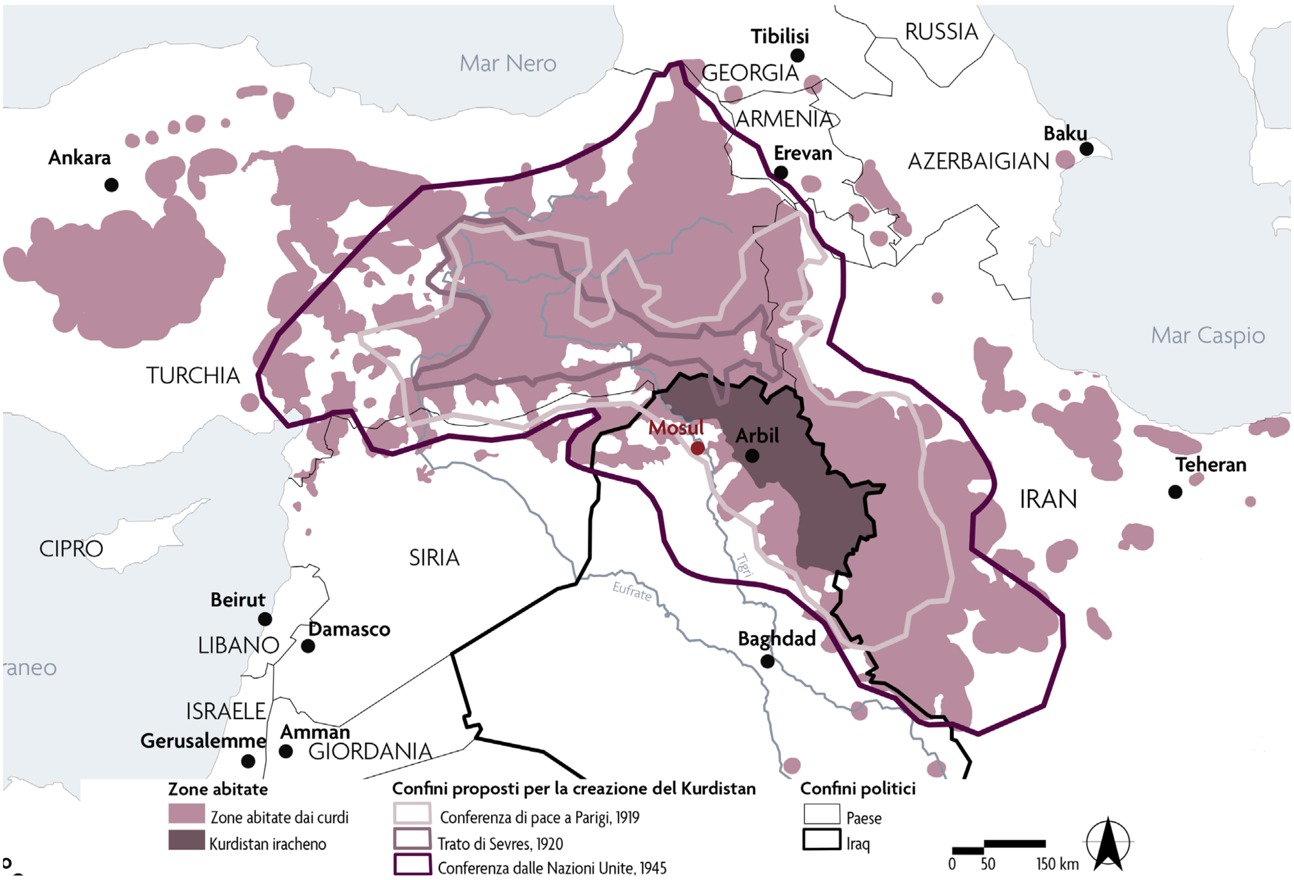


Fig. I-16.Mappa del Kurdistan

4. RELIGION

According to the Constitution of the Republic of Iraq, "Iraq is a country of many religions and faiths" (art.3).

Iraq is dominated by Islam for 96% of the total. Christianity is represented by 3%. There are some religious minorities such as Yazidis, Sabaeans and Bahá'ís in Kurdistan and on Iran's borders.

4.1. Islam

Iraq in its history and identity is linked to Islam, in fact it is the most widespread religion in the country. Islam is the official religion of the state and is fundamental in legislation. The flag takes up from 1991 the Muslim motto ''Allah is the greatest''. For this reason, knowing the basis of this religion made it possible to better know the reason for Iraqi society.

2.4.a. Basic ideas:

Islam is based on the sacred text of the Qur'an brought by the Prophet Muhammad. It consists of numerous revelations called Surah. The first revelation of the Qur'an places education at the base of everything. The text begins like this:

"Read! In the name of your Lord who created, He created man from an adherence. Legislation! And your Lord is the Most Generous, the One who taught through calamus, who taught man what he did not know."

The Qur'an considers education as the first necessity of the human.

The principles of greatest importance are the seven pillars:

1. Testimony

2. The Five Daily Prayers

3. Payment of the Koranic tax

4. The pilgrimage to the Holy House, that is, to Mecca

5. The fast of the month of Ramada

Fig. I-17. Bandiera attuale dell'Iraq

The Qur'an writes principles that can be translated more precisely to help Muslims distinguish good (halal) from evil (haram). They constitute the Shariah. Other sacred texts try to develop all principles of the Qur'an into rules applicable in politics. The principle is Fiqh. However, children until puberty are exempt from all behaviors, they are not obliged to follow the principles.

The family is the heart of all relationships in Islam. While individuality exists only in the responsibility of actions.

One idea received about Islam is that of the separation of males and females. This cultural separation is a convenience, when the union of genders is not prohibited. The separation made it possible to ensure the principle of mahran. Relations between the two genders are born in blood or marriage.

2.4.b. Opposition between Shiites and Sunnis:

Today there are five schools of Islam: Hamifi, Maliki, Shafii, Hanbali, Jaffari. The first four constitute the Sunni stream, and the last Shia. A tension if it is developed between the Shiites and the Sunnis. In Iraq, the conflict was real. Shiites represent 60% of Iraq's population while Sunnis are estimated at 37%. The territorial division is not clear, but the Shiites are more located in the plains of the south of the country. Although they are the majority, the Shiites were not excluded from the decision-making process by Saddam Hussein during the Baasisto period.

The split between these flows was made at the death of the prophet in 632, in the face of disagreement over who will succeed him. Subsequently, the two religions developed differently. The difference that creates conflicts at the national and political level concerns the relationship between politics and religion. The Shiites consider the imam to be the only religious authority and have a very structured religious organization separate from other forms of authority. While, Sunnis want a single authority both religious and political. The Sunni Shiite opposition always questions the identity of the Iraqi government.

4.2. Christianity

Bakhdida, small towns in southeast Mosul is the most important Christian city in Iraq. Christians have been the subject of numerous attacks and repressions in the face of the importance of Islam. As a result, the number of Christians in Iraq has halved in twenty years.

4.3. Other religious minorities

The Sabeans, more than a hundred thousand in 1980, now about ten thousand, are about to disappear. The biggest problem is that the Sabians do not convert new believers: a person is born a Mandean, but cannot become one. They are monotheists. Since their religion is strongly linked to water, they live near rivers.

In the north of the country in the governor of Nineveh, around Sinjar, are the Yazidis. They are estimated to be 500 000 in Iraq. Their religion is considered pre-Islamic, their calendar begins 4750 years before the Christian one. They worship Malek Taous, the peacock angel who in Islam is none other than Sheitan. But in their religion, Sheitan and God are not in conflict. They believe that he was commissioned by God to watch over Creation. This opposition has been used as a justification for many persecutions by Muslims. Moreover, Islam in its texts does not recognize the existence of Yazidism as opposed to Christianity.

Baha'is are one of the minorities not mentioned in the Iraqi Constitution of 2005. The Bahá'ís are one of the minorities not mentioned in the Iraqi Constitution of 2005. The Baha'i faith is the youngest monotheistic religion. It was created by Bahá'u'lláh in Iran in 1844. The first Baha'i writings are published in 1853 in Baghdad but the Baha'i faith is based on other texts such as the Bible, the Gospels, the Koran. This use stems from the belief that humanity constitutes a single family where prejudices must be rejected. Bahá'ís believe in a unique world society that will bring Great Peace. To this end, they place the importance of education and research

Etnia	Lingua	Nombre	Religione
Arabi mesopotamici	arabo	39,7 %	islam sciita
Altri arabi	arabo	27,1 %	islam sunnita
Curdi	curdo	20,3 %	islam sunnita
Azeri	azero	5,9 %	islam sciita
Yazidi	curdo	1,4 %	yadizismo
Iraniani	farsi	1,1 %	islam sciita
Turkmeni	turkmeno	1,1 %	islam sunnita
Assiri	assiro	0,4 %	cristianismo
Louri	louri	0,2 %	islam sciita
Caldei	caldeo	0,2 %	cristianismo
Armeni	armeno	0,1 %	cristianismo ortodosso
Bajelani	bajelani	0,1 %	islam sciita
Herki	herki	0,1 %	islam sciita
Zingari	zingari	<0,1 %	islam sunnita
Hawrami	hawrami	<0,1 %	islam sciita
Ceceni	ceceno	<0,1 %	islam sunnita
Sabei	arabo	<0,1 %	sabeismo
Urdu	urdu	<0,1 %	islam sciita
Turchi anatolici	turco	<0,1 %	islam sunnita

Tab. I-01. Etnie e religione in Iraq

at the centre. The first Bahá'ís were Shia Muslims. Their historical opposition to Islam has justified so much persecution against the Bahá'ís.

HISTORY OF IRAQ

1. INTRODUCTION

Iraq is a young country, its history has its roots in the history of ancient Mesopotamia. It is a fundamental cultural place for the whole Middle East thanks to three powerful populations the Sumerians, the Babylonians and the Assyrians. In modern times, this region has been highly coveted by international forces that give Iraq a history full of conflicts and challenges.

6000BC. First cities of Mesopotamia

3200 BC. Writing the epic of King Gilgamesh, the first known document

1750 BC First unification of Mesopotamia by King Hammurabi

632 AD. Death of the Muslim Prophet Muhammad without successor, Shiite and Sunni division

632 AD. Death of the Muslim Prophet Muhammad without successor, Shiite and Sunni division

762 AD. Foundation of the city of Baghdad

1187 AD. Conquest of Saladin's Jerusalem against the Christians

2. BIRTH OF IRAQ

2.1. Key events

1914

UK colonialism

1914. The United Kingdom's intervention in Iraq against the Ottoman Empire.

1920. Treaty of Sèvre (abandoned in favour of the Treaty of Lausanne) with the creation of a Kurdish state from Turkey and the province of Mosul

1921. Creation of Iraq after the fall of the Ottoman Empire
Beginning of the monarchy with King Faysal, under British colonialism

1927. Creation of the Iraq Petroleum Company to manage Iraqi oil

1932. Independence of Iraq from the United Kingdom

1946. Creation of the Kurdistan Democratic Party

1947. Creation of the Baas Party

1958. Proclamation of the Republic of Iraq

1959. Family Code: minimum marriage age 18, ban on polygamy

1961

1961. Creation of the Iraqi Islamic Party

Iraq was brought under British control by the League of Nations in 1920. During the period of the British Mandate of Mesopotamia, the British soon faced violent insurrections.

Proclaimed in 1921, the Kingdom of Iraq gained its independence in 1932. The monarchy lasted until 1958, when Iraq became a republic.

3. BAASIST REPUBLIC

3.1. Key events

1963

1963. First Baath Party coup

1968. Second coup d'ètat of the Baath Party: Saddam Hussein comes to power.
1969. Criminal Code: Article 911, exemption for a man who kills a woman to defend his honour

1970. Iraqi Constitution: guarantees equality between men and women

1972. Nazionalisaion of Iraq Petroleum Company

1974. Kurdish insurgency
1975. Creation of the Patriotic Union of Kurdistan

War Iran/Iraq

1988. Operation ''Anfal'' against the Kurds ordered by Saddam Hussein

02/08/1990. Invasion of Kuwait by Iraq

1991. Shia uprising

Americain embargo

Kurds civil war

2003. 16 /05 ''DeBaathification of Iraqi Society'', start of government dissolution

2003

Saddam Hussein takes over the country. He established a secular (at first), nationalisation, exclusionary policy led by his party and the Sunnis. His government caused social rifts, particularly between Sunnis and Shiites.

Militarily, the Baath regime sought to extend Iraqi territoryandendedupalienatingWesternpowersworried by this development. The American embargo degraded the management of Iraq and put an end to the regime

3.2. Period characteristics

- Dictatorship with many human rights violations
- Good health coverage 97% of urban and 79% of rural population
- Well developed water and sanitation system
- Fall in infant mortality from 7.1% to 2.9% in 23 years
- Women have been incorporated into the workforce and the public sphere
- Beginning of a religious radicalisation of the governm

4. AMERICAN OCCUPATION

4.1. Key events

1990

Americain embargo

Americain occupation

17/01/1991. ''Desert Storm'', start of the American counter-invasion operation in Kuwait

14/04/1995. ''Oil for Food'' , help programm of the UN

2003. 16/05 ''DeBaathification of Iraqi Society'', start of government dissolution
19/08 Attack in Bagdad against the UN
13/12 Saddam Hussein arrest

2005. 30/01 First parliamentary elections and Sunni boycott.

2007. 10/01 ''Surge'', reinforcement of the American presence in Iraq.
09 Tribal movement Shawa

2010

2010. Complete withdrawal of US forces.

During this period, the US government decided to overthrow the Baath regime. The economic embargo imposed on Iraq had serious consequences for the whole country. The military occupation that followed reinforced the country's weaknesses and divisions. In particular, extremist religious movements supported by Al-Qaeda emerged. The transitional government set up was weak and would not be effective afterwards. This period in Iraqi history was severely marked by American interference in the country's situation.

5.2. Period characteristics

- Rationing of medicines
- Malnutrition, poverty and child mortality on the rise
- Economic crisis
- School enrolment rates are falling, despite the investment of the Oil for Food programme
- Reinforced Al-Qaeda presence

5. JIHADIST EXPANSION

5.1. Key events

Americain occupation

Civil war

2004. Introduction of Sharia into law

2006. Attacks made by Al Qaeda against the Shia population
15/10 Creation of the Islamic State

09/04/2013. Daech creation from the union of the Iraqi Islamic State and the Syrian Victory Front
2014. 10/06 Daech's attack on the city of Mosul . 29/06 Restoration of the califa in Mosul by Daech
25/05/2015. Completed conquest of al-Anbar governorate by the Islamic State

10/07/2017. Reconquest of Mosul

2017

Come notato in precedenza, lo jihadismo sta crescendo in tutto il paese, spinto dalle divisioni etniche e sociali e dal risentimento verso gli occupanti statunitensi. Durante l'embargo, Saddam Hussein aveva basato la sua politica sociale e la sua comunicazione sull'Islam, il che ha cambiato in anticipo il profilo religioso della popolazione. I sottogruppi presenti in Iraq permettono ad Al-Qaeda di iniziare la sua invasione del paese e ad espandere lo Stato Islamico.

L'organizzazione è fermata a Mosul dalla coalizione internazionale dopo tre anni di occupazione violenta.

5.3. Caratteristiche del periodo

- Crisi economica
- Regressione delle istituzioni e dei servizi
- Distruzione di infrastrutture
- Spostamento di popolazioni
- Precarietà della popolazione

6. RECONSTRUCTION OF THE COUNTRY

After the wars, the American occupation was unable to solve all the challenges Iraq was facing. The birth of jihadism showed that the country had to be rebuilt at least politically by the hyraxes.

In May 2018, the national election began the redesign of the country. But with American weapons still present, the growth of Iranian influence, jihadism not completely exterminated and the inexperience of the government, tensions remain strong. In October 2019, mass demonstrations spread to the south of the country due to the lack of basic services and work. International humanitarian organizations helped the country rebuild itself on a material and social level with the support of the government. For example, UNESCO helped rebuild the city of Mosul with the Revive the spirit of Mosul program in 2018, Education above All, and Save the children helped children get back to school.

7. COVID-19 PANDEMIA

In May 2020, the COVID-19 pandemic hit Iraq. The promiscuity of the camps and the weakness of the services in the country advocate the management of the disease. In the context of the global health crisis and containment measures spread to many countries, humanitarian organizations are struggling to maintain optimal support.

- Poverty increases from 22% to 34%.
- Failure of the health system
- Disruption of the education system
- Labour market crisis

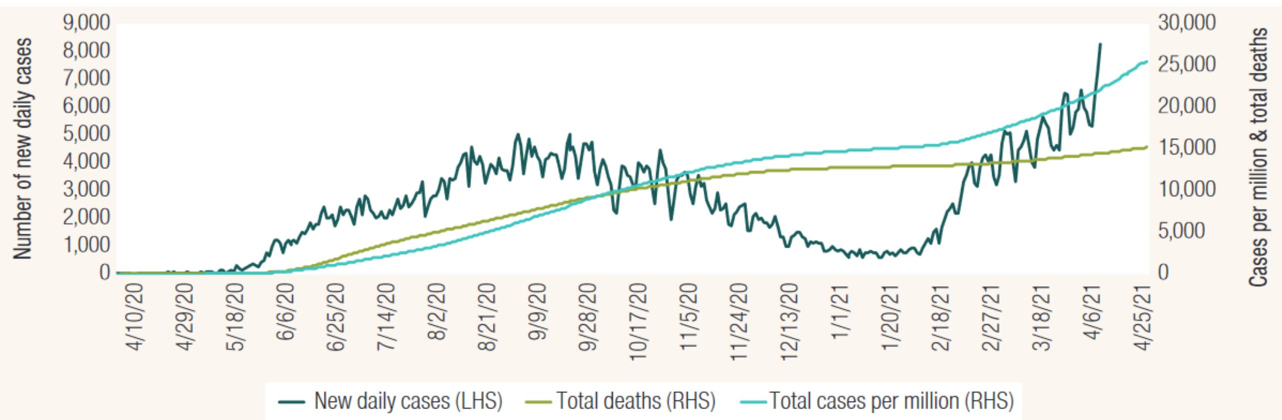


Fig. I-18. Evoluzione degli casi di COVID-19 in Iraq (WorldBank Group, 2021)

THE CITY OF MOSUL

1. NATIONAL LEVEL

Fig. I-19.Localizzazione

Mosul is located in the north of Iraq and lies at the foot of the mountains of Kurdistan. Administratively, it is the capital of the Nineveh governorate in the south of the Kurdish province of Dahuk. Part of the governed is Kurdish. Mosul remains the most important city in the north of the country both demographically, politically and economically.

2. NINEVEH GOVERNORATE

محافظة نينوى

Capital city.	Mosul
Surface area.	37 323 km2
Population.	2 811 000 (2012)
Density.	75 inhabitants/km2

In 1976, Iraq is in the hands of 19 governors to facilitate the administration of the territory. Today three governments are autonomous forming Kurdistan and four are semi-autonomous. In the midst of these is the Governor of Nineveh. It has a particular political situation given its proximity to Kurdistan and its border with Syria. Kurdistan recalls a part of the territory of Nineveh. It offers a diversity of landscapes that characterizes Iraq with mountains, plains and desert.

The governorate is divided into eight districts. The three main ones are Al-Mosul, Sinjar and Tel Kaif. The North concentrates population and activity in the major cities.

The population is divided between Arabs, Kurds, Turkmen but predominantly Sunni.

Fig. I-20. Mappa del governorato di Ninive

3. THE CITY

لصوم
ڵسووم

Altitudine.	223m
Superficie.	180 km2
Popolazione.	721 000
Densità.	3 700 abitanti/km2

Mosul is an ancient city of the seventh century BC. The eastern part was the capital of the Assyrian Empire under the name of Nineveh.

3.1. Quadro generale

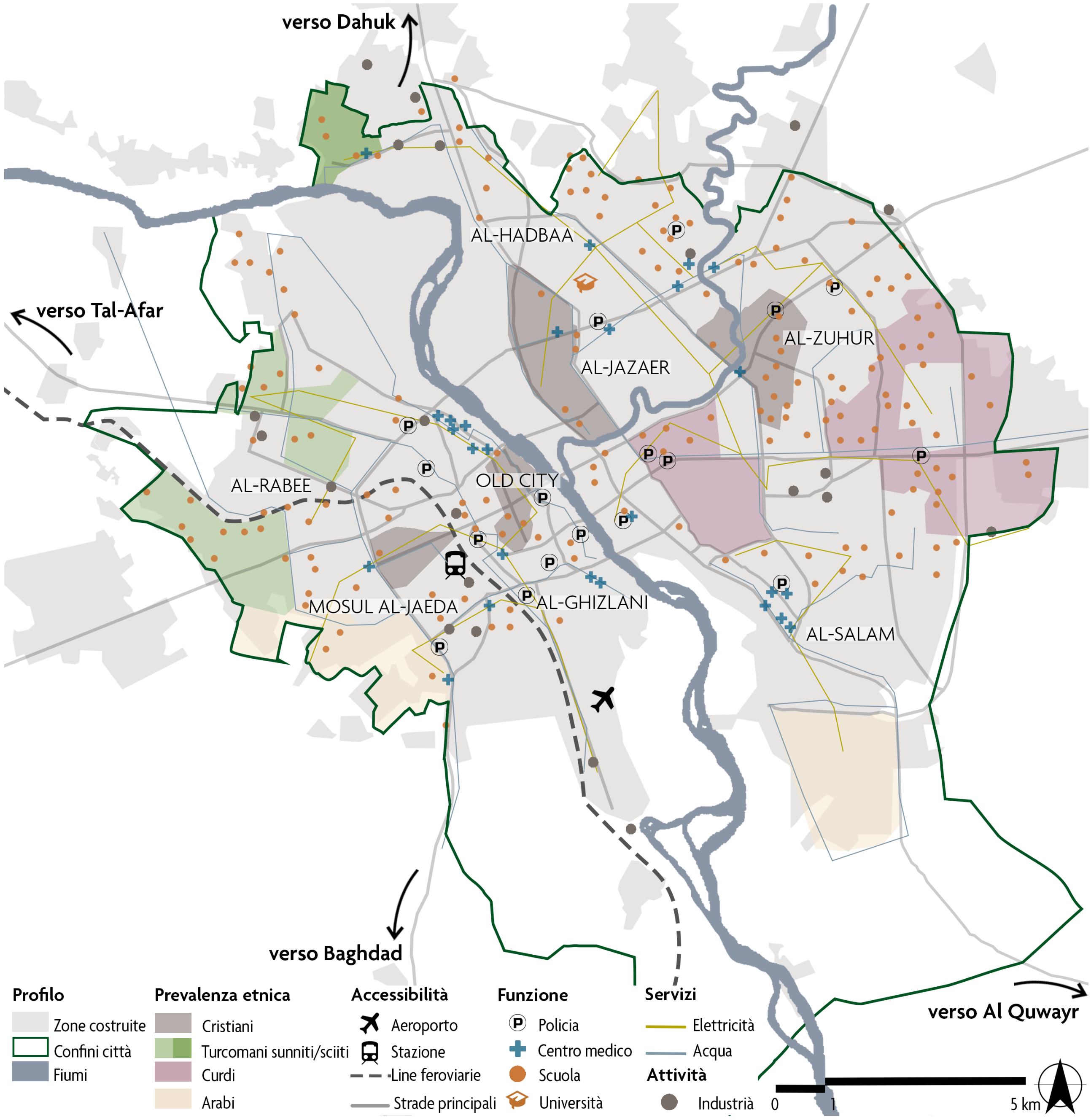


Fig. I-21. Mappa funzionale di Mosul

The urban and economic development of Mosul experienced a golden age during the Atabeg dynasty in the twelfth century. During this period the Al Nouri mosque was built. In 1926, with the defeat of the Ottoman Empire, Mosul became the capital of Nineveh. It was the second most important city in Iraq. Due to its political importance in northern Iraq, Mosul was taken by Daesh in 2014 and makes it its capital. On July 9, 2017, Mosul was liberated from jihadists.

Fig. I-23.Layout urbano di Mosul 1700

3.2. Urban evolution

Mosul is a growing city. It is founded on the west side of the Tigris River, in place of the Old Town district. During its growth it absorbed the remains of Nineveh. Urbanization has spread along the Tigris River and its tributary Khosr. Between 2014 and 2002, the city expanded by 68km2. The growth took place in the eastern part of the city while the masterplan envisaged an expansion to the west. The new neighborhoods are mostly informal without access to basic services. A revision of the masterplan was planned to control the growth of the city.

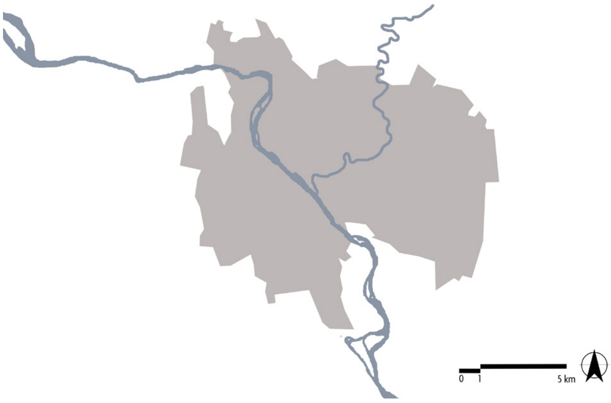


Fig. I-24.Layout urbano di Mosul 1944

3.3. Accessibility

Mosul is a road and rail junction on the Baghdad-Aleppo line. There are five train stations in the city. Mosul is connected to Raqqah by Highway 47. There was an international airport in Mosul, but because of the war it is no longer operational. A relocation project is underway to build a more suitable airport.

Fig. I-25. Layout urbano di Mosul 2000

3.4. Demography

The city was multicultural and brought together Arabs, Kurds, Turkmen, Shabachi, Assyrians and Chaldeans. It was an important place for Iraqi Christianity. There were three main buildings for Christians that were then all demolished by Daesh. It is estimated that about 80% of the population is Sunni Muslim. Generally peoples live together in the city, however some neighborhoods are dominated by a group. Taking into account the discrimination instituted by Daesh, it is to be thought that the current situation in Mosul has changed.

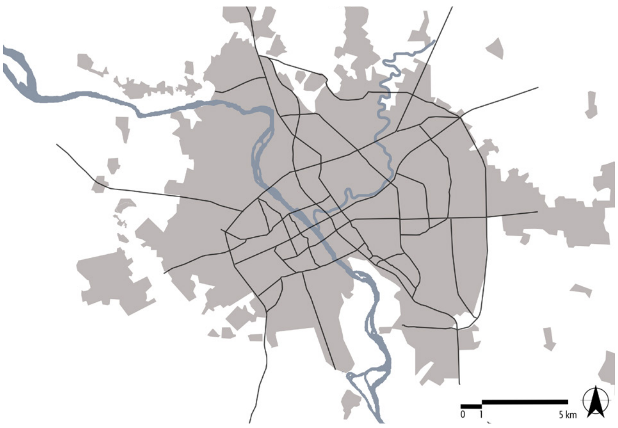


Fig. I-22.Layout urbano di Mosul 2016

4. A CITY IN RECONSTRUCTION

Fig. I-26. Fotografia di una strada nella Città Vecchia, Mosul, 2020 ©Levi Clancy

For the governor of Mosul, the starting point for the reconstruction of the city was the Conference for the reconstruction of Iraq held in February 2018. During this conference, the help of international forces was requested for the reconstruction projects of among other 25 000 houses, 2 hospitals, 2 bridges...

4.1. Current challenges

4.4.a. Policy challenges

The reconstruction of the city has become a political challenge between foreign countries, humanitarian organizations and the governor of Mosul. In this context, cases of corruption in the Iraqi authorities are spreading. In addition, the intervention of foreign governments is sometimes conditioned by political influence over the future performance of the country.

4.4.b. Economic challenges

Rebuilding a country costs a lot. Iraq is one of the top oil producers, but except for this resource, there are not so many opportunities. For now, Iraq is dependent on external media. Due to all the events of the last decades, Iraq has lost 40% of its agricultural production. Today in its normal functioning, without taking into account reconstruction, Iraq imports 70% of the resources. Depending on import is not a long-term solution. The development of its domestic and international economy is critically necessary.

4.4.c. Societal challenges

The occupation of Mosul by Daesh has created a strong split in the population. During the three years, many people joined Daesh. Today, their families are stigmatized. It is impossible for them to get ID cards, without these they can not get a job or go to school. Anger is strong and resentment increases.

4.4.d. Cultural challenges

The occupation by Daesh has changed the city. A new way of life has been imposed. New and different ideas have been put into the mentalities of children. The historical heritage in opposition to the ideas of Daesh has been destroyed. The military intervention caused other damage. From a cultural and identity point of view, the city is being changed. Today, reconstruction has the responsibility to revitalize the historical culture while respecting the last few years that have changed the inhabitants.

4.2. Revive the city of Mosul

Revive the Spirit of Mosul is a program for the reconstruction of the city of UN-Habitat, UNESCO's subdivision for the development of cities and other housing areas. The strategy focuses on housing recovery for the 15 000 families who have moved to the camps and economic recovery.

4.4.a. Priority

The strategy for the entire city is summarized in 16

Fig. I-27. Logo del programma del UN-Habitat

points. It is mainly about rehabilitating the structure of the city thanks to the services.

1. Provide new residential investment projects
2. Update informal accommodations
3. Rebuilding the plants of the agricultural industry
4. Rehabilitating markets
5. Developing the new Mosul International Airport
6. Rebuilding the Ministry of Water Resources
7. Rebuilding the Ministry of Agriculture Building
8. Develop the infrastructure for the new industrial area
9. Completing the peripheral road of Mosul
10. Rebuilding the bridges over the Tigris River
11. Rehabilitate the key facilities of al-shifa hospital
12. Renovate bus stations and lines
13. Start the redevelopment of the railway station
14. Building new greywater treatment stations
15. Setting up waste recycling plants
16. Establish a large public park in the west zone

The historic center of Mosul was one of the areas most affected by the war. For this reason, the Revive Mosul program pays special attention to this neighborhood. In the old town, all services are to be put back in place, find accommodation for the inhabitants to stay and above all protect the historical heritage.

4.4.b. Architectural considerations

Context

Historically, Mosul is a Muslim city. The Old City was a fortified city with the main mosque at its center. In the city before 2017, the historic buildings follow two different architectural styles. The Zengid style, born with the Atabeg dynasty, is a simple style, based on proportions and simple geometry. Zengid buildings are rectangular courtyard. The Badr Al-Din Lu'lu style, born from the Yazidi influence, is much more decorated.

The typical residential building of Mosul is a rectangular or squared court house. Up to four floors, it is built mostly with terracotta bricks and river stones. Architecturally, the buildings follow the principles of Muslim vernacular architecture. The spatial organization is oriented towards the courtyard thanks to open transition spaces.

4.4.c. UN-Habitat Strategy

The destruction of the city offers the possibility of building better. UN-Habitat, aims to be the regulator and supervisor in the reconstruction. This program aims to organize the reconstruction in accordance with the architectural layout and culture of the city. So it includes training and communication on how to design in accordance with the city.

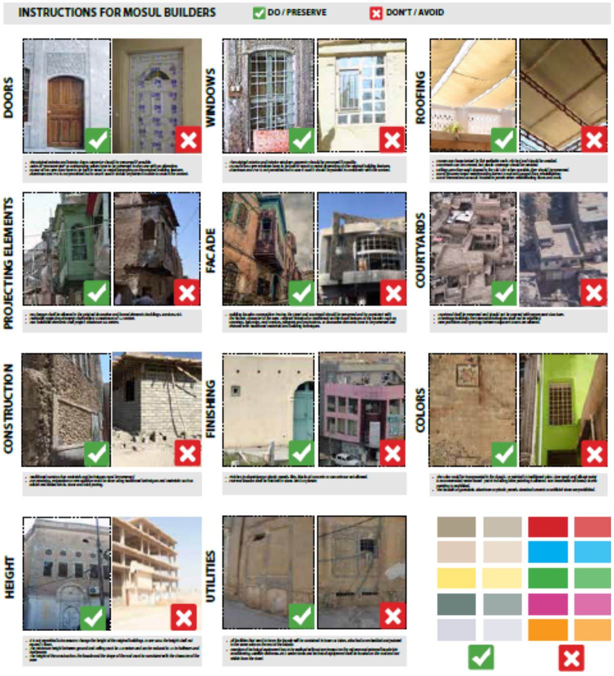


Fig. I-28.Istruzione architettoniche ©UNESCO

4.4.d. Schools

The Revive the Spirit in Mosul programme launched a competition in November 2020 for the reconstruction and rehabilitation of the Al Nuri complex. The project will take place around the Al Nuri Mosque, creating a religious, community and educational space. A secondary school and a high school are planned as an extension to the religious complex. This thesis is concerned with the design of the school. The Voices of the Children of Old Mosul programme, brought in by the Government of Japan, was born with the same intention. This programme requires the reconstruction of primary schools and the accompaniment of teachers in the transition. The involvement of humanitarian organisations does not stop at the material level. They seek to accompany the educational systems in their education, social opening, international development...

UN-HABITAT
FOR A BETTER URBAN FUTURE
IRAQ COUNTRY OFFICE

UN-Habitat would like to thank the following partners for their generous contributions: European Union, Government of Japan, the United States of America, Iraq UNDAF Trust Fund, Germany, Iraq Ministry of Planning, Alwaleed Philanthropies, Kuwait Relief Society, Iraq Humanitarian Fund and France.

ISSUE 7 — July 2021

UN-Habitat partners with Mosul University for "Engineering Week"

UN-Habitat Iraq partnered with the Faculty of Engineering of Mosul University to hold the 2021 edition of the Engineering Week under the theme "Building Back Better" – key urban recovery approach of the European Union-funded programme "Supporting Recovery and Stability in Iraq through Local Development". Academics and practitioners specialised in environmental sustainability delivered 27 public lectures and 67 students publicly presented their final year projects. One of the major highlights of the event was the organisation of an Exhibition Fair where 13 Iraqi companies displayed innovative construction materials and renewable energy solutions produced in Iraq. The Fair alone was visited by over 1,000 people.

Fig. I-29.Estratto dalla newsletter di UN-Habitat Iraq©UNESCO

CLIMATOLOGY OF MOSUL

The city of Mosul is located in the northern belt where the climate is arid except for a few months of the cold season. It is its place in the plains along the Tigris River that allowed Mosul to have a less extreme climate than other Iraqi cities.

Thanks to the History+ climate estimation software from MeteoBlue, it was possible to bring together climate data to analyze the climate of the cities of Mosul.

1. TEMPERATURES

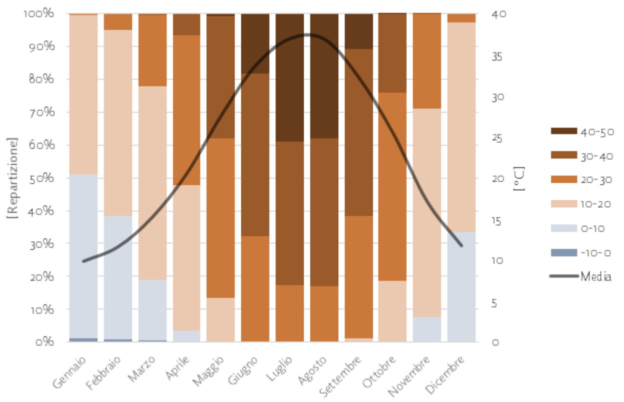


Fig. I-30. Profilo di temperature annuale

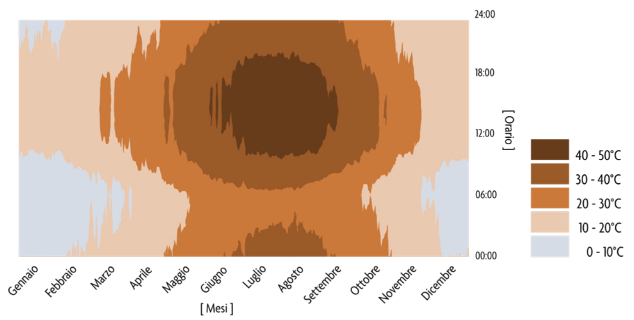


Fig. I-31. Profilo di temperature orario

In the warm semester, the weather is extremely warm with the highest monthly average of 37°C in August. During the two hottest months, July and August, 39% of temperatures are between 40°C and 50°C. 10% of temperatures are between 20°C and 30°C, which represents night temperatures.

In the cold semester, the climate is milder. Temperatures drop with a lower monthly average of 11°C. From November to March about 30% of temperatures are between 0°C and 10°C. At the maximum extreme the temperature rises to 30°C.

In the time profile, it appears that throughout the year night temperatures are much lower than during the day. This is due to the lack of moisture in the air: the water contained here helps to reflect heat and consequently to trap daytime heat.

2. SOLAR RADIATION

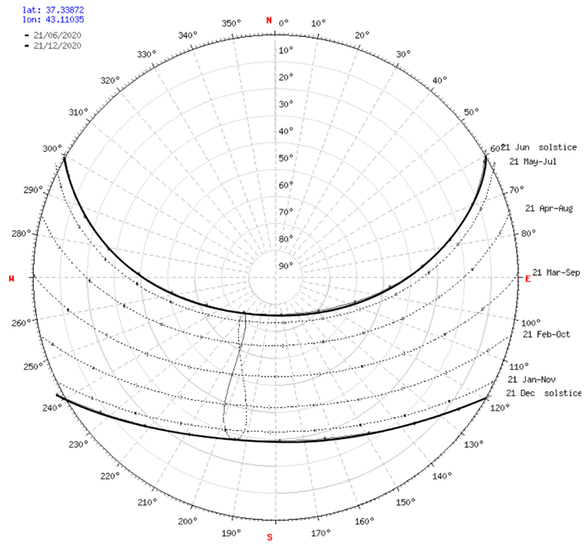


Fig. I-32.Orientamento del sole a Mosul ©SunEarthTool

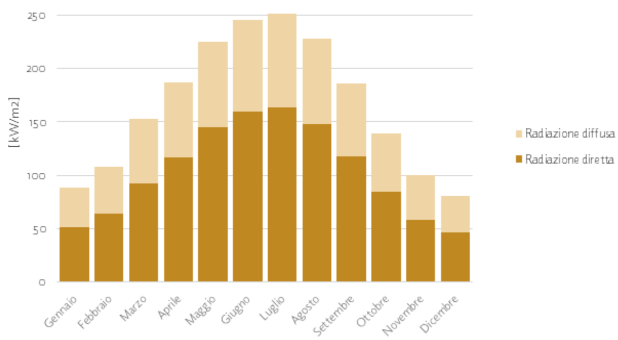


Fig. I-33.Profilo di radiazione annuale

The Solar radiation profile has a summer maximum with 160 kW/m2 of direct radiation and 90 kW/m2 of diffuse radiation. The minimum reached is 50 kW/m2 of direct radiation and 35 kW/m2 of diffuse radiation.

Due to its location in the northern hemisphere, solar days lengthen in summer and reduce in winter. Solar availability is maximum in June with about 12 hours. In winter, it is minimal with about 7 hours. Of course, due to the course of the planet around the sun, the winter sun is less powerful: in Mosul the radiation does not exceed 600W/m2 in winter.

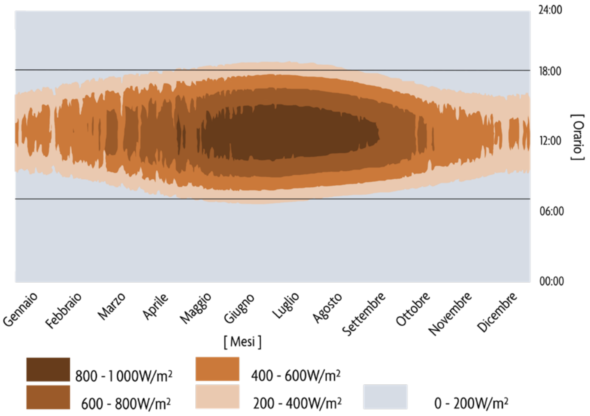


Fig. I-35. Disponibilità solaria

3. PRECIPITATION AND HUMIDITY

Rain occurs only during the winter months. From October to May, there are about seven rainy days per month. Due to climate change it has snowed in Mosul twice in the last ten years.

Rainfall is not enough to give Mosul water self-sufficiency. This is why the Mosul dam, the largest in Iraq, was built.

The external relative humidity reaches a maximum of 55%. In summer the climate is very dry with 10% humidity.

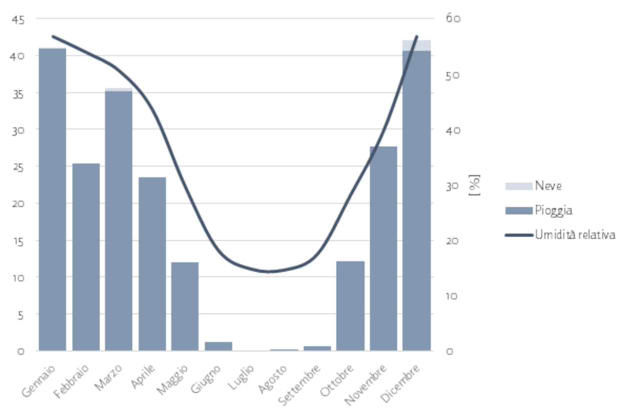


Fig. I-37. Profilo idrometrico annuale

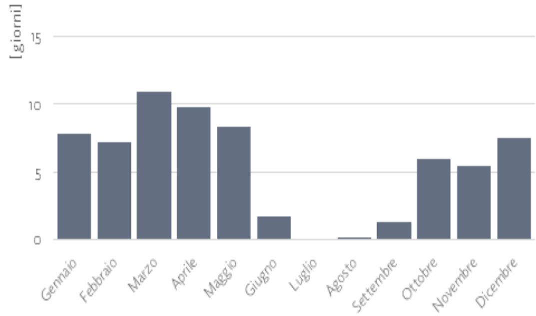


Fig. I-36. Disponibilità idrometrica mensile

4. WIND

The wind that blows throughout the year is not strong. It presents two different trends according to the season.

During the cold semester, from May to August, the wind is light and constant about 1-2 m/s. It blows northwards. Instead, during the warm semester the wind blows more towards the West. There are slight gusts, which blow at more than 4m/s.

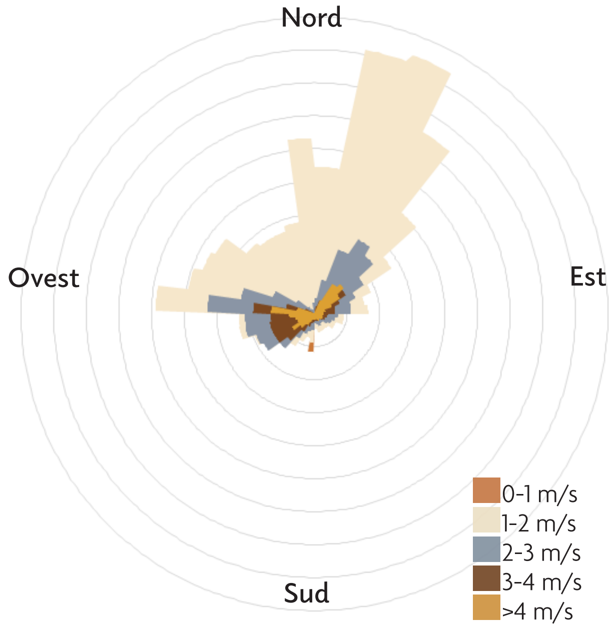


Fig. I-34. Profilo dei venti annuale

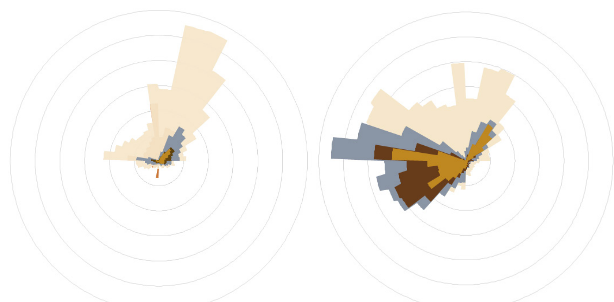


Fig. I-38. Profili nelle stagioni fredda e calda

THE EVOLUTION OF EDUCATION

In Iraq's second civil war, Mosul fell into the hands of Islamic State jihadists in June 2014. For three years, the city was occupied by jihadists. The release was officially completed on July 9, 2017. Onwards, the fugitives are returning to the city to recover a normal life. But all aspects of daily food have been changed. the education system has been deeply affected in these four years.

1. BEFORE THE 2000S

Criteri	Tasso
Alfabetizzazione, totale adulti (% delle persone di 15 anni e più)	74
Alfabetizzazione, totale dei giovani (% delle persone tra i 15 e i 24 anni)	84.7
Frequenza Educazione della prima infanzia	5.23
Frequenza Primaria	88.8
Frequenza Secondaria inferiore	37.7
Frequenza secondaria superiore	12.1
Completamento Primaria	56.2
Completamento Secondaria inferiore	28.6
Gravidenza adolescenziale (nascite per 1.000 donne tra i 15 e i 19 anni)	63.8
Bambini in lavoro, studio e lavoro (% dei bambini occupati, età 7-14 anni)	48

Tab. I-02. Situazione in Iraq, inizio 2000 @WorldBank e MICS

1.1. The school system

6.1.a. Generality

The Iraqi education system begins at about 4 or 5 years old when the child starts kindergarten. It is not mandatory. The government has made school compulsory from the age of six and for the duration of primary school. As a result, public primary schools are free.

Despite this government move, in 2013 26% of children under 15 remained illiterate.

6.1.b. Academic career

After primary school, children enter middle school for three years, where genders are separated. In middle school, they have 34 hours of classes per week with Islamic education, Arabic language, English, science, history, geography, social studies, mathematics, art education and military physical education. In addition, the girls have lessons in home education. Kurdish, sociology, economics and patriotism education are optional. At the end of middle school, they pass a certification exam at the end of studies.

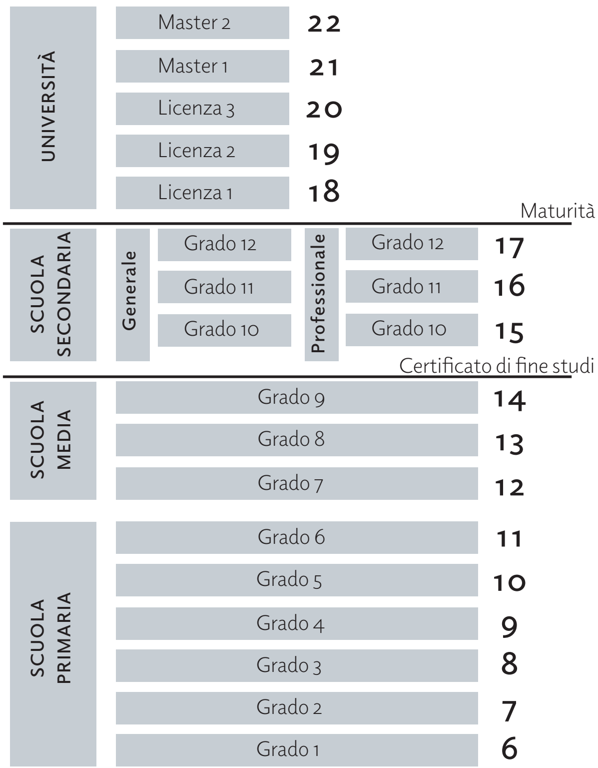


Fig. I-39. Sistema scolastico iracheno

After passing the certificate, students enter secondary schools for three years. They are divided into two types: schools of general education and schools of vocational education. Vocational schools allow you to work in the agricultural, industrial or commercial sector. The study in secondary school is validated by the baccalaureate exam.

Following a general secondary school, students have the opportunity to enter the university on condition of passing the entrance exam.

6.1.c. Calendar

The academic calendar runs from the beginning of September to the end of June. Teaching is interrupted twice, for winter holidays at the end of December and for spring holidays in mid-March and in addition national holidays. During the summer closure period some students attend the summer school.

6.1.d. Cultural profile

Iraqi public schools tend to be mono-cultural although this is not encouraged by the government. There are schools with multicultural classes that bring together different religions, particularly in cities with a strong demographic difference.

1.2. The institutions of Mosul

In Mosul, there are 56 nurseries, 435 kindergartens, 362 elementary schools and 112 middle schools, 78 secondary schools and 3 universities.

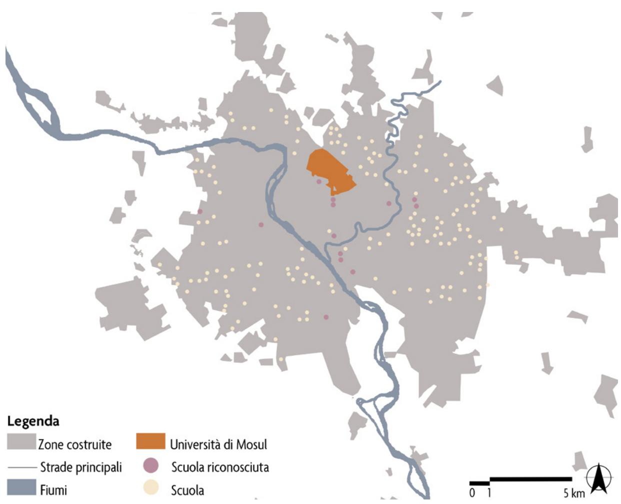


Fig. I-40.Localizzazione dell'istituzione

2. JIHADIST OCCUPATION

Criteri	Tasso
Alfabetizzazione, totale adulti (% delle persone di 15 anni e più)	82
Alfabetizzazione, totale dei giovani (% delle persone tra i 15 e i 24 anni)	92

Tab. I-03. Situazione in Iraq, 2016 @WorldBank

In this period it was not possible to obtain precise data for clear reasons.

2.1. Change of government

During the three years of the occupation, Daesh imposed a new culture and new rules on the inhabitants of Mosul.

6.2.a. The constitution by Isis

Art 1. Congratulate the followers of the SIS for the release of prisoners

Art 2. Talk about the rebirth of the glory of the Islamic Caliphate and fight the injustices imposed on its citizens

Art 3. Notice how Isis will treat citizens based on their needs

Art 4. The followers of Isis will have justice

Art 5. The public money in the banks will all become the property of ISIS which will use it according to its needs.

Art 6. Mosques are the most important buildings of the Islamic State and are used as a place of prayer

Art 7. Instruct the citizens to follow the order of the religious of the Caliphate and obey them

Art 8. Citizens must never have to deal with the central government and its representatives

Art 9. Policemen and soldiers must leave their jobs immediately or they will be punished

Art 10. Citizens are forbidden to carry any type of weapon

Art 11. All the peoples of the Islamic State must live together

Art 12. When Isis has completed the liberation, it will rule with justice

Art 13. All shrines and tombs will be destroyed

Art 14. Women will have to follow Islamic rules and wear Islamic clothes

Art 15. Everyone will have to rejoice and enjoy life in the Islamic State

Art 16. The secular regimes under which the peoples have lived end up under the rule of Isis

2.2. Educational reform

6.2.a. A new ideology

When ISIS militants arrived, they closed all schools to rewrite the program according to their jihadist values. They distributed the free sign books to spread the idea. The militants forced the boys to watch the executions and propaganda videos. They taught how to use weapons.

Fear of the influence of Daesh's ideology makes families reluctant to send their children to schools.

6.2.b. De-schooling

Under the law of Daesh, girls are forbidden to study any scientific subject. Interest in receiving an education dissolves. Despite the victory of Daesh, the city is not at peace, violence is used as a weapon against those who try to resist the law of Daesh, arrests and destruction flood the streets. The streets are not safe and many parents make the decision to ban their daughters from going out.

In addition, Daesh imposes tuition fees on students in all schools, including public schools. Families whose free education allowed children to go to school withdraw their children. Often children start working, among other things to compensate for the loss of work of the father.

In fact, economic insecurity is amplified with the crisis that is affecting the city now cut off from the world.

As a result, many children did not go to school during the three years of employment.

3. A LIBERATION WITH CONSEQUENCES

3.1. Material damage

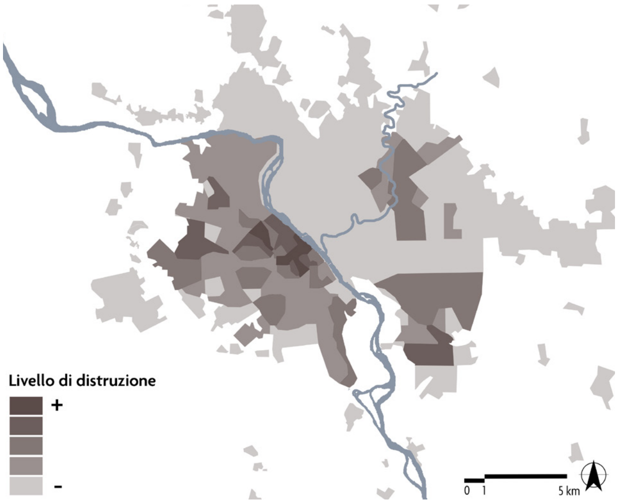


Fig. I-41. Quartiere con danneggi materiale

The first impact of the war is material. Fifteen out of fifty-four neighborhoods were destroyed. In the old city nine school installations were destroyed during the war and many others damaged.

With their house destroyed, many people cannot return to live in the city. The reconstruction will change the demographic profile of the city. So the needs in schools in the city will change.

On some sides, electricity and running water services do not work. It disturbs the operation of public buildings and lowers comfort.

With stations and railway lines damaged, Mosul remains cut off from the country. In addition, damaged bridges and the state of the roads slow down the inner workings of the city. Only 10% of Mosul's neighborhoods have access to school. Non-operational transport systems prevent other neighbourhoods from accessing education.

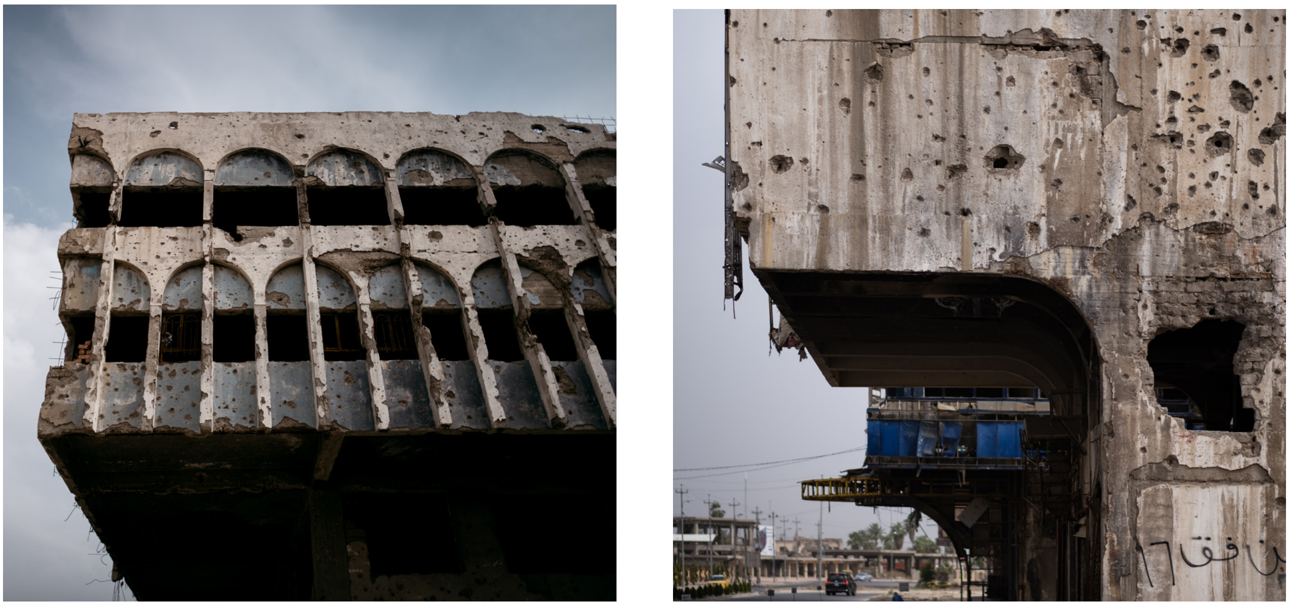


Fig. I-42. Edificio della Città Vecchia, 2020 ©Levi Clancy

3.2. Influence on the school system

The slowdown in the city's economy puts the inhabitants in a situation that makes it necessary for public schools to function.

Today they have redone the entire school program. In addition, it is necessary to dismantle the ideas that ISIL has put into young mentalities. In addition, the school system needs to be reformed to take into account the psychological impact of employment on people in order to help heal them. In addition, it is necessary to increase the capacity of compulsory classes to integrate children who are at least three years away from school.

Criteri	Tasso
Alfabetizzazione, totale adulti (% delle persone di 15 anni e più)	85.6
Alfabetizzazione, totale dei giovani (% delle persone tra i 15 e i 24 anni)	93.5
Frequenza Educazione della prima infanzia	2.4
Frequenza Apprendimento organizzato	32.0
Frequenza Primaria	91.6
Frequenza Secondaria inferiore	57.5
Frequenza secondaria superiore	33.1
Completamento Primaria	75.7
Completamento Secondaria inferiore	46.4
Completamento secondaria superiore	44.3
Totale lavoro infantile (% dei bambini dai 7 ai 14 anni)	7.3

Tab. I-04. Situazione in Iraq, 2018 @WorldBank

CHILD PSYCHOLOGY

Iraq has experienced many periods of violence. This generation has survived numerous traumas. Although the inhabitants of Mosul have shown themselves to be quite resilient thanks to Iraq's past, the four years of occupation and conflict have left deep marks.

"Remember what my father used to say: our past is sad, our present is tragic. Luckily we have no future." Zero kilometer

The children of Mosul have not all seen the same situation. Some left when ISIS attacked the city in 2014 and did not experience the occupation. Others fled during the occupation or when the Iraqi government began liberating the city. Some inhabitants remained in Mosul all the time. These three populations have experienced different things, but they have all experienced a radical and violent change in their lives.

What is the psychological repercussion of an experience like the one that the people of Mosul have experienced?

1. GENERALITY

1.1. Children

Children are particular human beings, they are not stable. Their personality, their thinking is being built.

Freud distinguishes different states of development of a child. Children enrolled in school go through two states: the latency period between five to twelve years and a period of socialization and greater learning. Adolescence is the most important period when the word is overcome by the will to act to have one's independence.

1.2. Birth of the disorder

A strong event generates an emotional and psychological load that is sometimes not overcome by the subject. Then the individual implements mechanisms of psychological and physiological safeguard. Very often it is expressed with different post-traumatic stress disorders, mood change, anxiety creation...

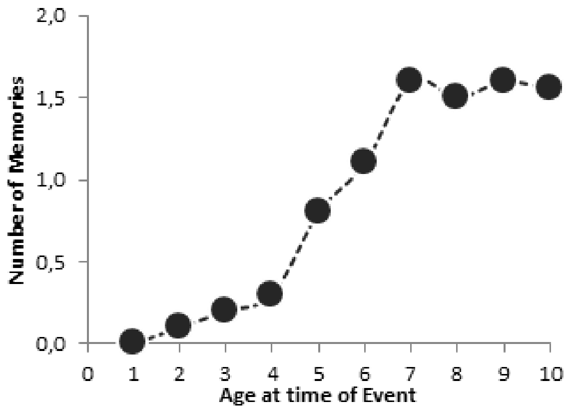


Fig. I-43.Ricordi creati dai bambini @Rubin et al.

1.3. Sensitivity of children

Children are the most exposed to the consequences of trauma. They are growing, so they are very malleable. Children arespective, absorb everything that happens around them. They are hypersensitive, the same event has the potential to tear??? a child is stronger than an adult. They are, among other things, more sensitive to poor nutrition. In such a situation of generalized stress, the impact is aggravated by addiction to their parents.

Children have a greater ability to adapt. They may suffer less from war because they tend to adapt more easily, feel less worried, and are too young to understand. In addition, they have more future to distract them from the past. Children are less vulnerable during the latent period.

2. PSYCHOLOGICAL IMPACT OF WAR

Studies show that war victims have between a 15 and 50% chance of suffering from post-traumatic stress and a 15% up to 70% chance of falling into depression.

2.1. Development factor

The appearance of psychological trauma after living a violent experience is favored by certain factors.

Among the risk factors are traumatic events, poverty, marginalization, poor physical health, collapse of social networks, daily stress, lack of control, lack of school education.

Among the protective factors to increase the resilience of the population are social network, social support, employment, leisure activities, the possibility of performing cultural rituals and adaptability.

2.2. Symptoms

Children not yet enrolled in school tend to cry, have nightmares and difficulty sleeping. At an early school age, children tend to be nervous, irritable, intimidated and develop psychosomatic effects. In addition, they begin to be afraid to disturb others with their anxiety. At school age they have difficulty concentrating, have aggressive behavior or hyperactivity, or do not express their feelings. Adolescents have similar symptoms compared to school-age children, but they have access to material means. So they have a very strong tendency to self-destruction. In addition, their growing sense of responsibility increases their guilt.

Criteri	Tasso	Data
Alfabetizzazione, totale adulti (% delle persone di 15 anni e più)	85.6	2017
Alfabetizzazione, totale dei giovani (% delle persone tra i 15 e i 24 anni)	93.5	2017
Frequenza Educazione della prima infanzia	2.4	2018
Frequenza Apprendimento organizzato	32.0	2018
Frequenza Primaria	91.6	2018
Frequenza Secondaria inferiore	57.5	2018
Frequenza secondaria superiore	33.1	2018
Completamento Primaria	75.7	2018
Completamento Secondaria inferiore	46.4	2018
Completamento secondaria superiore	44.3	2018
Donne che si sono sposate all'età di 15 anni (% delle donne di 20-24 anni)	7.2	2018
Gravidenza adolescenziale (nascite per 1.000 donne tra i 15 e i 19 anni)	71.2	2020
Difficoltà funzionali 5-17 anni	22.1	2018
Totale lavoro infantile (% dei bambini dai 7 ai 14 anni)	7.3	2018
Bambini in lavoro, studio e lavoro (% dei bambini occupati, età 7-14 anni)	66.4	2011
Bambini in lavoro, lavoratori salariati (% dei bambini che lavorano, età 7-14)	11.7	2011
Bambini in lavoro, lavoratori familiari (% dei bambini che lavorano, età 7-14)	81.2	2011

Tab. I-05. Situazione in Iraq, 2018 @WorldBank

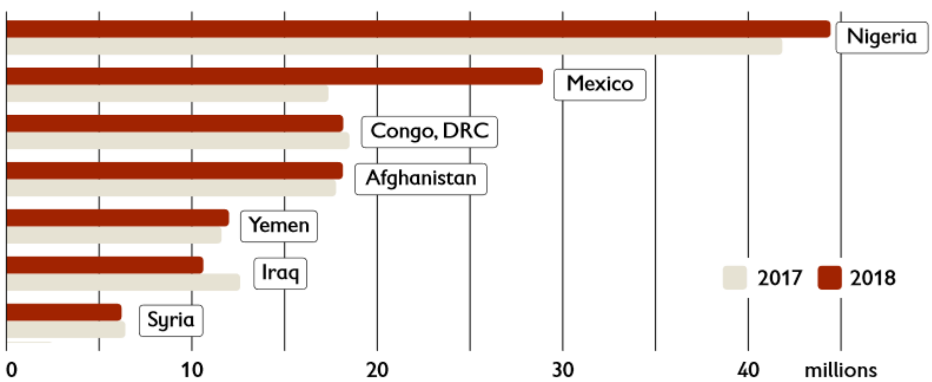


Fig. I-44. Bambini che vivono in zona di guerra intensiva @Save The Children

3. SITUATION IN IRAQ

Due to its history full of instability, the indicators for children are red compared to a Western country.

3.1. The war

During the jihadist expansion in 2016, Iraq was considered by the body Save The Children as the seventh country in conflict most dangerous for children. In fact, the civilian population including children is not spared from conflicts, sometimes civilians are used as means of war. The consequences are multiple for children. Except for the psychological impact directly due to the violence experienced, daily life is changed with poverty and precariousness that drive school children away.

3.2. Geographical disparities

Obviously, the Iraqi situation does not reflect the situation of the nineveh ruler or even that in Mosul. The inequalities observed are partially due to the war, the provinces along the river being much more affected. Other factors, such as the level of urbanization, economic development, the standard of living of the population, influence disparities. From this point of view, the situation in the governed Nineveh is problematic. The malnutrition rate and mortality under five years provide a picture of the situation of poverty and the precariousness in which children live.

The potential for development in early childhood is measured as a rate i.e. the Early Child Development Index (ECDI), currently represented in the Multiple Indicator Cluster Survey (MICS) which assesses children aged 36 to 59 months in four domains: language/literature, calculation, physical, socio-emotional and cognitive development. Each of these four domains is measured through instruments based on real-time observation. This rate demonstrates the advancement or delay that children will bring to school.

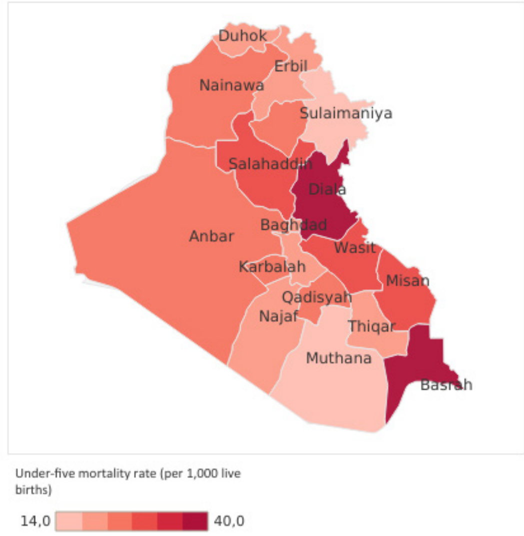


Fig. I-45. Mortalita sotto 5anni @SaveTheChildren

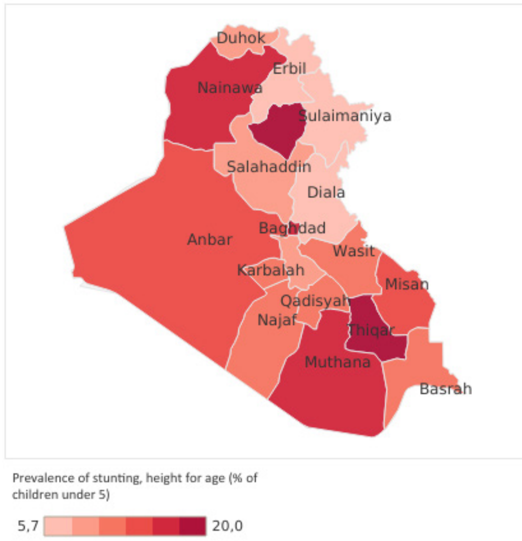


Fig. I-46. Malnutrizione @SaveTheChildren

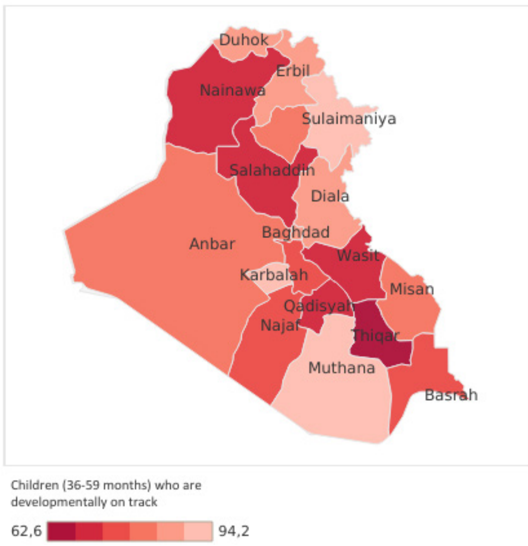


Fig. I-47. Potenziale di sviluppo @SaveTheChildren

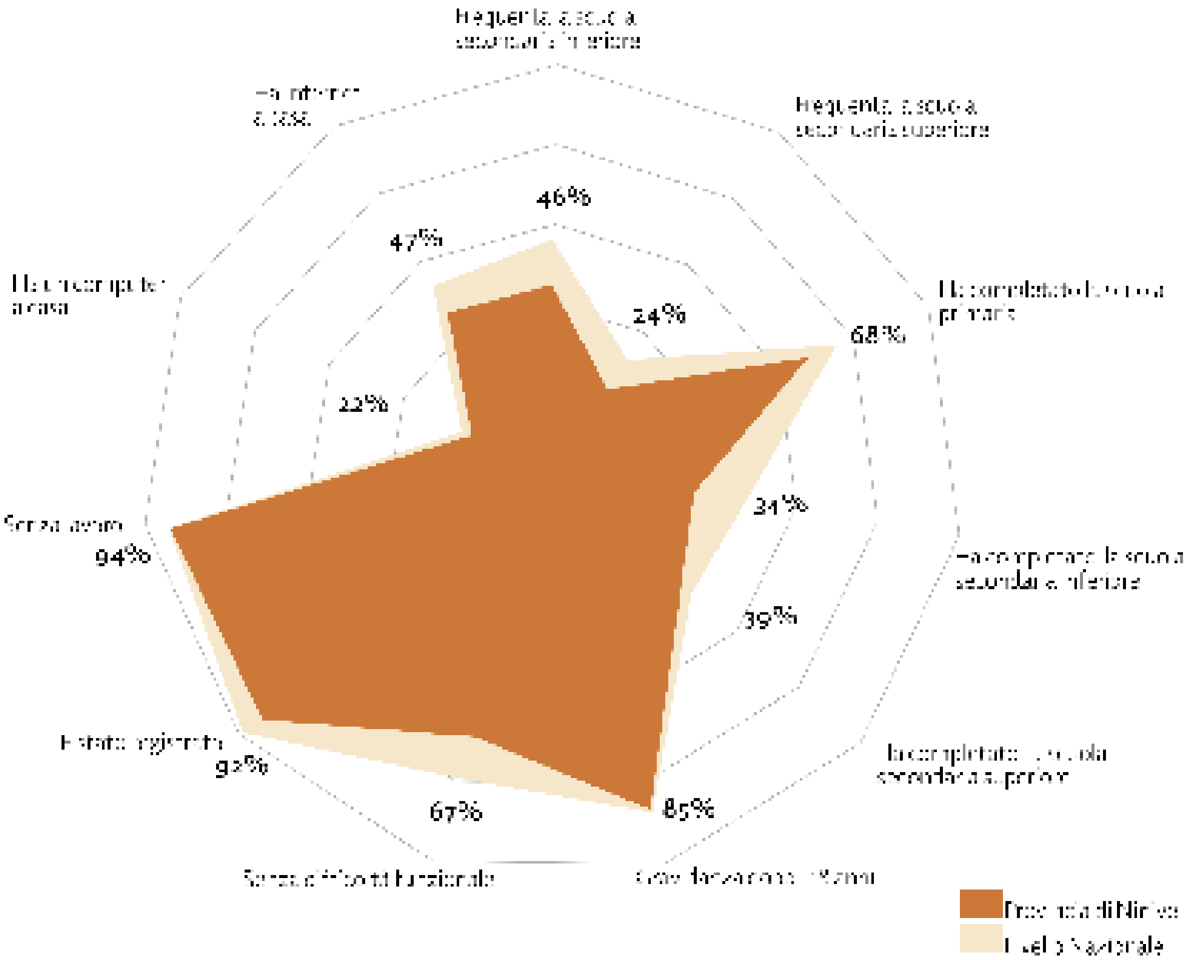


Fig. I-48.Situazione di Ninive, con data da MICS

3.3. Nineveh inside Iraq

Thanks to the MICS report, it was possible to know the living conditions related mainly to the education of children in Nineveh. The situation within the governed is slightly worse than the average situation in the country.

Fig. I-49.Logo SaveTheChildren ©SaveTheChildren

We need a global improvement in the living conditions of children.

4. THE CHILDREN OF MOSUL

In 2017 and 2018 the humanitarian organization Save The Children conducted two studies on the psychological impact of events on children in Mosul. About 600 children and their relatives from the shelter camps were studied.

4.1. Children's experience

All children have experienced events of strong violence. Almost everyone has seen a member of their

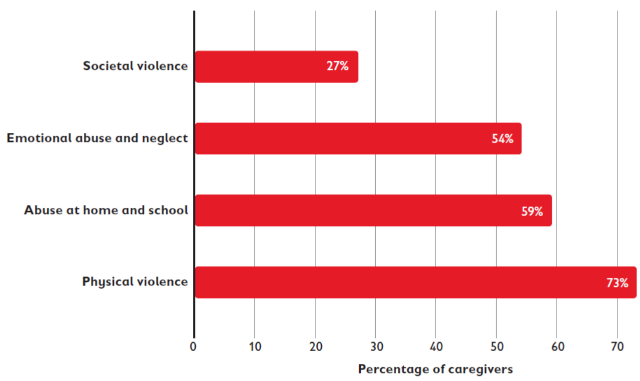


Fig. I-50.Tipi di violenza sui bambini riportati dagli curatori ©SaveTheChildren family be killed.

In the refugee camps, the situation was precarious with financial problems and insecurity. Boys went to work, girls got married before the age of fifteen, and about 50% of children did not go to school.

After the liberation, the population found a city of Mosul destroyed. With half of the schools damaged in conflict-affected areas.

4.2. Psychological response

76% of children have changed their behavior. They are introverted, nervous, aggressive. Many have difficulty sleeping and have nightmares. But children who fled before the ISIS occupation have fewer symptoms of post-traumatic stress.

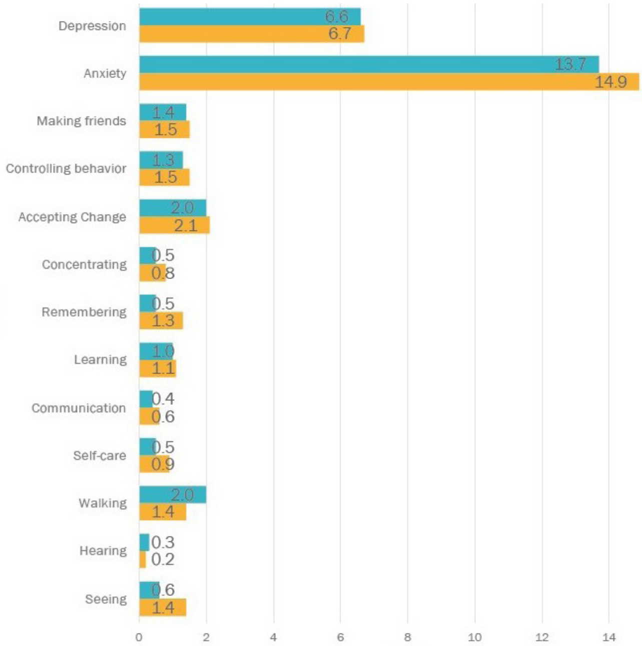


Fig. I-51.Difficoltà di funzionamento negli adolescenti in iraq©MICS

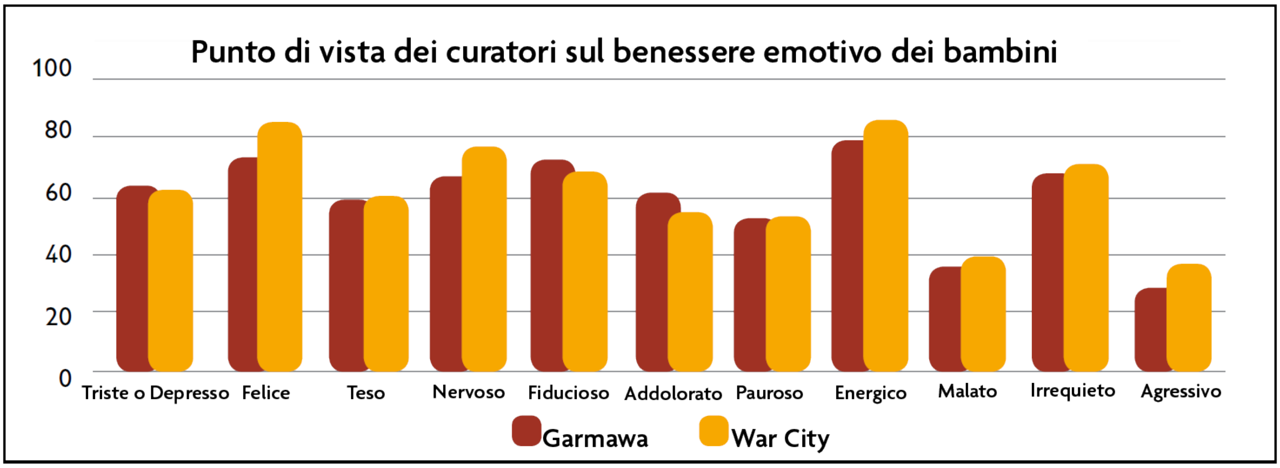


Fig. I-52.Stato mentale dei bambini nei campi vicini a Mosul ©SaveTheChildren

The idea that most disturbs the minds of children is that they do not have a secure future. The feeling of hopelessness is enormous. In save the children's second study, 30% of parents report an attempted suicide by their child.

During the four years, the children experienced a situation of cumulative stress.

4.3. Media

The first support for children was the family, but parents are also victims of post-traumatic stress and this makes the situation at home more complex and violent.

School has a greater importance in the recovery of children. In the Garmawa camp, AbdulAzim a child's grandfather wrote this: ''We got electricity, water, toilets and, most importantly, a school: a space for children, the only safe place to play and be children again. This had a huge influence on them: they went every day and came back different, you could feel the joy on their faces. Since it was closed weekends, the kids hated the weekend and wanted time to pass quickly so they could go back to school. This space, theirs, had been recovered at least 70% of the time before the crisis.'' The school allowed children to cultivate a sense of belonging to a community.

4.4. Proven solutions

Save The Children has organized activities based on heart (Healing and education through the arts), SEL (Social and Education Learning) and the Mind Body program in the fields. They are methods that allow between gentle activity ??? such as limbs, meditation on being able to bring psychosocial assistance and give basic solution to children to manage themselves. Part of these types of programs can become solutions to be implemented on a large scale.

Fig. I-53.Obiettivi SDG 2030©UN

5. START OF SOLUTIONS

5.1. Worldwide

To solve problems in all countries of the world, the UN has defined 17 social sustainability goals to be achieved in 2030. Considering that the stability of the country leads to an improvement in mentalities, work on these goals is essential. Some goals are more directly related than others to the situation of children and have a stronger impact.

5.2. Psychological theory

According to Steven Hobfoll's theory, the pillars of psychosocial care are security, calm, self- and community effectiveness, social bonds, hope. The sense of security is created by objective reality and perceived reality. If security is not recovered, memories of the trauma are present. Calm helps in the management of emotions. Effectiveness and hope are engines for reconstruction. Social bonds help the support of the individual.

Mosul mainly needs to recreate a sense of community, security and hope.

5.3. In schools

7.5.a. Role of schools

The reconstruction of schools is essential. They are important places for the recovery strategy. It allowed to reverse in adolescents by putting back in school. Creating a sense of community at school is important. They have the task of inducing a feeling of security in children, but today schools are not safe places. Among other things, it is not recommended to use schools for another use in addition to education. The school is thus a privileged place for children and is no longer a strategic place used by the armed forces.

The worrying situation of the girls is an encouragement to create reserved places for them.

At school, a methodology of group education with different activities reinforces social ties.

7.5.b. Governmental movements

To protect schools, Norway founded the Safe School Declaration in 2014. The countries that sign it agree to do everything possible to protect the right to education, to ensure the continuity of education in conflict zones. They also agree not to use schools as places of military operations during a conflict, whether they are open or not. Schools must never be destroyed for military reasons. Military forces involved in the conflict should not be used to ensure the safety of a school, if possible a neutral force does. Iraq, unlike its neighbors, signed this declaration in 2015, it is important that it is respected today in Mosul.

The Iraqi government among the Iraq Education Cluster body recommits some services to ensure the well-being and protection of children at school:

Update the existing reference system and/or develop a new reference pathway that includes direct connection with the nearest healthcare facilities

Take specific steps to mitigate protection risks while girls and other marginalized groups are out of school through greater community involvement and better referrals

Establish and/or strengthen the Child Friendly feedback mechanism to ensure the full expression of boys' and girls' feelings about interrupting the learning process.

Physical education, sports and games, art etc. should be an integral part of co-curricular activities as part of physical and mental well-being

Sessions and support for teachers and children for psychosocial well-being are to be guaranteed

Ensure that schools are free of violence and that greater attention is exercised

Identify children who need additional support; use a reference system.

Share messages about fear and anxiety and promote self-care methods for all school-related communities

These recommendations are extended to the situation of the COVID-19 pandemic. Monitoring is planned to ensure the application of most of the rules.

SOME APPLICABLE PEDAGOGIES

The situation of children in Mosul is very special and is full of dangers for the new generation. The recovery of the educational system cannot be done in the traditional way in the continuity of the past. Traumatized children do not have the same interest, behavior, or even the same ability to concentrate as a normal child.

Alternative pedagogies are a way of helping to recover the education of children. They sometimes pass between architectural space.

1. MONTESSORI SYSTEM

Montessori pedagogy is one of the most widespread pedagogies in the world. It aims to teach the child to behave as a responsible and autonomous adult, taking into account all his rhythms, weaknesses and strengths.

1.1. Birth

Fig. I-54.Maria Montessori

This theory was developed by Maria Montessori in the 1900s, an Italian doctor born in 1870 in Chiaravalle. He began his research with mentally disabled children in Rome, then extended his methodology to all types of children, from pre-primary to secondary schools.

1.2. Principles

8.1.a. Let it go

And the main point of this ideology. Dr. Montessori is convinced that freedom is the perfect way to grow and learn. On the other hand, as long as freedom gives the mind the opportunity to absorb so many things unconsciously, a suitable scope of application is needed without endangering the safety of children.

The organization of the spaces develops with equal importance the internal and external spaces.

8.1.b. Didactic subject

Teaching uses physical material to give a concrete knowledge of the world. The teacher must observe the children manipulating objects

8.1.c. Autonomy

The methodology encourages autonomy to amplify self-confidence. The individuality of the child is strong, enduring to reduce the space between adult and child.

1.3. Compatibility with the situation in Mosul

Montessori pedagogy is interesting to apply in Mosul because it gives more importance and attention to children than traditional systems.

One of the limits is the school level of the school, a theme covered in this thesis. The Montessori system is very simple to apply to children.

1.4. Montessori School

The simultaneity of different activities in Montessori pedagogy makes the space traditionally square, completely unsuitable. The choice in the project was to organize the L-shaped class with an over-elevation to divide the space.

The entrance is moderately vast and covered to accommodate students who tend to arrive before the start of class.

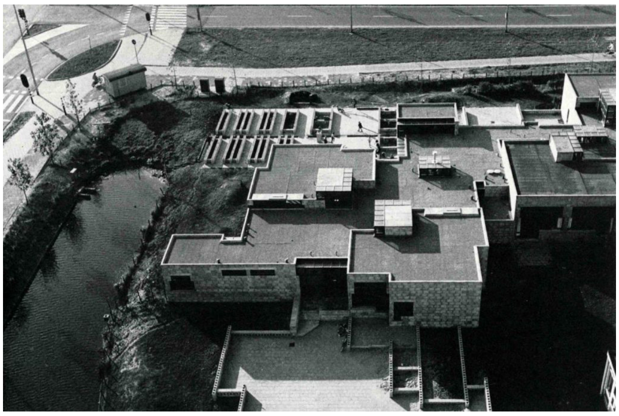


Fig. I-55.Scuola Montessori @HidenArchitecture

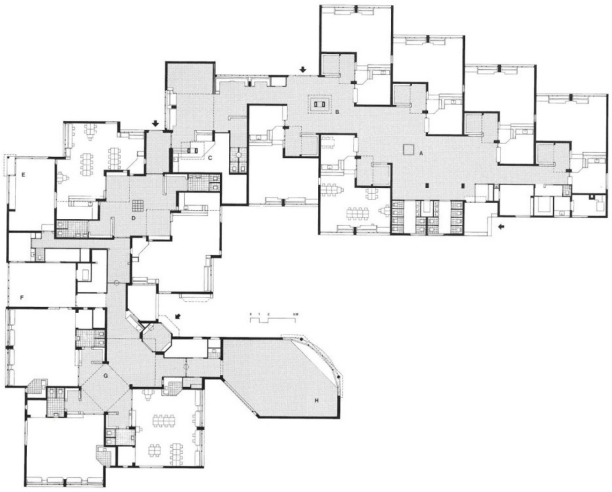


Fig. I-56.Pianta della scuola @HiddenArchitecture

2. FREINET METHODOLOGY

Created by Celestin Freinet, war wounded. It is opposed to the Montessori methodology as it is less individually centered. This methodology is mainly used in primary schools.

2.1. Principles

8.2.a. Free expression

give us the opportunity to express ourselves through art, drawing...

8.2.b. Cooperation

8.2.c. Experimental trial and error

action before reflection. According to this tactic, students start with exercises before class. This principle allowed to short-circuit the mind, place of trauma, and reflection giving priority to experimentation.

8.2.d. Educational techniques based on autonomy

Democratic participation:

It recreates a micro-community where students are actors. Of course, the issues of safety and education are the sole responsibility of the teacher, but the organization of the projects and the class are decided in agreement with the students in a cooperative way.

2.2. Compatibility with the situation in Mosul

As seen before, the community is one of the most solid pillars in recovery after a war trauma. Freinet's methodology strongly develops this principle. In addition, learning between experience made it possible to integrate the student into his environment.

3. STEINER METHODOLOGY

Similar to the Freinet methodology, it is based on the right to error, experimentation and cooperation. The biggest difference is that the Steiner system is competitive. Considering, the aggression developed by the children of Mosul, competition can become a way of channeling violence to them or amplifying it.

Art has a centered place thanks to the importance given to manual activities, it is a privileged theme of study. Other is inserted in all subjects of study in order to give more life.

In secondary school, all subjects are taught with the aim of making students aware of the problems of today's world and their responsibility.

II. VERNACULAR ARCHITECTURE

INDICE DEL CAPITOLO

GENERALITY

1. DEFINITION

The vernacular architecture covers a vast and difficult to characterize area; it is an architectural style designed according to local needs, the availability of building materials and reflects local traditions. The architecture is composed of local materials not imported and handmade by the local community. Originally it is an architecture that does not imply an architect, in 1964 Bernard Rudofsky defined it as "architecture without architects". Culturally it is a connection between design, construction, use and sustainability that, being the first buildings built, is most often applied to residential buildings.

2. USE OF EARTH

Fig. II-01. Uso vernacolare della terra

Earth, because of its advantages, is the first-choice material in vernacular architecture.

In the Egyptian desert the Romans already built with bricks of raw earth. Without other materials except earth, the construction adapted to local conditions.

All of Africa is a territory of earth architecture: in Mali and Senegal the techniques used are freemasonry and mud bricks. The vernacular architecture is reasoned around the vital needs and all the elements that compose it are well thought out. Social life is articulated around religion, so special attention is given to religious buildings, more elaborate than the simplest dwellings.

In the Dogon, the tanks for cereals (gôh) seem of greater importance, they are raised with a conical wooden roof, this elevation extends the shelf life of food.

The city of Djenne, built in 250 BC.C., is another of the greatest treasures of Mali's vernacular culture. The city covers about forty-five hectares. The architecture of the city recalls Moroccan culture. Masons began to build the city with ferey: cylindrical bricks shaped by hand before using a wooden formwork. Animist beliefs gave special power to masons who still today transmit the knowledge of traditional earth construction.

Vernacular architecture remains an important knowledge. Vernacular buildings are the result of hundreds of years of passive design evolution.

Fig. II-02.Rovine nel deserto egiziano

Fig. II-03. Villagio nel Mali

IRAQI HERITAGE

1. INFLUENCE OF ISLAM

In the Middle East and throughout the Arab world, the culture that influenced vernacular architecture was mainly born with Islam. This designs the architecture and urban planning of cities; the principles that have the greatest influence are the sense of community (muamalat) and humility.

1.1. The community

Islam is a religion that privileges social interactions. The neighborhoods of the cities are full of social diversity, the poor live next to the rich. Often, the roofs are connected, and the narrow streets with shops scattered throughout the city facilitate the meeting. The city is organized around a mosque and a market. Mosques, like schools, must be easily accessible to all, less than 300 meters from a residential neighborhood. For this reason, the school and the mosque are normally built close together.

1.2. Humility

Humility translates into a tendency towards uniformity and simplicity. The buildings do not have exaggerated decorations on the facades, and the interior rooms are simple. All spaces have their own function, dirt is not acceptable, so the dimensions are minimal.

1.3. Privacy

From humility comes the principle of privacy. According to Islam, conflict is to be avoided absolutely, everything must be done to prevent the disturbance. Acoustic disturbance is solved with thick walls and shops on the ground floor. While, visual disturbance is avoided with small windows with blackouts, high parapets on the roof and uniform building heights.

2. UNESCO WORLD HERITAGE SITE

Fig. II-04. Localizzazzione del patrimonio iracheno del UNESCO in terra cruda

In Iraq, raw earth is a material that is part of the history of ancient Mesopotamia. This history can be symbolized by the sites inscribed by UNESCO as World Heritage Sites.

Hatra was the first Iraqi city to be inscribed in 1985. Built in 100 a.d.C., this city has distinguished itself for its rich multicultural architecture: Greek, Roman and Oriental.


Fig. II-05.Città di Hatra

East of Hatra, along the Tigris, the city of Ashur (or Assour) was the first capital of the Assyrian Empire. This heritage, witnessed by 3 000 a.C., has not yet been fully discovered.

In the north of the country, the center of the capital of Kurdistan is a fortified citadel with an ovoid plant entirely made of mud bricks.

To the south are the best-known ancient cities of Samarra on the Tigris and Babylon on the Euphrates. In Samarra the great mosque and the spiral minaret are for now the most remarkable monuments of the site, however, 80% of the city is still to be excavated. Of the ancient city of Babylon remain today only the outer and inner walls of the city, the gates, some palaces and temples.


Fig. II-06.Città di Ashur


Fig. II-09. Città di Babilonia, tempio Ninmakh


Fig. II-08.Città di Samarra, il minareto


Fig. II-07.Cittadella di Erbil

ARAB HOUSING SYSTEMS

1. THE TYPICAL HOUSE OF YAZD, IRAN

Yazd is a city in the center of Iran. The climate is dry, hot during the summer and cold in the winter. The humidity of the air is similar to that of Mosul but with less rainfall. The city is known for its typical and well-preserved layout of traditional Iranian houses. In 1996, 53% of the buildings in the old town were made of raw earth.

Fig. II-10.Fotografia di Yadz ©Jean DETHIER

1.1. Generality

Traditional dwelling in the city of Yazd is made of raw or baked and plastered earth bricks. It is spread over one or two floors at most. The flat roof is used for housework or for sleeping during hot summer nights. It is an introverted house with a few small windows to the outside, the rooms open onto the two central courtyards generally thanks to an odd number of windows (three or five).

The Iranian house is a house that you walk through in a year. The rooms are used in a temporary way, the summer rooms oriented towards the north and the winter rooms oriented towards the south are distinguished. The rooms oriented towards the east are generally bedrooms, while towards the West, being the worst orientation, sometimes there are no rooms. In front of this non-permanent use the rooms are not furnished.

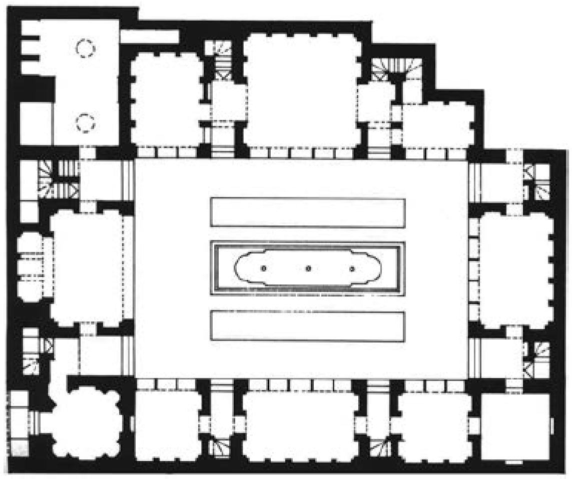


Fig. II-11.Pianta tipica ©Ahmadreza FORUZANMEHR

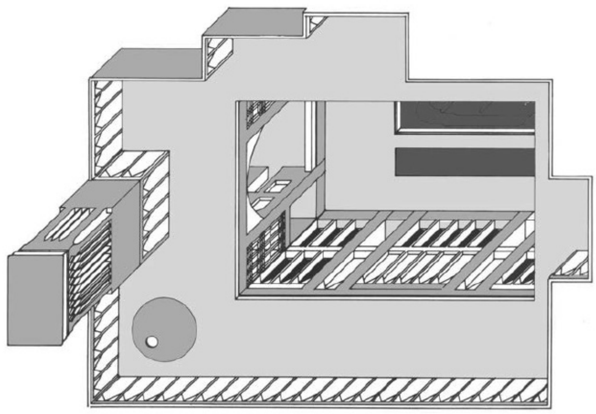


Fig. II-12.Assonometria della stessa casa ©Ahmadreza FORUZANMEHR

1.2. Wall (divar)

Brick walls are between 50 and 80 cm thick. The aim is to maximize the storage heat capacity and thermal phase shift, as well as to give sound insulation for privacy. The walls make the way to furnish the room with shelves to leave the floor free.

1.3. Court (hayat)

The rectangular courtyard is built lower than street level in order to trap fresh air.

The water tank (howz), arranged in the center of the courtyard, helps to cool the house thanks to the evaporation of water. The garden takes the air trapping the sand, raises the humidity and acts as a protection against solar radiation.

In its system the central courtyard reduces the temperature in the house as well as ensuring privacy and security.

1.4. Loggia (talar and eyvan)

The Iranian loggia is a semi-open covered space on the court. Its level is higher than the court. Below it develops a basement space from which the window releases cold air into the courtyard. The loggia, generally located adjacent to the summer rooms, is a socially appreciated space because it is shaded and ventilated.

1.5. Wind Tower (badgir)

All elements described above do not allow to have ventilation in the house, for this reason iranians use badgir. They are tall towers (in the city of Yadz about three meters) of brick and reinforced with wooden beams that bring the winds into the house. The openings are on all sides, and need to be opened following the greater direction of the wind. Its efficiency is better if the air outlet occurs through an area with water, where evaporation cools even more the air sent into the house.

On windless nights, the badgir acts as a chimney to evacuate the internal heat of the building. The walls transfer the heat captured during the day to the air creating an upward current to take away the hot air. When it is windy it is slightly heated before entering the rooms. During the day the badgir is a poured chimney, cooling the incoming air to the point when the walls are heated by the daytime environment. Iranian wind towers are useful throughout the year but the control is not practical.

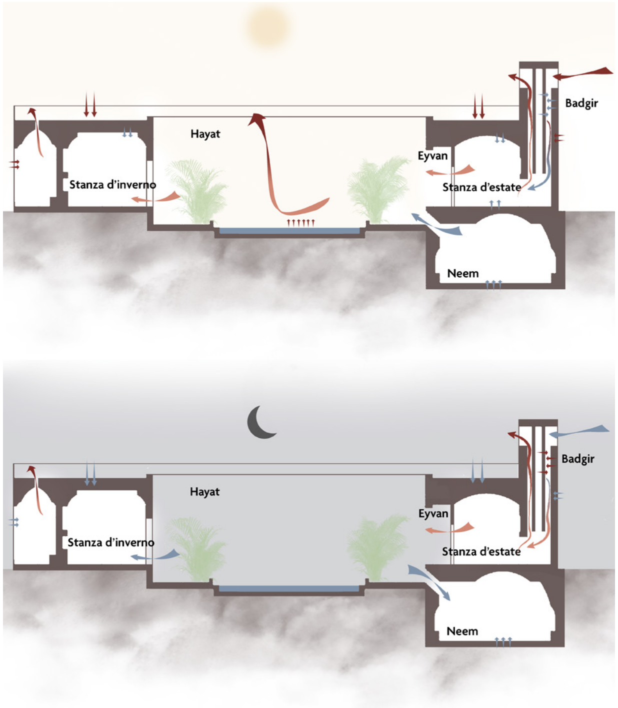


Fig. II-13.Fonzionamento termico della casa

2. EGYPTIAN VARIATION

At the end of the British occupation of Egypt in 1930, the Nahda movement was born to change Egyptian architecture. Particularly supported by architect Hassan Fathy, the aim is to redefine Egypt's artistic identity. He was criticized as, with the modernization of the country, the architecture had changed. In the documentary "Il ne suffit pas que Dieu soit avec les pauvres" (It is not enough for God to be with the poor), Hassan Fathy expresses his confusion in front of an Egypt that has forgotten its culture by developing the modern way of building in an expensive and inadequate way. According to him, the development of Egyptian identity passes through reconciliation with vernacular architecture.

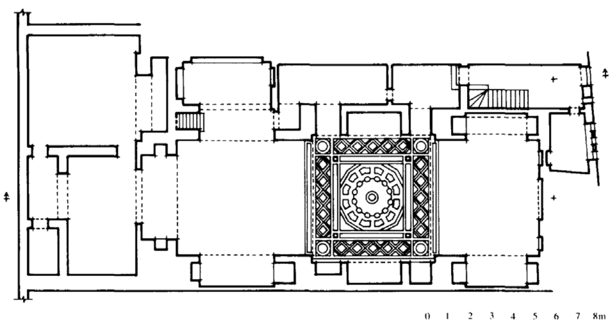


Fig. II-14.Piano terra ©HassanFATHY

2.1. Basic Qa'a House

The Qa'a house is a widespread model of home in Egypt, originally brought from Iraq.

The house is organized into two T-shaped spaces, called iwan, around a courtyard with a fountain in the center. One iwan is oriented north to have the wind cool in summer, the other is oriented south to pick up the winter sun. Qa'a has evolved over time. Subsequently, the courtyard is covered with a tower (durq'a) that sucks in the hot air. Then the malqaf are added, north-facing balconies, open towards one of the two iwans. The building is spread over two or three floors open to the courtyard.

Similar to Iran, we find in Egypt the court houses with loggias and pools of water, even if, crossing the Arabian Peninsula, the composition suffers from some modifications. Architects such as Hassan Fathy have brought back the particularities of traditional Egyptian design.

2.2. Egyptian design lines

3.2.a. Taking advantage of water

Evaporative cooling is an adiabatic cooling. The total amount of heat does not change but is transferred from the floor to the water for its phase change, so the floor cools. One technique that uses this phenomenon is to put damp plants or fabrics in front of the windows. The air it passes through cools by passing its heat to the water.

The water tanks also take advantage of evaporative cooling, amplifying it with a fountain in the center. When there is not enough pressure to use a fountain, the Egyptians use salsabil : an inclined marble slab on which water flows.

3.2.b. Darken

Mashrabiya is a typical wood darkening that helps control the amount of light and ventilation.

The wood used is porous and retains water that helps cooling. Unlike brise-soleil, mashrabiya does not create glare but produces diffused light. Typically a window has two types of mashrabiya, the upper part with large openings and the lower part with small openings.

Roof management

The roof is the part most exposed to the sun. To reduce the absorption of heat from the roof, it can be done with perforated brick, with a green coating or with a double structure. When a flat roof sunbathes throughout the day, a cylindrical roof reduces the absorption of solar radiation. In addition, a curved ceiling increases ventilation for the Bernoulli effect.

3.2.c. Ventilate

The walls are perforated at the top to evacuate the air at the top of the wall. However, in order to create a complete ventilation of the building, the Egyptians use malgaf. It has a similar functioning to the badgir, trapping the winds above the building to ventilate it with the internal distribution of deflectors to promote the Venturi effect.

2.3. The Nubian vault

The Nubian vault is an architectural element of

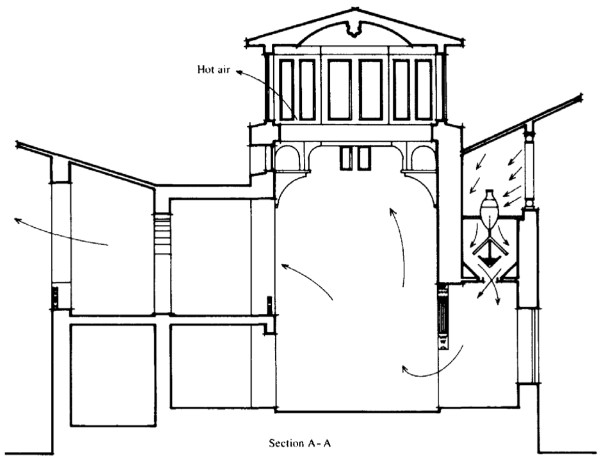


Fig. II-15.Sezione di uno malgaf ©Hassan FATHY

Egyptian architecture, rediscovered and popularized by Hassan Fahty. In an Egypt in economic crisis, in poverty, among corruption, Fathy tried to build cheaply. The Nubian vault responds to the problem of building in an economic way, without supporting carpentry, reviving the Egyptian vernacular culture.

3.2.a. Features

Once Nubian it is 3.3 meters wide at most, the height of the vault is generally 1.5 meters and never exceeds 1.75

meters. The most economical configuration of material compared to the covered surface requires an internal width of 2.9 meters, and a vault height of 1.2 meters.

3.2.b. Design

In accordance with the design methods with raw earth, the foundations of the vault are more made of stone and sand. Openings weaken the building. For an inner wall, it is recommended not to exceed three-fifths of an open surface. For an external closure it is recommended not to exceed one third, except in the case when the vault is wide, so full walls avoid the use of reinforcement. To ensure stability, the distance between two bearing arcs must be a maximum of 8 meters.

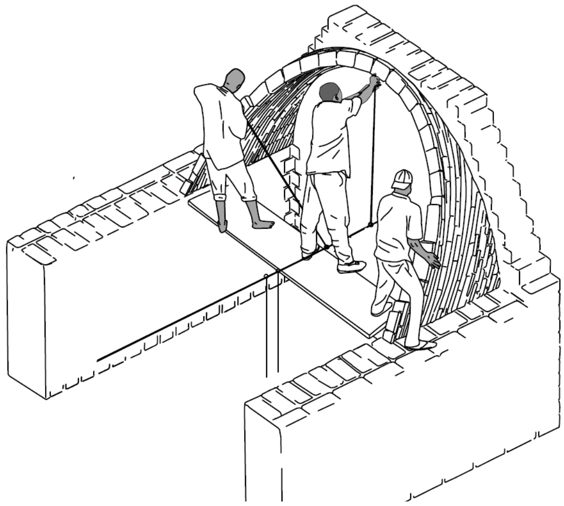


Fig. II-16.Montaggio della volta ©Voute nubbienne

3.2.c. Reinterpretation

After his research on true Egyptian architecture, Hassan Fathy begins an essential project for the future development of earth architecture. Reinterpret vernacular architecture to fit a new construction: an entire village required by the government to rebuild Gourna.

In New Gourna, the architect makes a mixture of the characteristics of the Qa'a with the Nubian vault. Its urban organization is based on local tribal social relations. The village will never be finished due to sabotage that, slowing down the construction site, exhausts all financial resources.

3. NAJD ARCHITECTURE

Najd vernacular architecture is the typical architecture of central Saudi Arabia. The first capital of Saudi Arabia, Diriya, was built in 1446. The region already had a strong architectural identity. Until 1953, Najd architecture remained the only way of designing, then, with the opening to Western countries, vernacular architecture gradually disappeared.

Fig. II-17.Mercato di New Gourna @Hassan FATHY

The Najdi build essentially of mud bricks, mixing clay extracted from the river with desert sand. Stones are used for foundations, plinths and arches. The structure of the scaffolding is made of local wood. The building is then all plastered in the ground, from the walls to the floors.

Saudi houses have a rectangular courtyard, similar to Iranian and Egyptian houses are introverted, with interior decorations.

The peculiarity is the ventilation system. Najd houses often do not use any wind tower (badgir or malkaf) but only work with the court and openings. The court is oriented in the main direction of the wind. The length of the courtyard does not exceed three times the height of the building so as to take advantage of the flow of the wind. When the wind arrives on the building, the pressure is lowered, then the wind is sucked inside the building thanks to small openings arranged at the top of the walls. This configuration creates an internal breeze in the courtyard that works with any wind direction and limits the ingress of dust inside the building.

The interior decoration is made with a plaster plaster applied locally and then carved into geometric patterns, and the wooden doors are painted in rich colors.

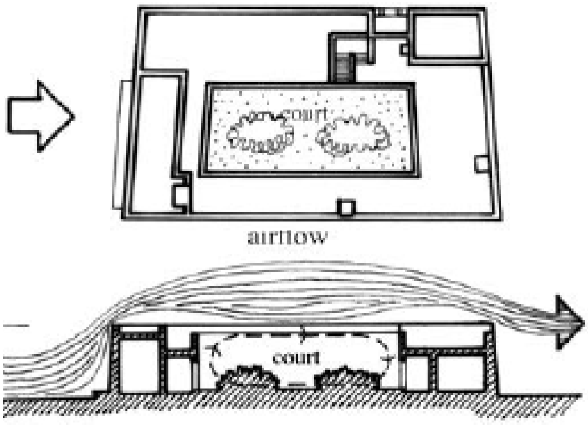


Fig. II-18.Principio di ventilazione @Facey

4. THE FORTIFIED CITY,KSAR

In the Sahara desert, especially in Algeria and Morocco, Muslim peoples have built ksour. The Ksour involves a Ksar: a fortified city and a palm so artificial that feeds the city. If possible the ksar is built on top of a hill. The city brings together between a dozen to a hundred squatrate houses at court. The urban fabric is dense and irregular, the streets are covered with storage spaces. The courts are of minimal size, sufficient to allow the entry of light and ventilation. The city is centered on the mosque and fortified with walls and watchtowers (bordjs).

The ksar has a very particular organic appearance for Muslim architecture. The palm is an oasis, sometimes artificial, and with a hydraulic system that guarantees water supply. It contains some houses that are summer dwellings, built in raw earth, with a stone base.

Fig. II-19.Casa Nadj @WikipediaCommons

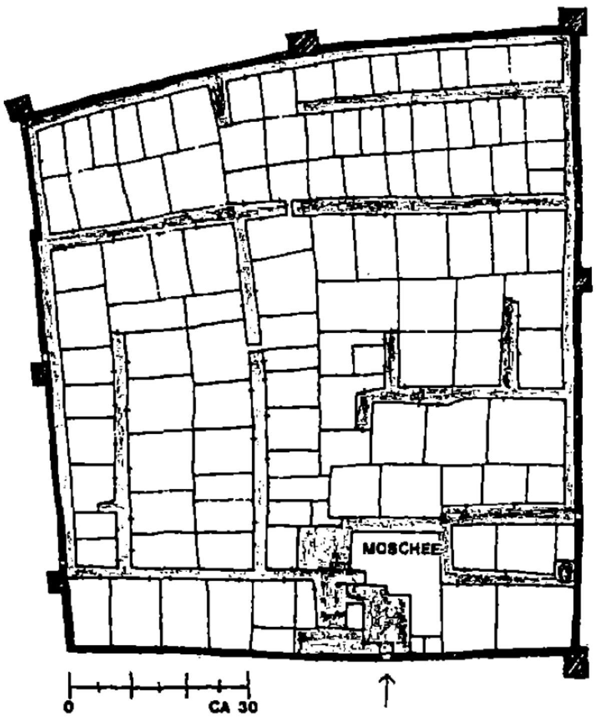


Fig. II-20.Ksar of Boukhla @Adam JURGEN

CURRENT IMPLEMENTATION

1. HASSAN FATHY, VERNACULAR IN RAW EARTH

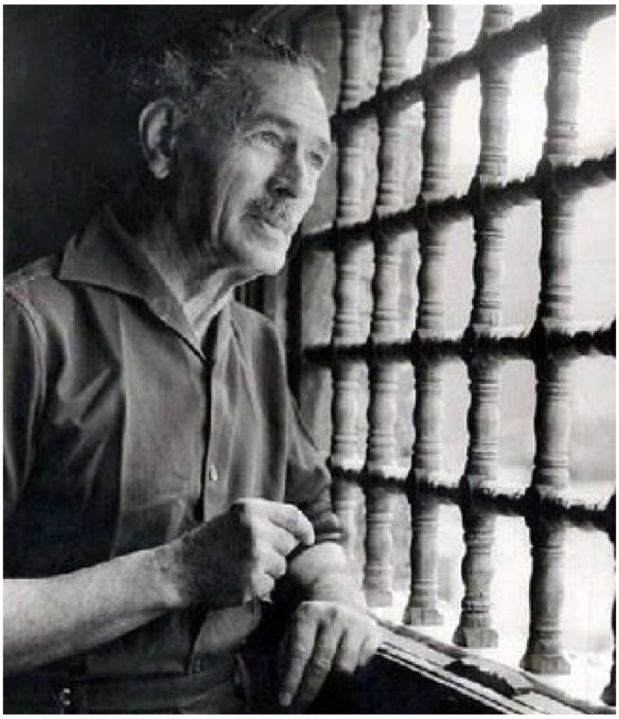


Fig. II-21.Hassan FATHY @DevenirArchitecte

Hassan Fathy (1900-1989) is known for reviving traditional raw earth construction techniques with strong vernacular architecture.

He sought Egyptian architectural identity particularly in the countryside where the technology that had changed the urban landscape was less accessible.

He writes three design principles:

First, "The ways and means of building environments must increase people's control over their existence."

Second: "The ways and means we build must generate and maintain material wealth where it is most needed, even when it is not possible to redistribute what already exists.

Third: "The construction and maintenance of environments should make optimal use of abundant and renewable resources, and preserve those that are scarce and polluting."

1.1. New Gourna

Its most famous achievement is the village of New Gourna. The project consists of the relocation of a village requested by the government. To minimize construction costs, he chose raw earth in his social project. One of his goals was to participate in the reconversion of the inhabitants by starting a Freemason training during the construction of the houses.

Obviously, the architecture of the project and the urban organization is based on the social layout of the previous village. It gathers neighboring families around the same courtyard.

Fig. II-22.New Gourna @DevenirArchitecte

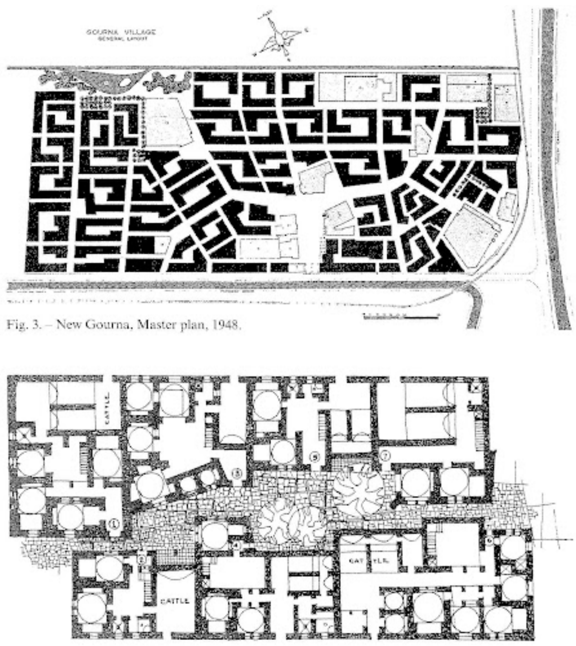


Fig. II-23.Masterplan di New Gourna @Hassan FATHY

"One man alone cannot build a house, but a hundred men can very easily build a hundred houses, even a thousand houses." Hassan FATHY

1.2. Other projects

Fig. II-24.Casa Akil-Sami @DevenirArchitecte

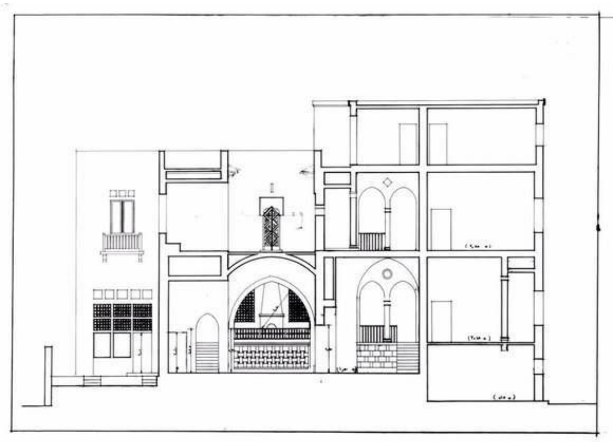


Fig. II-25.Casa Toussoun Abou-Gabal @DevenirArchitecte

2. CANDILIS' CASBAH

In the 1950s, Georges Candilis used the traditional Muslim house as a model for a series of projects.

He made the holiday village of Carrat in Port-Leucate in France a social place thanks to its architecture. Composed of houses with cubic forms, its roof terraces, patios, collective buildings and numerous public places (squares, playgrounds) are reminiscent of Arab cities.

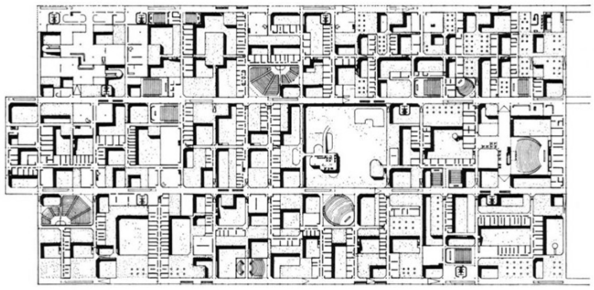


Fig. II-26.Villagio di vacanza, Port-Leucate @Dezeen

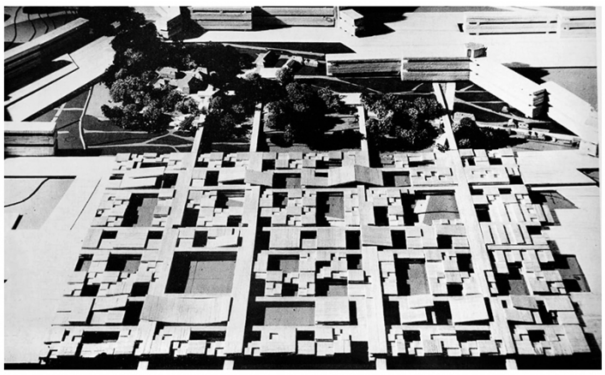


Fig. II-27.Università del Mirail, Tolosa @Dezeen

3. VILLA ALHAMBRA

Architetto.	Richard ROWLAND
Anno.	2014
Luogo.	Senegal
Tipologia.	Casa
Materiale.	Terra cruda

Richard Rowland with Atelier Koe has done numerous projects in Senegal, all inspired by the architecture of Muslim houses.

The Al-Hambra villa is a large house in the arid land near Dakar. A 12-metre high wind tower helps to circulate fresh air throughout the building.

Fig. II-28.Villa alhambra @AtelierKoe

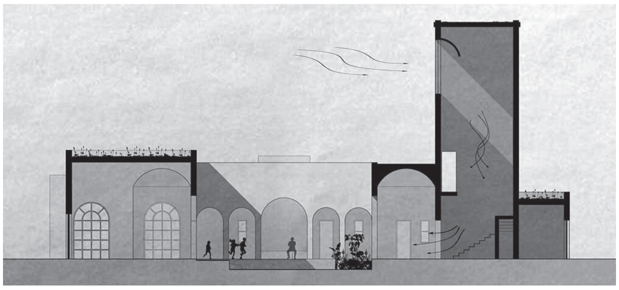


Fig. II-29.Sezione @AtelierKoe

Fig. II-30.Corte interna @Atelier Koe

4. VILA NOVA DA BARQUINHA

Architetto.	Manuel e Francisco AIRES MATEUS
Anno.	2009
Luogo.	Portogallo
Tipologia.	Scuola
Superficie.	4 600m²
Materiale.	Calcestruzzo

Volumes of different heights corresponding to the different programmes emerge from a quadrangular white enclosure pierced only by a few doors giving access to the school on the Ksar model. Each unit (nursery school, science centre, gymnasium...) is organised like an Arab introverted house.

Fig. II-31.Involcro della scuola @AiresMateus

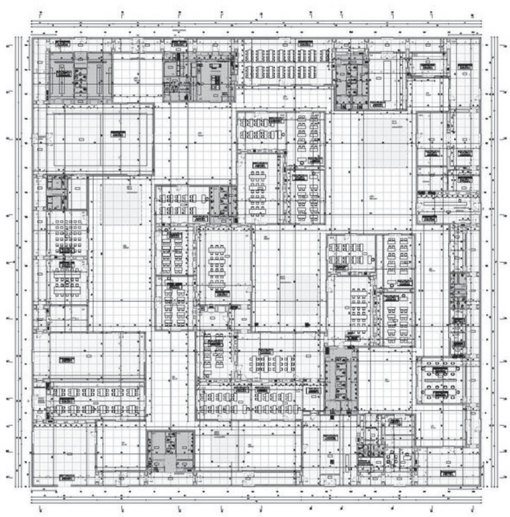


Fig. II-32.Pianta del piano terra @AiresMateus

III. FRAMEWORK OF THE PROJECT

INDICE DEL CAPITOLO

RECONSTRUCTION AND REHABILITATION OF THE AL-NOURI COMPLEX IN MOSUL

The project that will be born from this competition belongs to the Revive the spirit of Mosul initiative formed by UNESCO. It is supported by the Minister of Culture, the Sunni Waqf Office and the United Arab Emirates. The goal is to rebuild a new complex by integrating the remains of buildings of historical value. In 2017, the Al-Nuri complex was destroyed by Daech shortly before the liberation of the city. Al-Nuri was a historical, cultural and community landmark site in the old city of Mosul. For this reason, its reconstruction is an essential challenge for the restart of the city.

1. PROGRAM

1.1. Rebuilding the Al Nuri Mosque

The biggest challenge is the identical reconstruction of the Al-Nuri mosque. The remainder has been provisionally consolidated. It requires consolidation before being integrated into the new building.

1.1.a. History

Fig. III-01.Moschea Al-Nuri dopo 2017

This mosque was built during the golden age atabeg of the city in 1170. Its construction was to move back to the demographic expansion of the city. The main building was adjacent to the traditional house to the south and built with a madrasa, a Muslim school. In 1925, now run by the Sunni Waqf Office, nearby houses are moved. The building is rebuilt increasing its capacity. In 1990, another project to enlarge the mosque is planned.

1.2. Rehabilitating the religious complex

In addition, from the main building, there are other services to be designed. In fact, it is planned in the area in front of the mosque, a summer prayer space, bathrooms and ablution spaces. The buildings of tombs and shrines are rehabilitated. The square is rehabilitated in its relationship between the external services and the mosque.

To allow accessibility, the complex will open thanks to four pedestrian accesses and a car with a parking lot.

1.3. Extending the complex

In its new version, the area is enlarged by an urban block. Today, about destroyed completion presents an opportunity to insert new functions in the old city. The extension contains a secondary school for 360 students, a higher institute of Muslim art and architecture, and a sociocultural auditorium for the community. It was decided to preserve and integrate into the new project the remains of three houses of historical value.

2. OBJECTIVES OF THE PROJECT

The competition defines four general objectives to guide the nature of the project.

Create an integrated design inspired and compatible with the traditional architecture of the old city of Mosul, considering the maintenance of authenticity and integrity of the complex

Create an oasis of peace and tranquility for worshippers and a vibrant vital center for the community, through the new function centers

Integrate an environmentally conscious design, which in the Mosul context should take into account the materials available to local resources, climate and efficiency

Integrate the new buildings, the new urban landscape and the reconstructed portions with the historical remains within the complex.

3. FIELD OF THE THESIS

The work presented for this thesis will try to respond in a completely hypothetical way to the competition.

The first objective being to correspond to the degree exam, this competition is an inspiration of the framework in which this project intends to evolve.

Numerous design freedos were taken. In addition, simplifications have been made. For example, being alone, the project will be reduced to a more suitable size: secondary school.

FUNCTIONAL PROGRAM

This thesis, for reasons of time and means, focuses on the design of secondary school. Being aware of the unity of the project, I would try to suggest a compatible masterplan for the entire field of action of the competition.

1. THE AL-NURI SCHOOL

The school is a secondary school for boys and girls in three floors.

1.1. Functions

2.1.a. Class

12 classes each with a capacity to accommodate 30 students. The furnishings used are flexible, allowing you to create various seating arrangements. Add to these classes a multi-functional class for laboratories and projection.

2.1.b. Bookshop

The library contains group reading tables and tables with computers for the massiomo 15 students.

2.1.c. Bathrooms

On each floor, are the separate bathrooms for males and women

2.1.d. Gym/Sports Area

An indoor gym is provided with separate changing rooms, with bathrooms. During the first public review of the competition requirements, the feasibility of implementing an indoor gym in the project was questioned. UNESCO's requirements seemed too tight in terms of building area. The gym can be a small outdoor sports space.

2.1.e. Administrative spaces

In the administrative spaces are the director's office, two offices each for three people, a refreshment area, bathrooms and a storage space. In addition, they are two professor rooms each one with one private bathroom.

2.1.f. Spatial configuration

The spatial configuration follows the principle of gender separation set by the Iraqi government for secondary schools.

UNESCO provides for the following configuration. On the ground floor are the administrative and mixed function. The first floor is reserved for men, with classes for boys and a teachers' room. The second floor is female, with equally class and a professors' room. Bathrooms are separate is located on the appropriate floor. Unesco's notice always remains a compositional possibility. All other spatial separation solutions are acceptable.

1.2. Surface

For each required space, the surfaces dedicated to functionality and human occupation have been sized to a minimum by the UNESCO offices.

Funzione	Area	Unite	Area totale
Classe	45 m²	12	540 m²
Libreria	40 m²	1	40 m²
Classe multifonzionale	45 m²	1	45 m²
Bagni studenti	4 m²	12	48 m²
Palestra	380 m²	1	380 m²
Spogliatoi	15 m²	2	30 m²
Ufficio del direttore	12 m²	1	12 m²
Altro ufficio	15 m²	2	30 m²
Sala professori	22 m²	2	44 m²
Area ristoro	12 m²	1	12 m²
Bagni amministrativi	4 m²	2	8 m²
Spazio di stoccaggio	36 m²	1	36 m²
Corridoi			490 m²
Totale			**1715 m²**

Tab. III-01.Ripartizione spaziale nella scuola

1.3. Global Consideration

From the urban plan of the city, new buildings should be proposed only two-storey with a maximum punctual of three floors. The proposed new buildings will use colors and materials in accordance with those used in the Old City of Mosul. Local materials such as terracotta brick, stone and alabaster, Mosul marble, are preferred.

The composition should seek traditional architectural typologies or modern reinterpretations of elements of these types.

All buildings must be accessible to persons with disabilities, following the general requirements of the international disability guidelines.

The landscape design of the entire mosque complex should provide a conceptual design of the exterior furniture, flooring, vegetation and the type of shading system proposed.

2. CONSIDERATION FOR OTHER BUILDINGS

This thesis, for reasons of time and means, focuses on the design of secondary school. Being aware of the unity of the project, I would try to suggest a compatible masterplan for the entire field of action of the competition.

2.1. Source Area

The required work is strongly linked to the rehabilitation of the origin complex. The space organization will then follow the remaining buildings and Muslim rules.

Funzione	Area m²
Amministrazione - uffici, sicurezza	215 m²
Complesso di abluzione	192 m²
Area di preghiera d'estate	576 m²
Padiglione di abluzioni	20 m²
Cabine per guardie	12 m²
Tombe e santuari Al-Nuri	215 m²
Area di preghiera della moschea	698 m²
Portico della moschea	215 m²

Tab. III-02.Ripartizione nel area di origine

2.2. Extension

2.2.a. Higher Institute of Islamic Art and Architecture

The institute is able to accommodate 200 students, 10 professors and 7 administrative staff. The building contains cafeteria and a bookseller in addition to the classrooms and offices.

Funzione	Area	Unite	Area totale
Classe	42 m²	8	336 m²
Ingresso	15 m²	1	15 m²
Cafeteria	107 m²	1	107 m²
Libreria	100 m²	1	100 m²
Amministrazione	115 m²	1	115 m²
Area commune	20 m²	1	20 m²
Sala riunioni	75 m²	1	75 m²
Bagni	4 m²	10	40 m²
Corridoi			325 m²
Totale			**1 133 m²**

Tab. III-03.Superficie del istituto ©UNESCO

2.2.b. Auditorium

The auditorium is able to accommodate 200 spectators. If this building is close to the ablution space provided in the area of origin, it will be connected by a corridor or a covered passage.

Funzione	Area	Unite	Area totale
Ingresso con negozi	200 m²	1	200 m²
Spazio principale	300 m²	1	300 m²
Spazio per gli interpreti	5 m²	4	20 m²
Sala di stoccaggio	30 m²	2	60 m²
Palestra	380 m²	1	380 m²
Corridoi			20 m²
Totale			**600 m²**

Tab. III-04.Superficie del auditorium ©UNESCO

3. EVALUATION

3.1. From UNESCO

The design will try to meet some of the evaluation criteria set in the UNESCO competition:

Integration of new buildings in the historical remains, in the historical context
Impact on the urban and social fabric
Power of expression and reinforcement of cultural and community identity
Power to contribute to sustainable development
Competence in compositional approach and expression
Architectural quality
Integration into the historical landscape
Innovation and creativity
Analysis and documents
Ecological aspect
Functional aspect
Economy of material and means in the design approach
Feasibility
Consistency in the holistic approach

3.2. University environment

2.3.a. Generality

The priority criteria that will be taken into consideration for the work of this thesis are those related to the evaluation of the Politecnico di Milano. Considering that in the degree process the ''Degree Thesis consists in the development of an original project in which we should demonstrate the ability to integrate the disciplinary contributions of the subjects addressed in the course of study. This interdisciplinary process can be developed both by assuming a systematic methodological procedure, based on engineering controls; both addressing particularly advanced and complex issues, with specialized insights on particular innovative aspects of the project.''

As a result, the architectural composition will be accompanied and partially justified by engineering analysis of the building's performance in the fields of lighting technology, structural stability, construction techniques, comfort and energy consumption.

2.3.b. Requirements for a first-level design thesis

At a minimum, the work presented in this report covers:

a framing of the design problem with respect to the territorial and urban context, and with respect to the architectural culture of the site; cartography and surveys;

the definition of the design program;
the development of general graphic drawings;
the development of at least four significant technological nodes;
the development and calculation of energy needs and plant diagrams related to heating and cooling;
a structural pre-dimensioning.

THE OLD CITY

1. TERRITORIAL FRAMEWORK

1.1. Generalities

The project is located in the Old City district. It is the oldest place in Mosul. The Old City corresponds to the city that was built in the medieval period. It was surrounded by fortification walls. Two main roads cross the city according to the urban tradition of the period. Due to its fortified character, Mosul's growth densified the district before causing the city's external expansion. Today, the Old City is the historic heart of Mosul where urban development is compromised by population density and numerous winding streets.

Fig. III-02.Localizzazione

Fig. III-03.Fotografia satellitare @UN-Habitat

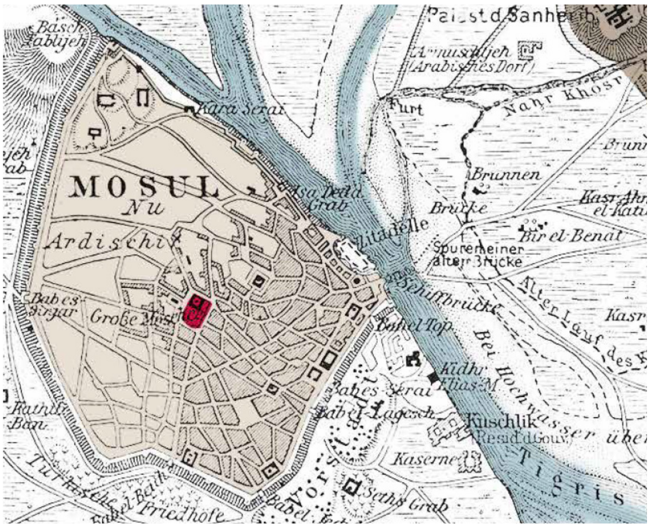


Fig. III-04.Mosul, la Città Vecchia 18 secolo@UN

Fig. III-05.Pieno vuoto approssimativo. Scala 1/2 000

Fig. III-06.Strada nella Città Vecchia. © AlJazeera

1.2. Urban layout

The urban layout of the Old City is characterized by a medieval layout with two main streets oriented North-South (Al Shaziani) and East-West (Via Nineveh). The rest forms a labyrinth of streets following the pattern of spontaneous growth of cities in the vernacular Middle East. It is comparable to the city centers of Jerusalem, Aleppo (Syria) or Gaziantep (Turkey). The old city consists of sub-districts: Farouk, Azersjkan, Kalakchi, Aba-at-Tub, Al Korneesh. The whole thing was surrounded by sticks in medieval times.

Today, considering the situation, the layout is no longer what they were before the war. The United States estimates 5 000 damaged buildings with areas that are completely erased, such as the riverside. It was a punishment, thinking that it was little influenced by modernization and had retained much of its traditional ethnic and religious heterogeneity.

1.3. Functional profile

The Old Town was a very multicultural vibrant nucleus. It is renowned for being the religious center of both Muslim and Christian Mosul, with the presence of numerous churches, mosques, shrines... In the northeastern part there are numerous souks, the markets covered. The urban density of the neighborhood was a facilitating factor for the development of commercial activity, especially on the ground floor of housing. Nevertheless, this density did not allow for new functions on a large scale. For this reason, the development of schools and other services have not followed population growth.

During the occupation, the functional layout of the city if lightened. In addition to the destruction of buildings, the movement of populations has totally changed the functioning of the neighborhood. For example, churches were closed or destroyed while Daesh tried to expel the Christian community of their Islamic State.

Today, except for the reconstruction of religious buildings, in their former place, the layout is being transformed. New inhabitants with new activities are settling in, with new ideas and hopes.

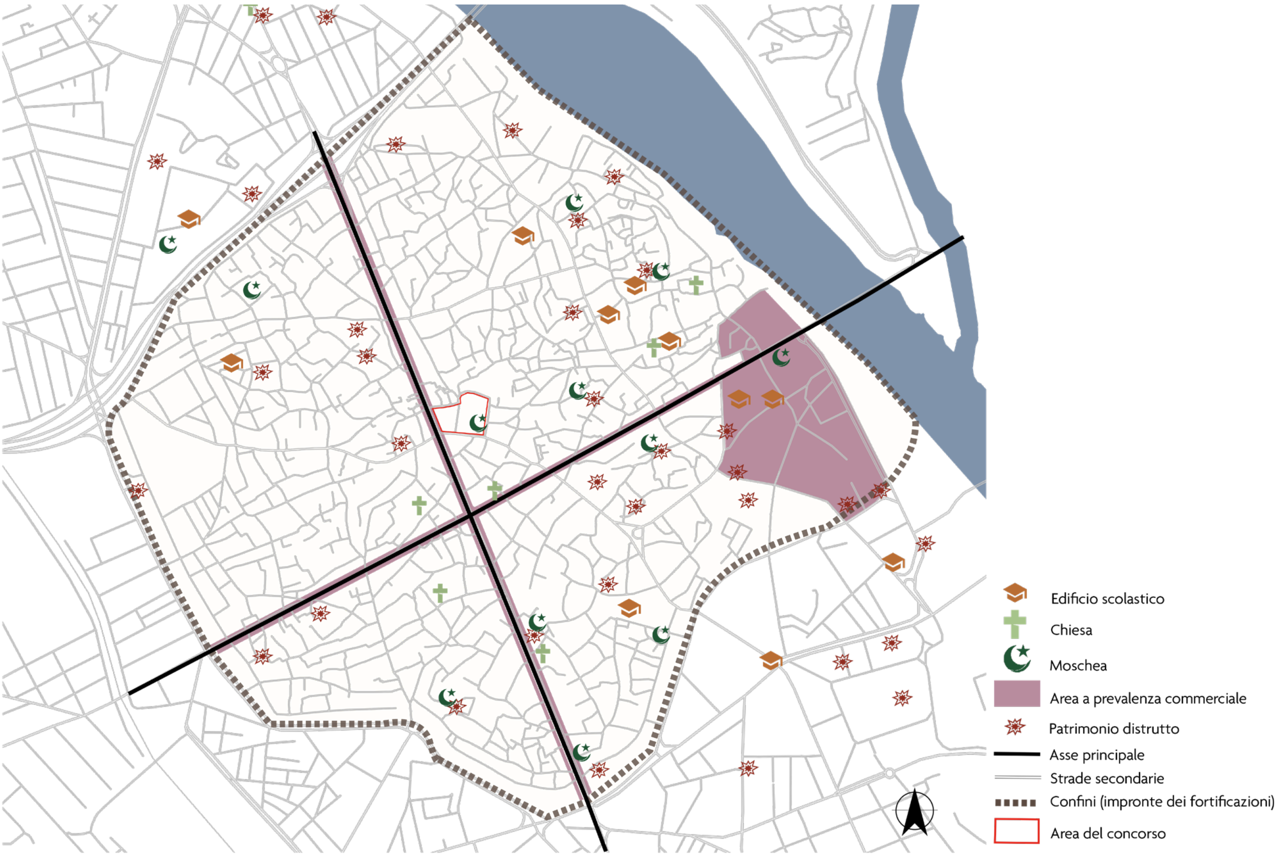


Fig. III-08.Layout funzionale. Scala 1/2 000

Fig. III-09.Mercato @UN

Fig. III-10.Via Al-Alada prima 2014 @NinevehTV

2. ARCHITECTURAL TRADITION

2.1. Architecture of Mosul

Due to the cultural diversity of its population, the city shows a rich architecture with many references. The architecture of Mosul's buildings is divided into two main styles: the Atabeg Zengid stylus and the Badr al-Din Lu'lu stylus.

3.2.a. The Zengid stylus

Zengid architecture is simple. It gives importance to proportions, dimensions and choice of materials. The decorations are rare, only geometric patterns.

3.2.b. The Badr al-Din Lu'lu stylus

Instead this architecture focuses on the aesthetics of the envelope: geometric patterns, epigraphic friezes, arabesques and figured reliefs. The references are the contemporary Shii architecture of Egypt and the Christian architecture of northern Iraq. Buildings have conical roofs, use mugarnas vaults.

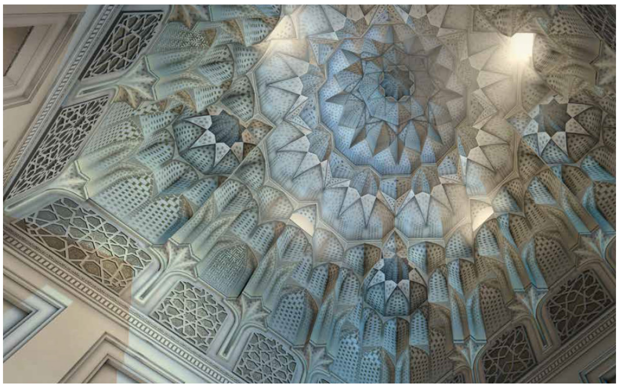


Fig. III-11.Volta mugarna @UN

2.2. Houses in the Old Town

The buildings of the Old Town are often dated from the 18th and 19th centuries. The urban fabric is made up of narrow streets, arched passages and courtyard houses with cantilevered enclosed balconies and accessible roof.

The shape of the houses is inspired by the mosques other public buildings. They frequently use Iwan spaces (sometimes closed space on three sides). In addition, due to the hot arid climate and the weakness of the

Fig. III-12.Strada nella Città Vecchia @UN

electricity grid, there are vernacular elements of passive ventilation.

2.3. Specific elements

3.2.a. Mejaz

The mejaz is an entrance space, often separated from the rest of the house, including the courtyard. This separation is important in Muslim culture, in the sense that it gives privacy and protection to the family. In some houses, this space accommodates service function.

3.2.b. Sirdab and Rhahra

The Sirab is an underground space, often under the courtyard. Instead, the Rhahra is basement, often under a space of the house 1-1.5m below.

3.2.c. Takthabosh

And a room between the ground floor and the first floor open to the courtyard. Traditionally, it is the space where the elderly sit during the day.

3.2.d. Iwan and Tarma

They are distribution spaces open to the courtyard. Unlike the Tarma, the Iwan is turned. It is considered as the most typical space of Mosul architecture. Located on the ground floor, it is very decorated with alabaster marble.

3.2.e. Riwaq

The Riwaq is a loggia or balcony used as a circulation space on the first floor.

3.2.f. Shanasheel

And another type of balcony. The specific of this space is to be thrown over the street. The aesthetics of this balcony, often made of musharabiah wall has a fairly

Fig. III-13.Casa vicina del complesso Al-Nuri @ Google maps commons

AREA DEL PROGETTO

1. DESCRIZIONE

1.1. Generalità

L'area del progetto è la parte Ovest del complesso considerato per il concorso. La parte Est è esclusivamente dedicata agli edifici a carattere religioso. Essendo la religione molto forte e soprattutto molto presente in tutte le sfere della vita quotidiana della popolazione, non è sembrato appropriato pensare di estendere il campo d'azione. Il tutto complesso copre una superficie di 10 200m² mentre l'area Ovest copre circa 4 000m².

L'area è al centro della Città Vecchia, vicina dell'incrocio delle strade principale. La Via Shiaziani confina con l'area sul lato ovest. Mentre i lati est e nord sono marcati da aere residenziale ad alta densità. Il tutto è in uno stato di ricostruzione e risanamento.

Fig. III-14.Render 3D on SketchFab ©UNESCO

L'area è ancora piene di rovine di edifici abitativi da pulire via. Tra loro, tre case sono in uno stato abbastanza attraente.

Fig. III-15.Area del concorso Al-Nuri. Scala 1/1000 ©UNESCO

1.2. Photographic survey

Fig. III-16.Elevazione nord ©UNESCO

Fig. III-17.Elevazione sud ©UNESCO

Fig. III-18.Elevazione est ©UNESCO

Fig. III-19.Elevazione ovest ©UNESCO

2. DESIGN CONSTRAINTS

2.1. By UNESCO

In order to ensure urban coherence, UNESCO imposes certain constraints on the composition of the project. The starting point is to evaluate the historical heritage by rebuilding the mosque identically, and rehabilitating three typical houses and the Al-Nuri sanctuary.

The old town is characterized by narrow and winding streets that make it difficult to get around. Among other things, to limit congestion, new car and pedestrian accesses to the complex are proposed. Finally, to maintain the landscape coherence and following the Iraqi regulation, the heights and footprints of the new

Fig. III-20. Vincoli progettuali iniziali. Scala 1/ 1000 buildings are limit.

2.2. Reviewing Constraints

After the applications of the participants in the competitions, a discussion began on the subject that prompted UNESCO to clarify and adapt some criteria at the request of the candidate architects. In the context of this thesis, several freedoms have been granted. Nevertheless, the revisions made give important information regarding the intentions behind the introduction of the constraints.

4.2.a. Spatial level

The constraint of 8 meters in height granted a margin of 1 meter. Although the preferences of the urban plan limit the buildings to have 3 floors, including the ground floor, it will be possible in the south-west part to build 4 floors.

The limitation in building surface to the ground was created to ensure the passage of the many believers to the mosque. It is flexible, adjustable provided that the value of this free space is preserved.

4.2.b. Functional level

It will be possible to share function between the different buildings. However, the buildings will have to remain separate, independent.

Fig. III-21.Casa da recuperare @UNESCO

3. EVALUATIVE ANALYSIS

3.1. Territorial level

The territorial level covers the situation of the country, the region. Large-scale factors have repercussions on the daily environment of the population. Moreover, in the situation where the search for information remains tiring, wide scales help to deduce the situation.

At the city level, there are three problems.

4.3.a. The climate and the geographical situation.

The scope so hot is arid in summer is not a win-win situation for design. The energy aspects are to be managed in a suitable way. The problem is amplified by the non-functionality of service networks.

4.3.b. The commitment in the face of the reconstruction of the city

And certainly an effective engine for the development of the project. For example, imagining a project built by the population is achievable. However, the commitment of both governments and the population creates conflicts in the organization. The city is already facing the emergency of informal construction that meet the official urban plans. The need is so strong that the administrative paths are not in a position to follow.

In addition, the destruction of the city creates the opportunity to redo well, to have a better quality urban living environment. In conclusion, the problem is not to waste this opportunity but to provide for immediate needs.

4.3.c. Psychological state

The post-war situation like the one Mosul has known has left scars in everyone's mentalities.

	Punti di forza	Punti di debolezza
Clima e territorio	• Pioggia rare • Terreno piano • Vicinanza con il fiume crea uno microclima di raffrescamento in estate	• Vicinanza con il fiume crea uno rischio d'inondazione • Estati molto caldi • Città con poche zone verde, oppure con zone verde distrutte dal conflitto
Patrimonio culturale	• Il patrimonio d'importanza maggiore che è la moschea Al-Nuri • Coerenza architettonica della Città Vecchia	• Edifici storici in uno stato precario
Conseguenze dopo-guerra	• Impegno internazionale nella ricostruzione • La distruzione della città da l'opportunità di alleggerire la densità urbana ed inserire nuove funzioni	• Insicurezza rimanente • Edifici distrutti • Tendenza a ricostruire di maniera disordinata con una qualità povera
Mentalità	• Volontà del governo e delle abitanti di Mosul alla ricostruzione • L'identità storica del posto come centro comunitario e religioso	• Stato psicologico a rischio della popolazione, specialmente dei bambini e adolescente

3.2. Urban level

This level concerns the place of the urban area in which the project inscribes us.

4.3.a. The Old City

We are in the heart of a neighborhood with a strong cultural identity. For this reason, new constructions are limited in the face of the stylistic coherence that exists. On the other hand, the traditionally dense layout of the area offers the possibility to implement a lung that will be welcome.

4.3.b. Mobility

Access to the Old Town is feasible by about all means. In fact, it is confined to the south by Mosul's central railway station and to the north of the river that runs through the city. The two main roads that cut through the neighborhood are also connected to the city's rapid main network.

The proximity to the main roads is a major advantage for the project. These two paths will not be changed and are probably prioritized regarding their rehabilitation. The second and tertiary road fabric knows a change. As a result, the east and south sides are wide streets and accessible by public transport, while the north and west sides are narrow, quieter and pedestrian.

4.3.c. Service network

The pear tree focuses us on the state of service networks. The whole neighborhood was before Daesh, not well served due to its seniority. After the occupation the situation is worse. Hesitant networks do not work at their former capacity. The situation concerns the gas, water and electricity networks but also the other public services.

As a result, the problem of the restructuring of services arises throughout the rebuilding. And in the meantime, the project will not be able to count on them.

	Punti di forza	Punti di debolezza
Layout urbano	• Localizzazione in centro città • L’area è uno spazio libero con pochi vincoli spaziali	• Limitazione urbanistica considerando l’altezza e le superficie edificabile • Densità urbanistica del quartiere
Mobilità	• Stazione ferroviarie e stazione pullman in bordo della Città Vecchia • Due strade principale che attraversano la città vecchia da un lato all’altro • Vicinanza del fiume	• Rete di trasporto pubbliche non tutte operative • Strade secondarie impraticabile • Mancanza di parcheggio
Funzioni	• Assenza di impianti industriali a rischio	• Mancanza di scuole nella città vecchia • Quartiere residenziale • Negozi delle strade principale distrutti • Mancanza di servici sanitari
Rete di servizi	• Vicinanza delle reti principali di acqua e elettricità	• Con il conflitto le reti di servizi di elettricità non sono totalmente operativi e incapaci di fornire ovunque uno servizio di qualità. • Sovraccarico della domanda in eletricità

3.3. Project level

Within the boundaries of the project area are the latest issues.

4.3.a. Spatiality

The area is vast, open, in direct contradition with the surrounded fabric. The project will have to manage this uncommon urban vacuum. The whole thing is really accessible for the population. The possibility of being a community nucleus is born.

4.3.b. Existing management

Managing the existing in this situation is a double-edged issue. From the three recoverable houses comes the opportunity to preserve the historical heritage of the city. The recovery is accompanied by all its design constraints related to spatiality, style, structure... The management of the other ruins is an additional work to fix the construction area. In addition, they are all ruins of war, therefore potentially dangerous with the presence of remaining exhibition systems.

	Punti di forza	Punti di debolezza
Specificazione dell’area	• Edifici a valore storica rinnovabile	• L’area è piena di resti edilizi da eliminare in tutta sicurezza • Possibile presenza di esplosivi
Accessibilità	• Area adiacente alle due strade principale • Stazione ferroviarie a 1.25km • Stazione pullman a 950m	• Operazione dei mezzi pubblici incerta

IV. EXISTING BUILDINGS

INDICE DEL CAPITOLO

INDICE DEL CAPITOLO

THOUGHT ON THE EXISTING

This project is about building in the center of the built and rebuilding in the center of the destroyed.

The existing with the concept. The destroyed state of the city cannot be hidden. Today, the inhabitants live in the ruins of their city. What is it like to manage this relationship? If so many buildings in Mosul have died, social and urban food remains. We are faced with a problem of rehabilitation rather than construction. The solutions are different, from the complete renovation to the complete preservation of the existing. With the help of UNESCO in this project as in many others, the city has become a vast construction site to heal from the past, without forgetting it.

As for the existing, the parts of buildings still standing have several tasks. Preserving an urban continuity, the Old City of Mosul collects almost exclusively buildings of the same era. The current buildings have the constraint of being compatible with the past identity of the city, of not completely changing Mosul. This consideration arises from the psychological need to have a social anchor, after a war. This for the inhabitants is their city for which they have suffered. Many have refused to leave.

On the other hand, it must be said that the ruins are memories of a hard history that they would have preferred to forget. The anthropologist Marc Auge attributes to the ruins, the ability to manage the contraditions in the relationship to time.

“While everything conspires to make us believe that the story is over and that the world is a show where that end is staged, we must find the time to believe the story. This would be the pedagogical provocation of the ruins.”

The ruins are a proof of the past that every one of us is not able to manage and know completely. Consequently they are the proofs of the existence of history. History with the past, present and future. Marc Auge describes the break with the past as an oblivion that if it takes root in the present and occurs with a break with the future. After the war, it is built for the future. This is why the existing is an essential component.

Fig. IV-01.Umbau Astley Castle da Witherford Watson Mann @DETAIL

Fig. IV-02.Can Tomeu, Andrea SOLE

For the architect, the ruins remain a material element with which the composition has the opportunity to play. A new way to design is born.

“The goal is rather reinvention than nostalgia: for architects, it is about reconciling ruins with today’s customs, to stitch up, preserve and modify, sometimes with a real economy of means. “ Olivier Darmon

GLOBAL MANAGEMENT

1. GLOBAL STRATEGY

UNESCO has created a strategy for the recovery of Mosul's buildings taking into account their historical value and state of destruction. The program made it possible to classify all buildings in Mosul. Above all, it represents a way of controlling the general reconstruction of the city and ensuring the preservation of the historical identity of the city.

Damage is considered serious if the structural elements are irreversibly deformed. Except in this case, one damage is greater if the non-bearing elements are perforated or missing. Minor damage is signaled by the presence of cracks and destruction of windows.

The value of a building is classified into four categories. The value is high if the building has a central role in the local, regional or national identity. The value is average if the building represents a particular historical period in the urbanization of the city, but it does not have a community role. Buildings of lesser value have an ecstatic or structure related to traditional local construction techniques. UNESCO considers buildings built in the twentieth century as buildings of no historical or architectural value.

Livello di danno	Valore storico e architettonico			
	A Alto	B Media	C Basso	D Nessun
4 Distrutto	A4	B4	C4	D4
3 Grave	A3	B3	C3	D3
2 Maggiore	A2	B2	C2	D2
1 Minore	A1	B1	C1	D1
0 Non rilevanti	A0	B0	C0	D0

Tab. IV-01.Matrice di intervento del UN Habitat

Following this classification, reconstruction projects follow different administrative paths. All projects related to buildings of type A2, A3, A4, B2, B3, B4 are controlled by UNESCO, the municipality and the governorate of Nineveh. Projects with buildings of types C2, C3, C4, D2, D3, D4, do not require the commitment of UNESCO. Finally, projects involving buildings with minor damage (categories 1 and 0) only need to be approved by the municipality.

This classification made it possible to customize the treatment of each building. In addition, he shared the commitment and responsibility of all actors in the reconstruction of the city. From this, the initiative on which we work is born.

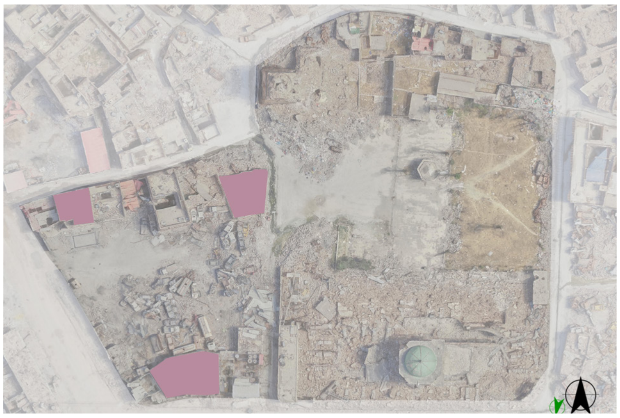


Fig. IV-03.Localizzazione degli edifici da valutare

2. PROJECT AREA

The project area is not an urban void. The building space was created by the more or less serious destruction of some buildings. As described above, demolitions of worthless buildings were envisaged. The entire religious complex is of greater importance for the local identity, so it is to be restored.

On the area considered as an extension of the area of the complex, are the remnants of three houses that have a medium or low value regarding their architecture. The future project will integrate these remnants by shaping a new building.

They are three typical courtyard houses with few rooms. In the three architectures we notice traditional spatial elements. In sum, the houses have an architectural value or a fairly solid structural state. All of them open to the outside of the building area.

The names of the buildings are the ones used by UNESCO for all official documents in the Revive Mosul rehabilitation program.

SURVEY

1. HOUSE N°8

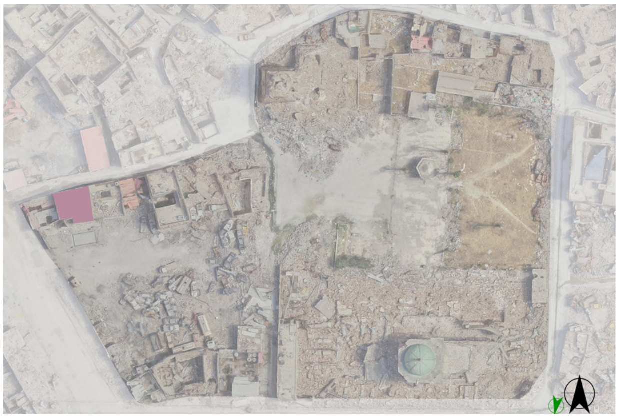


Fig. IV-04.Localizzazione della casa 8

House 8 is the lowest of the three houses to be rehabilitated. It is organised by a courtyard around which the different rooms are developed. A large majority of the original house remains.

1.1. Materials

As for the material, the walls of the house are made of 50cm of stone, plaster and limestone. They are covered with plaster and oil paint. The ceilings have the particularity of being made of arches of Jack. They are made of stone, plaster and limestone reinforced with concrete. The floors on the ground are covered with mosaic tiles, well preserved.

Fig. IV-05.Vista dell'alto della corte ©UNESCO

1.2. Photografic survey

Fig. IV-09.Fotografia corte interna ©UNESCO

Fig. IV-06.Fotografia corte interna ©UNESCO

Fig. IV-07.Prospetto sud ©UNESCO

Fig. IV-08.Prospetto est ©UNESCO

1.3. Geometric survey

3.1.a. Plans

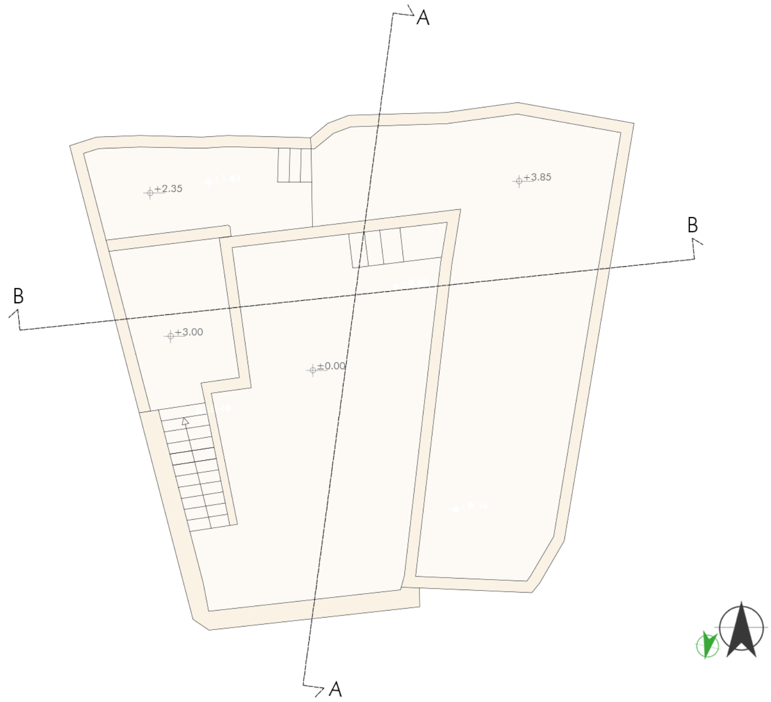


Fig. IV-10. Pianta del tetto. Scala 1/200

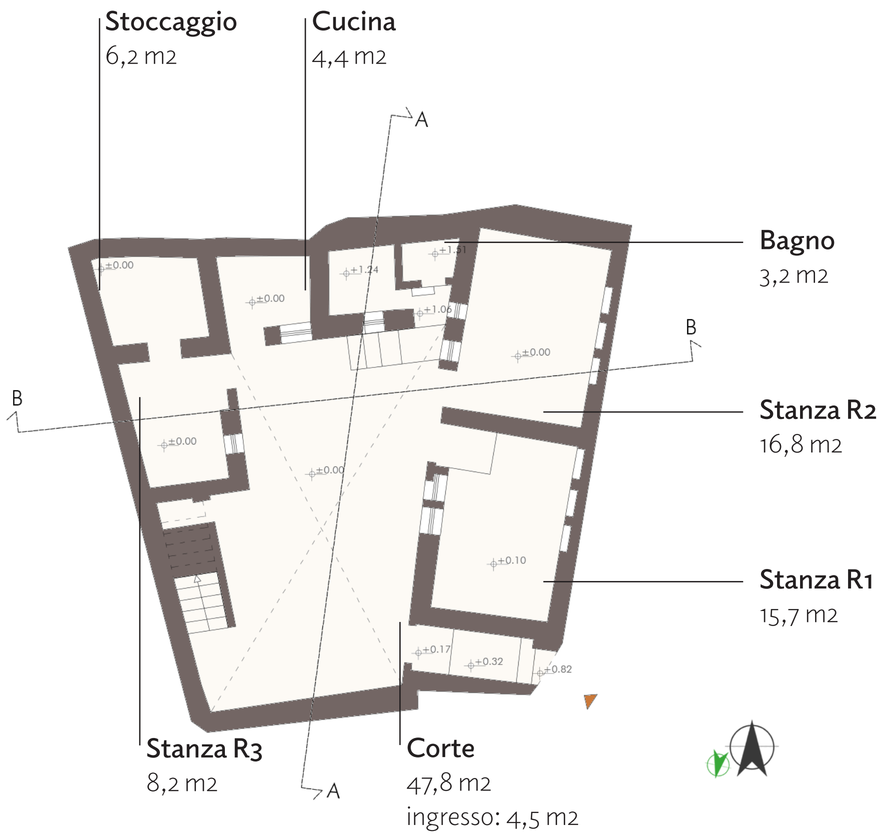


Fig. IV-11.Pianta del piano terra Scala 1/200

3.1.b. Front

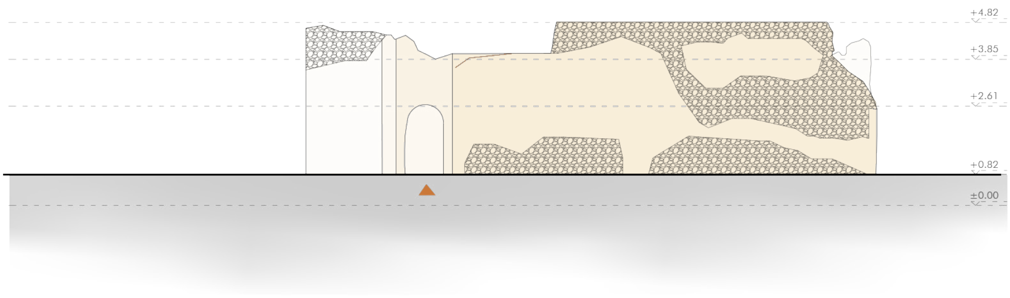


Fig. IV-12.Prospetto est della casa 8. Scala 1/200

3.1.c. Section

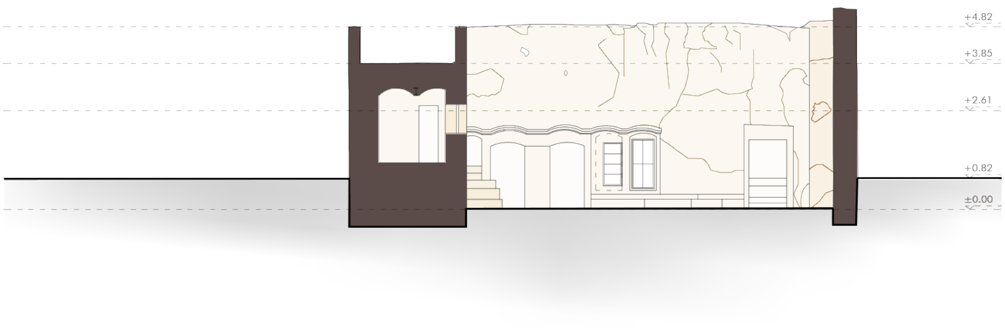


Fig. IV-13.Sezione A-A della casa 8. Scala 1/200

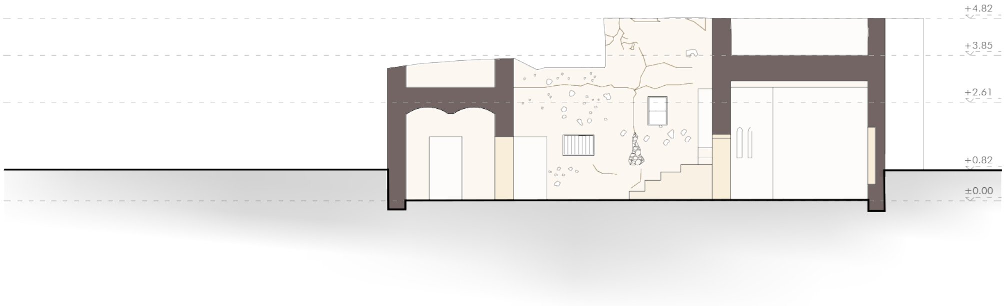


Fig. IV-14.Sezione B-B della casa 8. Scala 1/200

2. HOUSE N°9

House 9 has three floors. The basement is extensive. The ceilings are vaulted in almost all the rooms. The house was completely burnt down by an explosion.

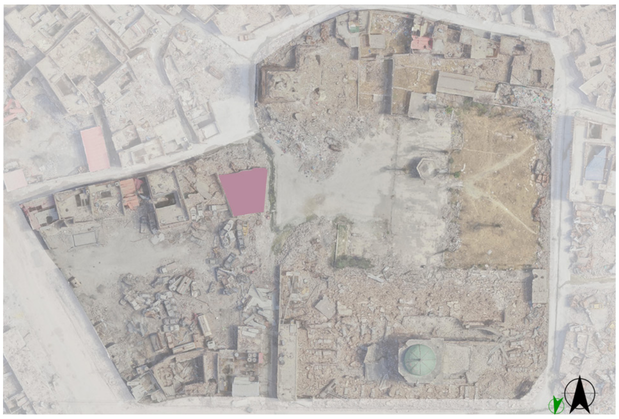


Fig. IV-19.Localizzazione della casa 9

2.1. Materials

The peculiarity of this house is that it is made of stone, plaster and limestone on one side and concrete blocks on the other. The floors are made of mosaic tiles or exposed concrete in the basement.

Fig. IV-20.Camera ©UNESCO

2.2. Rilievo fotografico

Fig. IV-15. Fotografia della corte ©UNESCO

Fig. IV-16. Fotografia della corte ©UNESCO

Fig. IV-17. Fotografia della corte ©UNESCO

Fig. IV-18. Vista dell'alto ©UNESCO

2.3. Geometric survey

3.2.a. Plans

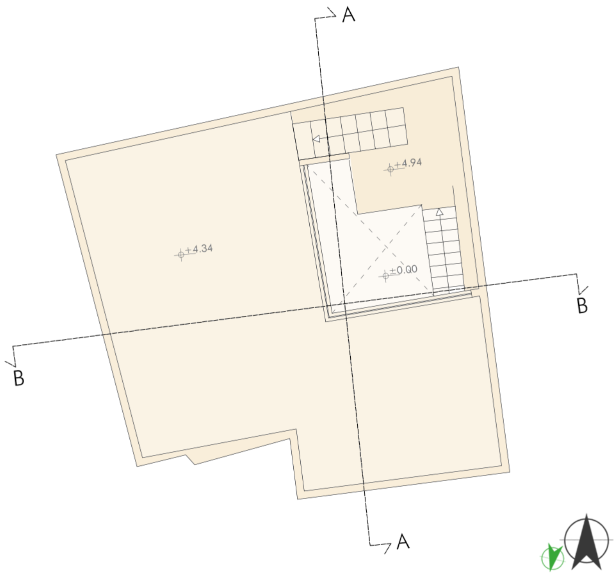


Fig. IV-21.Pianta del terrazzo. Scala 1/200

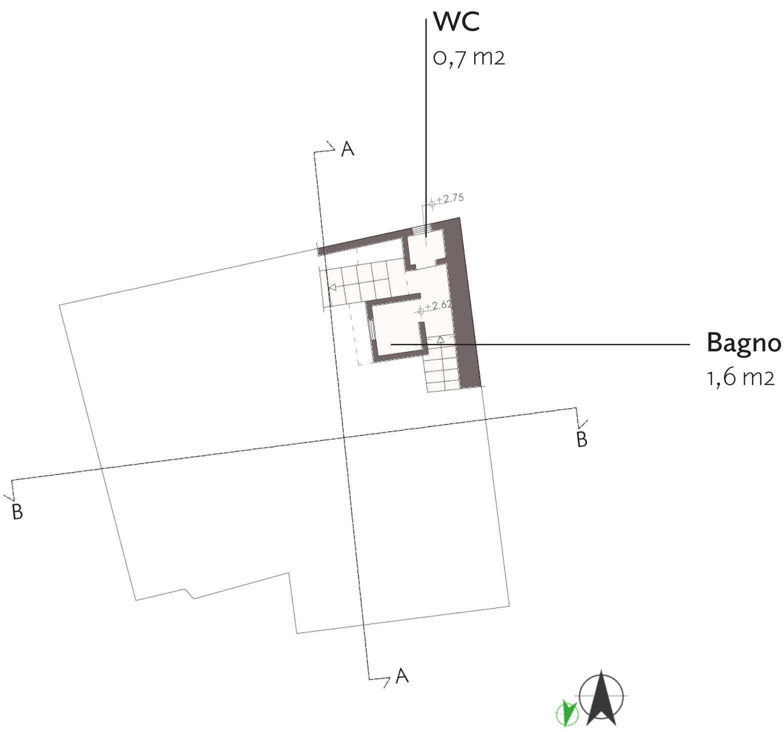


Fig. IV-22.Pianta del piano intermedio. Scala 1/200

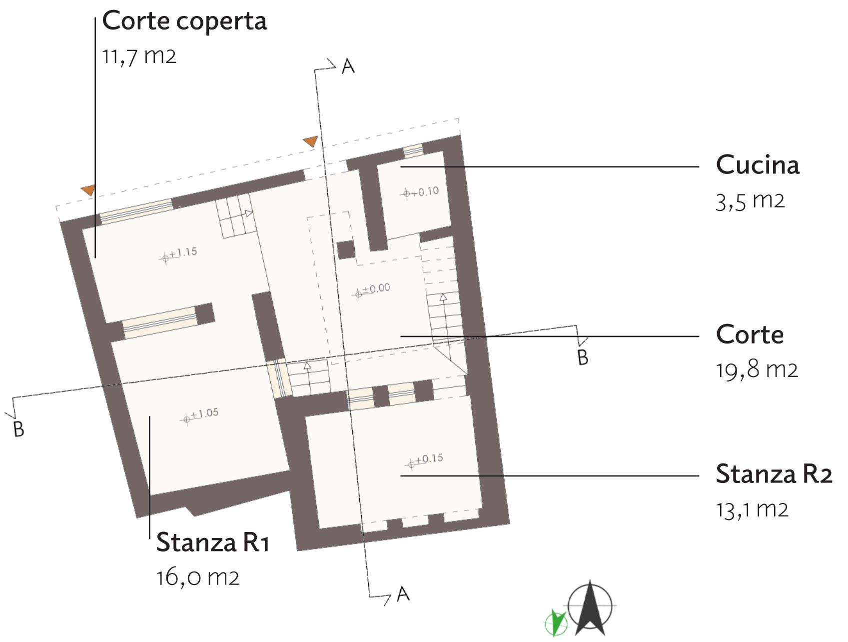


Fig. IV-23.Pianta del piano terra. Scala 1/200

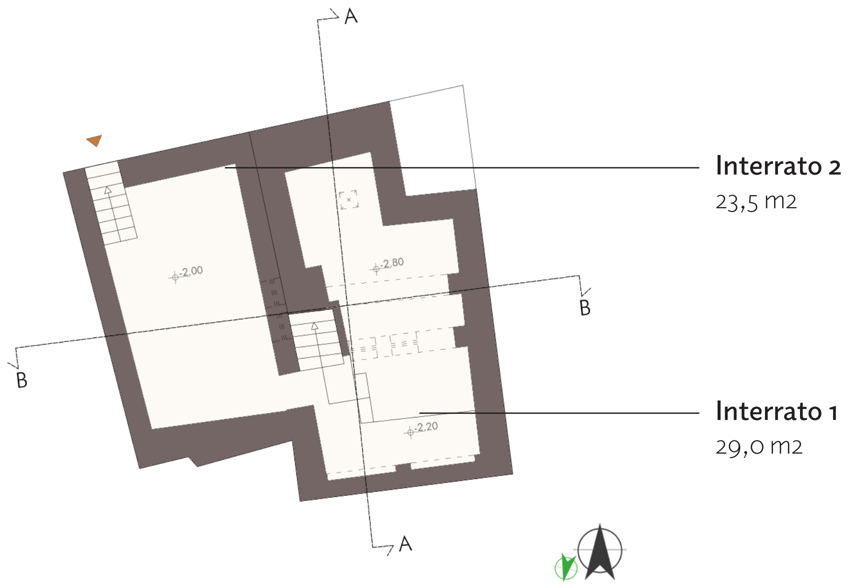


Fig. IV-24.Pianta del piano interrato. Scala 1/200

3.2.b. *Front*

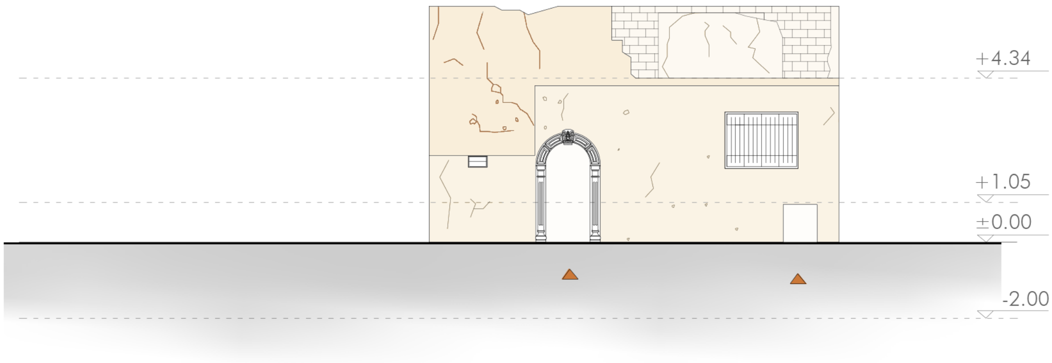


Fig. IV-25.Prospetto nord della casa 9. Scala 1/200

3.2.c. *Sections*

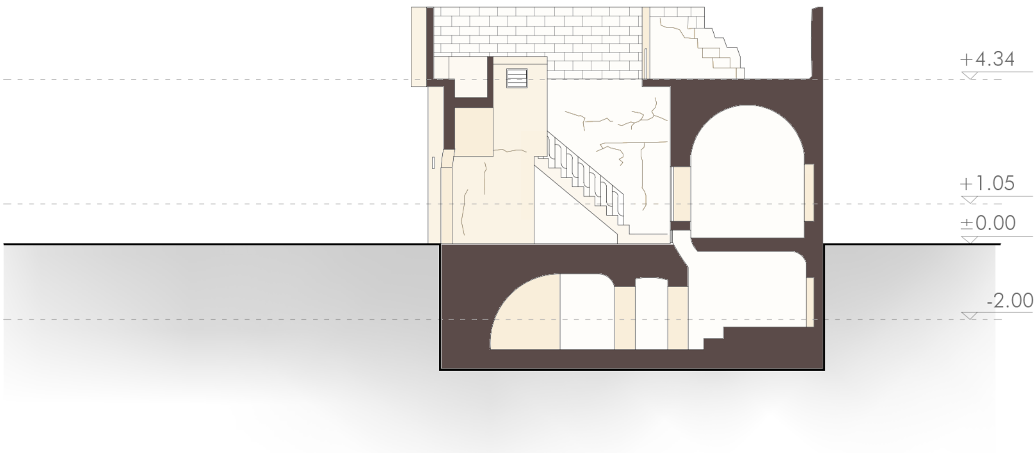


Fig. IV-26. Sezione A-A della casa 9. Scala 1/200

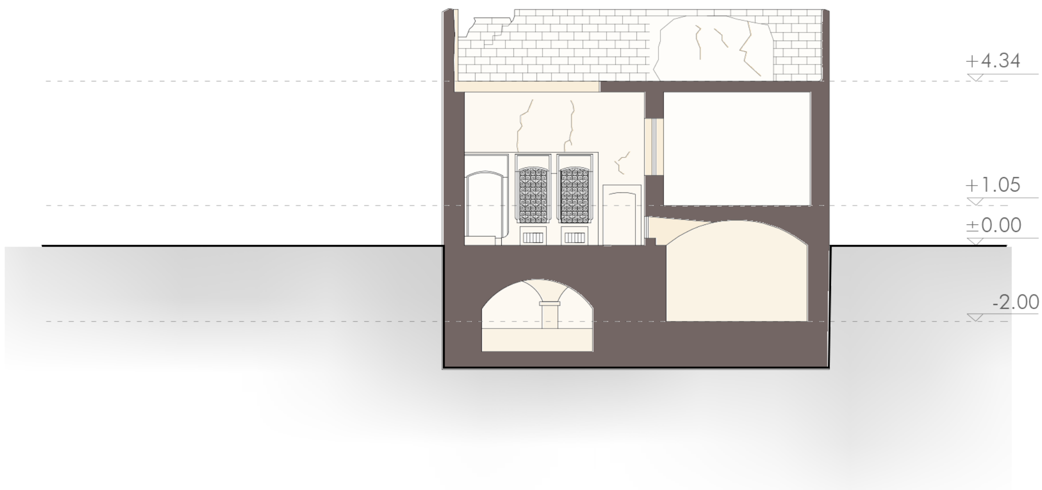


Fig. IV-27.Sezione B-B della casa 9. Scala 1/200

3. HOUSE N°10

House 10 is the largest of the three houses to be rehabilitated. It is distinguished by a large courtyard and a garage.

Of the original house, only the ground floor and two stairwells to the first floor and terraces remain. The east side of the house is the best preserved.

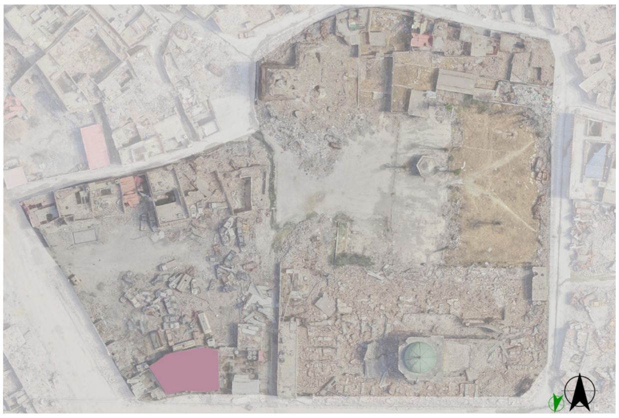


Fig. IV-29.Localizzazione della casa 10

3.1. Material

The walls of the house are made of 50cm of stone, plaster and limestone. They are covered with plaster and sometimes with alabaster marble at the bottom. Marble also covers the arches and columns in the courtyard and the basement. The ceilings are similarly made of stone, plaster and limestone. Sometimes they have been reinforced with reinforced concrete. The floors on the ground are made of concrete. When they are covered, mosaic tiles have been chosen.

Fig. IV-28.Fotografia del basamento ©UNESCO

3.2. Photografic survey

Fig. IV-30.Fotografie della corte©UNESCO

Fig. IV-31.Fotografie della corte©UNESCO

Fig. IV-32. Stanze del piano terra©UNESCO

Fig. IV-33.Ingresso del garage©UNESCO

3.3. Geometric survey

3.3.a. Plans

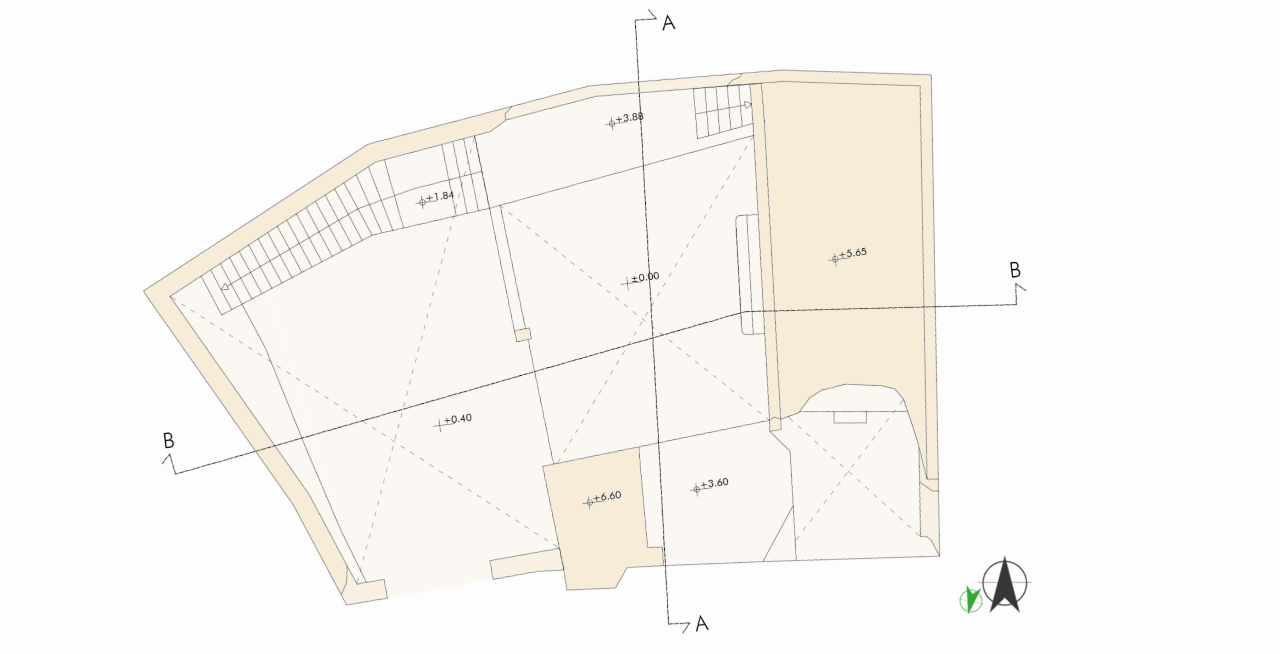


Fig. IV-34.Pianta del tetto. Scala 1/200

Fig. IV-35.Pianta del primo piano . Scala 1/200

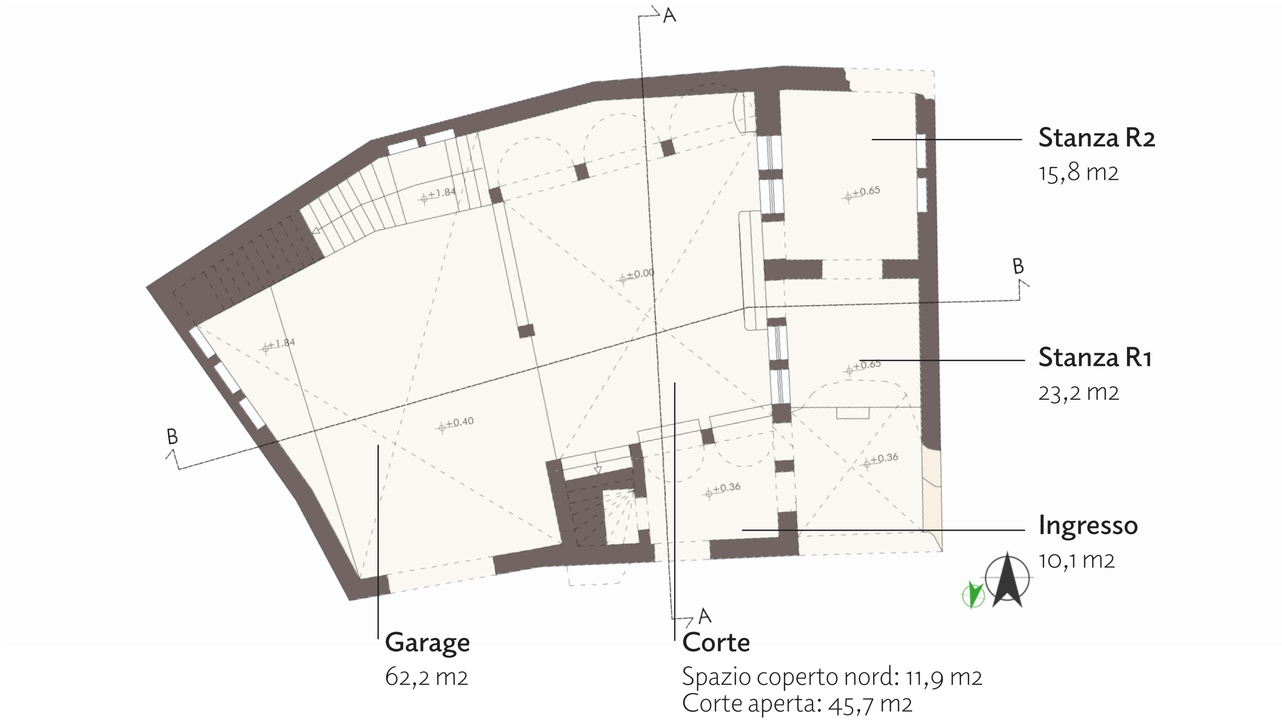


Fig. IV-36.Pianta del piano terra. Scala 1/200

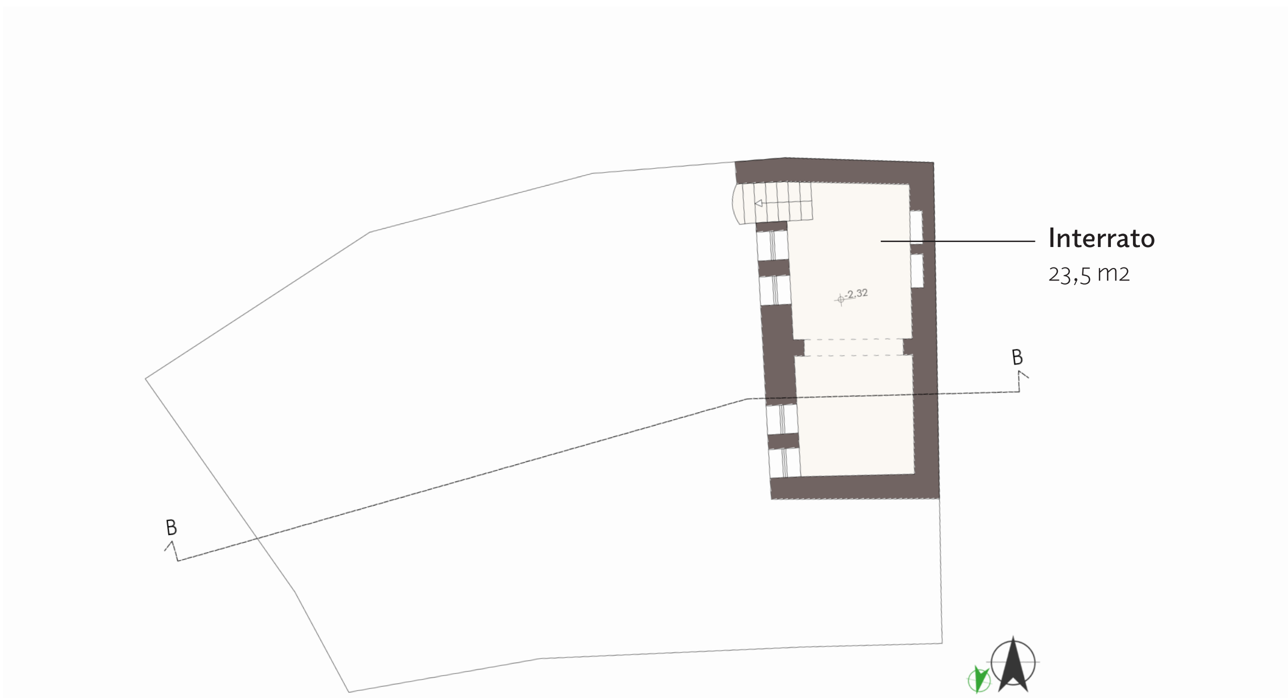


Fig. IV-37.Pianta del piano interrato. Scala 1/200

3.3.a. Front

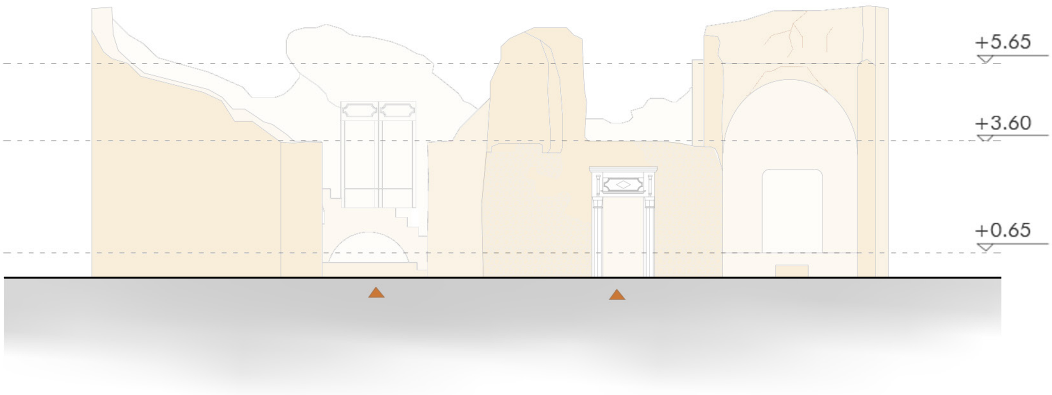


Fig. IV-40.Prospetto est della casa 10. Scala 1/200

3.3.b. Section

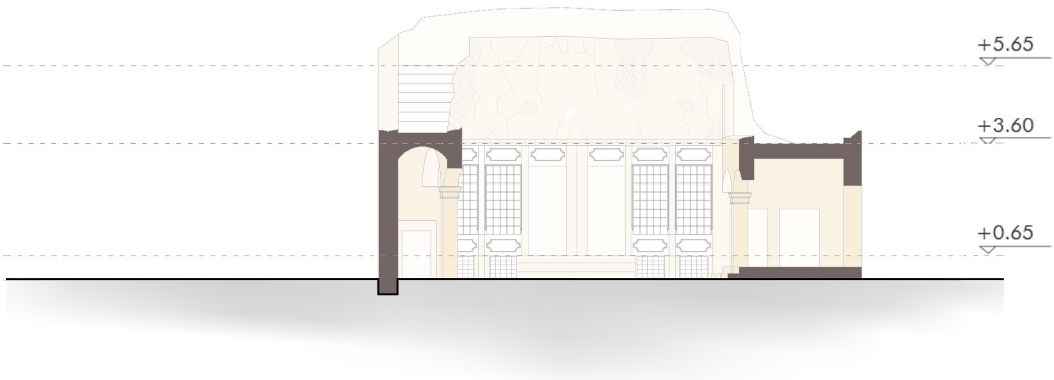


Fig. IV-38.Sezione A-A della casa 10. Scala 1/200

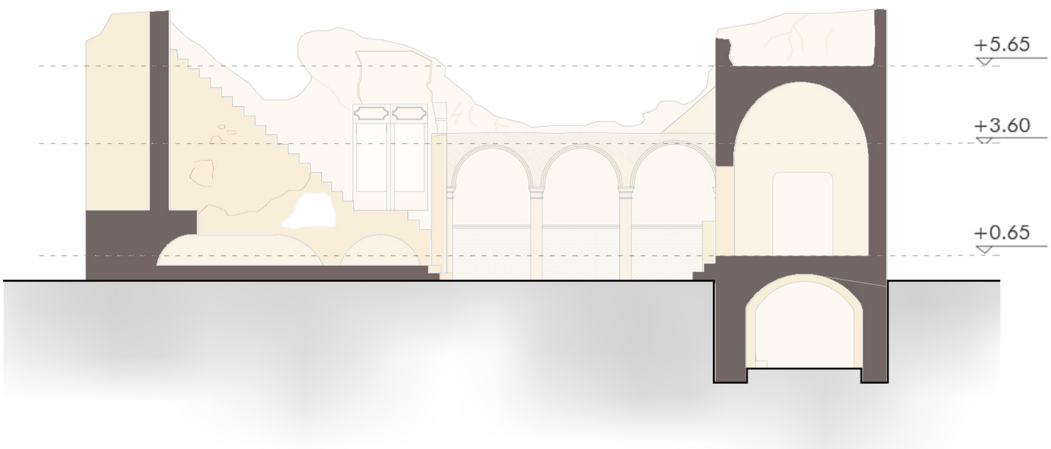


Fig. IV-39.Sezione B-B della casa 10. Scala 1/200

BUILDING PATHOLOGY

After its construction, a building is going to live for decades up to centuries or millennials. Over its period of operation, the building gradually deteriorates. The deterioration comes from different reasons, climatic events, human action, natural aging... In sum, the building is no longer as it was immediately after its construction.

Before recovering a building to integrate it into a new project that will have its lifespan it is important to know its state. It is a way of being able to design ensuring high durability.

Building pathology is the discipline that studies the ways of failure of building systems, the mechanisms of alteration of materials, the influence of the agents, defects and acts at the origin of the failures and alteration that can observe us on the systems.

1. CHARACTERIZATION

1.1. Sources of the study

UNESCO workers took pictures of the global state of every room in every home. Thus it was possible to deduce the pathologies, defects from which every building suffers. A very detailed study on the site will still be necessary to validate the assumptions. This study was not done due to the impossibility of going to people in Mosul.

To characterize the pathologies, the following study is based on two documents, the ICOMOS ISCS guide and the NorMaL recommendations. ICOMOS is an international organization of French origin that works as an expert with UNESCO for the preservation and protection of heritage. The NorMaL commission was created in 1977 for the conservation of stone materials in the field of cultural heritage. And an Italian government body.

1.2. Main defects

The pathologies of the three houses are due to three main phenomena.

4.1.a. Natural aging

Houses present evidence of the action of time on their casing. The natural degradation of paints and other coatings, and erosion caused by winds are major examples.

4.1.b. The war

Unsurprisingly, loved ones have been affected by armed conflicts. War-related damage is burn stains, collapses due to the use of explosive systems. In addition, the facades are covered with perforation that resemble bullet holes. Sometimes, pathologists are the most worrying because they create structural instability.

4.1.c. Humidity

At first glance, the particularly arid climate could preserve the constructions of the presence of moisture. However, it is noticeable in all the lower parts of the houses pathologies related to a rise of water. The proximity of the river fills the underwater with moisture.

1.3. Visible anomaly cards

For each anomaly detected, a card is made with the localization of this type of anomalies, the description, the possible causes and the procedure for treating the constructive element. Here are the anomalies detected on the three houses:

SAV 01. Biological colonization - Plants
SAV 02. Disintegration
SAV 03. Efflorescence
SAV 04A. Surface fracturing
SAV 04B. Critical fracturing
SAV 05. Rainwater infiltration
SAV 06. Gap
SAV 07A. Stain - Surface burn
SAV 07B. Stain - Critical burn
SAV 08. Lack - Partial collapse
SAV 09. Lack - Perforations
SAV 10. Discoloration - Graffiti
SAV 11. Discoloration - Humidity zone
SAV 12. Water rising damp

2. DETECTION OF VISIBLE ANOMALY AND INTERVENTION

2.1. SAV 01. Colonizzazione biologica - Piante

Fig. IV-41.Fotografia pianta ©UNESCO

Localizzazione

Unita tecnologia interessata - Chiusura orrizontale

Casa 8
- Corte: pavimento

Definizione da ICOMOS.

Colonizzazione della pietra da parte di piante e microrganismi come acteria, cianobatteri, alghe, funghi e licheni (simbiosi di questi ultimi tre). La colonizzazione biologica comprende anche le influenze di altri organismi come gli animali che nidificano su e nella pietra.
Pianta: Essere vivente vegetale, che ha, quando è completo, radice, fusto e foglie, anche se a volte consiste solo di una singola espansione fogliare.

Descrizione.

Une decina di piante alte fino un metro crescono tra le lastre nel pavimento.

Cause.

Mancanza di manutenzione
Progettazione del pavimento con lastre appoggiate direttamente a terra

INTERVENTO POSSIBILE

Obbietivo.

Ripristinare l'aspetto originale ed evitare che questa situazione si ripeta.

Protocollo operativo.

1. Strappare le piante
Strappare a mano oppure con strumenti. Fare attenzione a tirare fino alle radici.
2. Pulire il pavimento
Pulizia manuale con spazzole. Controllare lo stato del pavimento.
3. Rifare la pavimentazione
Considerando lo stato del pavimento e la composizione prevista, il pavimento potrebbe essere sia riparato parzialmente sia completamente rifatto. Nel caso di un ripreso, cambiare le lastre danneggiate e pulire i giunti. Altrimenti, togliere tutte le lastre, gettare una base in cemento prima di iniziare la nuova finitura.

Manutenzione.

Uno controllo periodico deve essere fatto. Si strapperanno le nuove piante appena possibile senza aspettare che crescono.

Note.

Nel caso di ripreso completo della pavimentazione con una base in cemento, è necessario prevedere un sistema di scarico delle acque piovana.

2.2. SAV 02. Disgregazione

Fig. IV-42.Fotografia disgregazione ©UNESCO

Localizzazione

Unita tecnologia interessata - Chiusura verticale

Casa 8	Casa 9	Casa 10
- corte: muri ovest, nord e est	- corte: muro nord	- corte: muro est - garage: muro ovest

Definizione da Normal.

Decoesione caratterizzata da distacco di granuli o cristalli sotto minime sollecitazioni meccaniche

Descrizione.

Distacco della finitura della parete fino a lasciare a vista lo strato strutturale. Le pietre dello strato strutturale si disgregano in polvere. Il distacco è presente esclusivamente all'esterno in zone abbastanza diffusa. Interviene sia in basso della parete, sia in alto sui lati

Cause.

Invecchiamento naturale
Mancanza di manutenzione
Scelta di materiali non appropriati

INTERVENTO POSSIBILE

Obbietivo.

Ripristinare l'aspetto originale ed evitare che questa situazione si ripeta.

Protocollo operativo.

1. Pulizia manuale con spazzole

La pulizia a secco della superficie viene effettuata con spazzole a setole naturali. Tutte le polveri e le particelle trattate da questo danno devono essere rimosse. In questo modo la superficie sarà sgombra. Si consiglia una pulizia uniforme per evitare di peggiorare i difetti.

2. Acqua deioizzata

Inumidire la superficie con acqua deionizzata con spray per preparare la superficie a ricevere una nuova malta.

3. Intonaco nuovo di calce e sabbia

Applicare un nuovo gesso dove il precedente era disgregante.

4.Tocco di finitura

Se necessario, aggiungere uno strato di vernice per raggiungere il colore dell'intonaco originale.

Manutenzione.

Un controllo dovrebbe essere fatto frequentemente per monitorare le condizioni delle pareti. Quando si ritiene necessario si può fare lo stesso intervento.

Note.

Tutto il nuovo materiale aggiunto deve essere simile e adatto al materiale del sottostrato.
L'intervento è da fare dopo aver risolto i eventuali problemi relativi all'umidità.

2.3. SAV 03. Efflorescenza

Fig. IV-43.Fotografia efflorescenza ©UNESCO

Localizzazione

Unita tecnologia interessata - Chiusura verticale

Casa 10
- interrato: tutti muri

Definizione da Normal.
Formazione di sostanze, generalmente di colore biancastro e di aspetto cristallino o pulverulento o filamentoso, sulla superficie del manufatto.

Descrizione.
Aree diffuse di macchie bianche sull'intonaco. Questo degrado è maggiormente accompagnato di umidità di risalita dell'acqua (SAV 12).

Cause.
Umidità ascendente proveniente dal terreno
Scelta di materiali non appropriati

INTERVENTO POSSIBILE

Obbietivo.
Ripristinare l'aspetto originale ed evitare che questa situazione si ripeta.

Protocollo operativo.
1. Pulizia
Pulizia con l'uso di un lavaggio a pressione.
2. Scrub
Strofinare la parte umida interessata per metterla in soluzione con acqua in modo che l'efflorescenza possa essere risciacquata.
3.Pulizia
Pulizia manuale con spazzole: se c'è polvere sulla facciata, utilizzare un detergente che tagli il grasso, che aiuterà il riempitivo a legare il cemento.
Sciacquare la superficie con acqua fresca in modo che non ci siano residui da asciugare sul cemento.
Utilizzare un getto d'aria o un aspirapolvere a umido per rimuovere l'acqua stagnante.

Manutenzione.

Controllo visivo regolare con uno controllo dell'umidità.

Note.
Si consiglia favorire la ventilazione nelle stanze colpite.

2.4. SAV 04A. Fratturazione superficiale

Fig. IV-44.Fotografia fissurazione ©UNESCO

Localizzazione

Unita tecnologia interessata - Chiusura verticale

Casa 8	Casa 9	Casa 10
-R1: muro ovest - R2: muri nord e est -Cucina: tutti muri -Bagno: muri ovest e nord	-R1: muri sud, ovest e nord	- R1: muro ovest - R2: muro ovest -corte: muri est e sud

Unita tecnologia interessata - Chiusura orrizontale

Casa 8	Casa 9	Casa 10
-Bagno: soffito - Corte: soffito		-R2: pavimento -Garage: pavimento

Definizione da Normal.
Degradazione che si manifesta con la formazione di soluzioni di continuità nel materiale e che può implicare lo spostamento reciproco delle parte.

Descrizione.
Fessurazioni sottile delle state superiori dell'unita tecnologia. A volte le fessurazioni coprono la maggioria della superficie. Non è uno degrado critico considerando che non concerna lo strato strutturale.

Cause.

Invecchiamento naturale
Mancanza di manutenzione

INTERVENTO POSSIBILE

Obbietivo.
Ripristinare l'aspetto originale ed evitare che questa situazione si ripeta.

Protocollo operativo.
1. Pulizia
Pulizia con l'uso della spazzola di setola: prima di utilizzare qualsiasi stucco, assicurarsi che non vi siano oli o sporcizia sulla superficie.
2. Sostituzione
Scalpellare la crepa pulita: usare uno scalpello a freddo e un martello per liberarsi dei grossi pezzi di formica nella crepa. Questo si chiama chiavettare il buco per rendere la crepa più grande che aiuta il nuovo materiale di rappezzamento a legare con la vecchia crepa.
3. Pulizia
Pulizia con spazzole e aspirapolvere: una volta che si è schiacciata la crepa è importante pulire la superficie, usare una scopa a frusta e poi passare l'aspirapolvere.
4. Toppa
Stendere una colla appropriato: utilizzare un riempitivo e controllare le crepe in pochi minuti per vedere se si è stabilizzato.
5. Finitura
Sigillare con una finitura simile a quella di origine e compatibile con gli sotto strati.

Manutenzione.

Controllare periodicamente che le fessure non si riaprano con controllo visivo.

Note.
Fare attenzione all'umidità e agli agenti atmosferici presenti che possono peggiorare la fratturazione.
Tutto il nuovo materiale aggiunto deve essere simile e adatto al materiale del sottostrato.

2.5. SAV 04B. Fratturazione critica

Fig. IV-45.Fotografia fratturazione ©UNESCO

Localizzazione

Unita tecnologia interessata - Chiusura verticale

Casa 8	Casa 9	Casa 10
R1: muro sud	corte: muri sud e ovest	R1: muri nord e sud
R3: muro sud		
Bagno2		
corte: muri nord e est		

Unita tecnologia interessata - Chiusura orrizontale

Casa 8	Casa 9	Casa 10
R2: soffito	R2: soffito	R1: soffito

Definizione da Normal.
Degradazione che si manifesta con la formazione di soluzioni di continuità nel materiale e che può implicare lo spostamento reciproco delle parte.

Descrizione.
Fratturazione di lunghezza maggiore, di larghezza fino ad alcuni centimetri. La fratturazione concerna gli strati superficiali e lo strato strutturale. A volte taglia l'unità tecnologia in due corpi distingui.

Cause.
Invecchiamento naturale
Mancanza di manutenzione

INTERVENTO POSSIBILE

Obbietivo.
Ripristinare l'aspetto originale ed evitare che questa situazione si ripeta.

Protocollo operativo.
1. Pulizia
Pulizia con l'uso della spazzola di setola: prima di utilizzare qualsiasi stucco, assicurarsi che non vi siano oli o sporcizia sulla superficie.
2. Sostituzione
Scalpellare la crepa pulita: usare uno scalpello a freddo e un martello per liberarsi dei grossi pezzi di formica nella crepa. Questo si chiama chiavettare il buco per rendere la crepa più grande che aiuta il nuovo materiale di rappezzamento a legare con la vecchia crepa.
3. Pulizia
Pulizia con spazzole e aspirapolvere: una volta che si è schiacciata la crepa è importante pulire la superficie, usare una scopa a frusta e poi passare l'aspirapolvere.
4. Rinforzo
Rinforzare strutturalmente l'unità tecnologica secondo un avviso esperto.
5. Toppa
Stendere una colla appropriato: utilizzare un riempitivo e controllare le crepe in pochi minuti per vedere se si è stabilizzato.
6. Finitura
Sigillare con una finitura simile a quella di origine e compatibile con gli sotto strati.

Manutenzione.
Controllare periodicamente che le fessure non si riaprano con controllo visivo.

Note.
Fare attenzione all'umidità e agli agenti atmosferici presenti che possono peggiorare la fratturazione.
Tutto il nuovo materiale aggiunto deve essere simile e adatto al materiale del sottostrato.

2.6. SAV 05. Infiltrazioni d'acqua piovana

Fig. IV-46.Fotografia soffito con infiltrazioni ©UNESCO

Localizzazione

Unita tecnologia interessata - Chiusura verticale

Casa 8	Casa 9	Casa 10
R1: tutti muri	Bagno	R2: muro ovest
R3: tutti muri		

Unita tecnologia interessata - Chiusura orrizontale

Casa 8	Casa 9	Casa 10
R1: soffito	Interrato2: soffito	R1: soffito
R3: soffito		R2: soffito
Cucina: soffito		Interrato: soffito

Definizione.
I danni da infiltrazioni d'acqua nelle murature intonacate si manifestano dapprima con la creazione di aloni di colori a seconda della presenza di acqua pulita oppure sporca, e successivamente con danni alla tinteggiatura: esfoliazione e caduta di piccole scaglie nel caso di tinteggiature sintetiche al quarzo, disgregazione, polverizzazione e formazione di efflorescenze negli intonaci a calce. Le infiltrazioni d'acqua causano tuttavia anche danni strutturali molto gravi che possono portare a veri e propri crolli.

Descrizione.
Infiltrazioni di acqua piovane all'interno dell'edificio dentro gli strati della chiusura oppure tra fessurazioni. Le infiltrazioni colpiscano tutti strati dell'unità tecnologica.

Cause.

Mancanza di manutenzione
Fratturazione
Pioggia

INTERVENTO POSSIBILE

Obbietivo.
Ripristinare l'aspetto originale ed evitare che questa situazione si ripeta.

Protocollo operativo.
1. Pulizia
Pulizia con l'uso della spazzola di setola: prima di utilizzare qualsiasi stucco, assicurarsi che non vi siano oli o sporcizia sulla superficie.
2. Verifica di danni sottostanti
Verifica dell'area indagata per verificare se ci sono problemi di struttura con l'utilizzo di specifici strumenti come martelli di legno o termocamere.
3. Sostituzione
Rimuovere le parte strutturale troppo colpite.
Con un avviso esperto, ricostruire la struttura con un attento particolare alla giuntatura con le parte rimanente. Fare attenzione alla continuità degli strati e guarantire la tenuta all'acqua.
4. Intonaco nuovo
Applicare un nuovo gesso dove il precedente era danneggiato.
5.Finitura
Aggiungere strati di vernice per raggiungere il colore dell'intonaco originale.

Manutenzione.
Un controllo dovrebbe essere fatto frequentemente per monitorare le condizioni delle pareti. Quando si ritiene necessario si può fare lo stesso intervento.

Note.
Tutto il nuovo materiale aggiunto deve essere simile e adatto al materiale del sottostrato.

2.7. SAV 06. Lacuna

Fig. IV-47.Fotografia lacuna ©UNESCO

Localizzazione

Unita tecnologia interessata - Chiusura verticale

Casa 8	Casa 9	Casa 10
cucina: tutti muri	corte: muri sud e est	tutti scale
R2: muro sud		corte: muri sud e nord
corte: muro est		

Unita tecnologia interessata - Chiusura orrizontale

Casa 8	Casa 9	Casa 10
		Interrato: pavimento
		Garage: pavimento

Definizione da Normal.
Caduta e perdita di parti di uno dipinto murale, con messa in luce degli strati di intonaco piu interni o del supporto.

Descrizione.
Distacco della finitura della parete fino a lasciare a vista lo strato strutturale. Sui lati esterni il degrado è peggiore e molto diffuso. All'interno, poche volte lo degrado è minimo, concerna solo la vernice finale.

Cause.
Invecchiamento naturale
Mancanza di manutenzione
Scelta di materiali non appropriati
Umidità

INTERVENTO POSSIBILE

Obbietivo.
Ripristinare l'aspetto originale ed evitare che questa situazione si ripeta.

Protocollo operativo.
1. Pulizia manuale con spazzole
La pulizia a secco della superficie viene effettuata con spazzole a setole naturali. Tutte le polveri e le particelle trattate da questo danno devono essere rimosse. In questo modo la superficie sarà sgombra. Si consiglia una pulizia uniforme per evitare di peggiorare i difetti.
2. Acqua deioizzata
Inumidire la superficie con acqua deionizzata con spray per preparare la superficie a ricevere una nuova malta.
3. Intonaco nuovo di calce e sabbia
Applicare un nuovo gesso dove il precedente era disgregante.
4.Tocco di finitura
Se necessario, aggiungere uno strato di vernice per raggiungere il colore dell'intonaco originale.

Manutenzione.
Un controllo dovrebbe essere fatto frequentemente per monitorare le condizioni delle pareti. Quando si ritiene necessario si può fare lo stesso intervento.

Note.
Tutto il nuovo materiale aggiunto deve essere simile e adatto al materiale del sottostrato.
L'intervento è da fare dopo aver risolto gli eventuali problemi relativi all'umidità.

2.8. SAV 07A. Macchia - Bruciatura superficiale


Fig. IV-48.Fotografia parete bruciata ©UNESCO

Localizzazione

Unita tecnologia interessata - Chiusura verticale
Casa 9
R1: tutti muri Bagno: tutti muri
Cucina: tutti muri Corte: muri nord, sud, ovest

Unita tecnologia interessata - Chiusura orrizontale
Casa 9
Bagno: soffito
Cucina: soffito
Corte: soffito

Definizione da Normal.
Alterazione che si manifesta con pigmentazione accidentale e localizzata dalla superficie, è correlata alla presenza di materiale estraneo al substrato.

Descrizione.
Macchia nera scura estende all'intera unità tecnologica. Risolte della bruciatura degli strati superficiali di finiture.

Cause.
Incendio accidentale

INTERVENTO POSSIBILE

Obbietivo.
Ripristinare l'aspetto originale.

Protocollo operativo.
1. Pulizia manuale con spazzole
La pulizia a secco della superficie viene effettuata con spazzole a setole naturali. Polvere e particelle devono essere rimosse. Nella fase di pulizia è importante fare attenzione a non rimuovere anche parte dell'intonaco non danneggiato.

Se la bruciatura conserna solo la finitura:
2. Applicazione del primer
Se necessario ripristinare il substrato e prepararlo con l'applicazione del primer.
3. Applicazione della pittura
È possibile ripristinare il colore dell'elemento applicando uno strato di pittura colorata. Il colore deve essere coerente con il precedente e il dipinto non deve essere aggressivo.

Se la bruciatura ha raggiunta l'intonaco:
2. Rifare l'intonaco
Togliere le parte danneggiate. Pulire la surfaci con spazzole e umidificarla. Intonacare di nuovo.
3. Finitura
Applicare uno primer e una vernice che raggiunge il colore di origine.

Manutenzione.
Nessun manutenzione straordinaria

Note.
Tutto il nuovo materiale aggiunto deve essere simile e adatto al materiale del sottostrato.

2.9. SAV 07B. Macchia - Bruciatura criticale

Fig. IV-49.Fotografia soffito bruciato ©UNESCO

Localizzazione

Unita tecnologia interessata - Chiusura orrizontale

Casa 9
R1: soffito

Definizione da Normal.
Alterazione che si manifesta con pigmentazione accidentale e localizzata dalla superficie, è correlata alla presenza di materiale estraneo al substrato.

Descrizione.
Macchia nera scura estende all'intera unità tecnologica. Risolte della bruciatura degli strati superficiali e strutturale.

Cause.
Incendio accidentale

INTERVENTO POSSIBILE

Obbietivo.
Ripristinare l'aspetto originale e consolidare l'unità tecnologica.

Protocollo operativo.
1. Pulizia manuale con spazzole
La pulizia a secco della superficie viene effettuata con spazzole a setole naturali. Polvere e particelle devono essere rimosse. Nella fase di pulizia è importante fare attenzione a non rimuovere anche parte dell'intonaco non danneggiato.
2. Verifica di danni sottostanti
Verifica dell'area indagata per verificare se ci sono problemi di struttura con l'utilizzo di specifici strumenti come martelli di legno o termocamere.
3. Sostituzione
Rimuovere le parte strutturale colpite.
Con un avviso esperto, ricostruire la struttura con un attento particolare alla giuntatura con le parte rimanente.
4. Finitura
Intonacare di nuovo e riverniciare.
4. Finitura
Intonacare di nuovo e riverniciare.

Manutenzione.
Controllare periodicamente che delle fessure non si creano alla giuntatura con l'esistente con controllo visivo.

Note.
Tutto il nuovo materiale aggiunto deve essere simile e adatto al materiale del sottostrato.

2.10. SAV 08. Mancanza - Crollo parziale

Fig. IV-50.Fotografia parete crollato ©UNESCO

Localizzazione

Unita tecnologia interessata - Chiusura verticale

Casa 8	Casa 9	Casa 10
R3: muro nord		R1: muro est
scale		R2: muro nord
		Garage: muri nord e sud

Unita tecnologia interessata - Chiusura orrizontale

Casa 8	Casa 9	Casa 10
R1: soffito	R1: soffito	R1: soffito
R3: soffito		R2: soffito
Stoccagio: soffito		Scala4

Definizione da Normal.
Caduta e perdita di parti. Il termine generico si usa quando tale forma di degradazione non è descrivibile con altre voci di lessico.

Descrizione.
Mancanza di una parte maggiore dell'unità tecnologica colpita.

Cause.
Invecchiamento naturale
Azione umana

INTERVENTO POSSIBILE

Obbietivo.
Ripristinare l'aspetto originale e consolidare l'unità tecnologica.

Protocollo operativo.

1. Pulizia

La pulizia a secco della superficie strutturale lasciate a vista viene effettuata con spazzole a setole naturali. Tutte le polveri e le particelle trattate da questo danno devono essere rimosse. In questo modo la superficie sarà sgombra.

2. Rinforzo strutturale

Secondo un avviso esperto, rinforzare le parte rimanente. Se nessun rinforzo è possibile, si consiglia distruggere l'intera unità tecnologica.

3. Ricostruzione

Ricostruire le parte mancante con un attento speciale alla giuntatura con l'esistente.

4. Finitura

Intonacare e verniciare le parte nuove

Manutenzione.
Controllare periodicamente che delle fessure non si creano con controllo visivo.

Note.
Tutto il nuovo materiale aggiunto deve essere simile e adatto al materiale del sottostrato.

2.11. SAV 09. Mancanza - Perforazioni

Fig. IV-51.Fotografia parete perforata ©UNESCO

Localizzazione

Unita tecnologia interessata - Chiusura verticale

Casa 8	Casa 9	Casa 10
Corte: muri ovest e nord		R1: muro sud corte: muro est Garage: muro ovest

Definizione da ICOMOS.

Una singola o una serie di forature superficiali, fori o spazi vuoti, praticati da un utensile affilato o creati da un animale. La dimensione è generalmente di scala da millimetrica a centrimetrica. Le perforazioni sono più profonde che larghe e penetrano nel corpo della pietra.

Descrizione.

Numerosi fori mettendo a vista lo strato strutturale della parete, di diametri fino a quindici centimetri. Alcuni fori sono traversanti.

Cause.

Impatto del proiettile
Azione umana

INTERVENTO POSSIBILE

Obbietivo.

Ripristinare l'aspetto originale.

Protocollo operativo.

1. Pulizia
Pulizia con l'uso di una spazzola a setole. Tutte le polveri e le particelle trattate da questo danno devono essere rimosse.Si consiglia una pulizia uniforme per evitare di peggiorare i difetti.
2. Acqua deioizzata
Inumidire la superficie con acqua deionizzata con spray per preparare la superficie a ricevere una nuova malta.
3. Correzione dello strato strutturale
Colmare i fori con una malta simile a quella usata tra le pietre della parete.
Assicurare la planarità della parete dopo l'intervento e verificare l'utilizzo di un materiale simile per il rivestimento.
4. Intonaco nuovo di calce e sabbia
Applicare un nuovo gesso
5. Vernice di finitura
Una volta che è asciutto, possiamo procedere al rivestimento.

Manutenzione.

Nessun manutenzione straordinaria.

Note.

Tutto il nuovo materiale aggiunto deve essere simile e adatto al materiale del sottostrato.

2.12. SAV 10. Scolorimento - Graffiti

Fig. IV-52.Fotografia graffito ©UNESCO

Localizzazione

Unita tecnologia interessata - Chiusura verticale

Casa 8	Casa 9	Casa 10
-Corte: muri ovest e nord		- corte: muri sud

Definizione da Normal.

Incisione, graffito, taglio o applicazione di vernice, inchiostro o materiale simile sulla superficie della pietra.
Le graffiti sono generalmente il risultato di un atto di vandalismo. Tuttavia, alcune graffiti possono avere valori storici, estetici o culturali e dovrebbero essere conservate.

Graffito senza valore estetica. Numero singolo alto circa cinquanta centimetri in vernice spray rossa.

Cause.

Azione umana

INTERVENTO POSSIBILE

Obbietivo.
Ripristinare l'aspetto originale.

Protocollo operativo.
1. Pulizia preparatoria
Pulizia a secco delle superfici rimuovendo tutte le polveri.
2. Sverniciare
Usare uno sverniciatore. Applica il prodotto direttamente sulla superficie da trattare e poi rimuovilo aiutandoti con un panno.
3. Pulizia ad acqua
Lavare le superfici con una idropulitrice a pressione idraulica. Evitare di utilizzare un attacco dotato di punta ristretta in quanto potrebbe danneggiare le superfici.

Manutenzione.

Nessuna manutenzione straordinaria

Note.
Se questo protocollo non dovesse dare i risultati sperati, ridipingere la superficie.

2.13. SAV 11. Scolorimento - Zona di umiditá

Fig. IV-53.Fotografia infiltrazione ©UNESCO

Localizzazione

Unita tecnologia interessata - Chiusura verticale

Casa 8	Casa 9	Casa 10
R2: muro nord	Interrato: tutti muri	Corte: muro nord
R3: muro sud		
Stoccagio		
Bagno 1		

Unita tecnologia interessata - Chiusura orrizontale

Casa 8	Casa 9	Casa 10
	Interrato: soffito	Interrato: soffito

Definizione da ICOMOS.
Modifica del colore della pietra in uno o tre dei parametri di colore: tonalità, valore e croma.
La zona di umiditá corrisponde all'oscuramento (tinta inferiore) di una superficie dovuto all'umiditá.

Descrizione.
Insieme di macchie nere risultando di patina biologica, accompagnate di rigonfiamenti minimi dello strato di vernice. Colpita solo gli strati superficiali. Sono dove a volta ci infiltra l'acqua piovana all'interno dell'edificio (SAV 05).

Cause.
Infiltrazione d'acqua
Mancanza di manutenzione
Umidità
Mancanza di ventilazione

INTERVENTO POSSIBILE

Obbietivo.
Ripristinare l'aspetto originale ed evitare che questa situazione si ripeta.

Protocollo operativo.
1. Verifica di danni sottostanti
Verifica dell'area indagata per verificare se ci sono problemi di struttura con l'utilizzo di specifici strumenti come martelli di legno o termocamere. Bloccare le infiltrazioni d'acqua eventuale (SAV 05).
2. Sostituzione
Gli elementi più danneggiati devono essere sostituiti parzialmente o totalmente.
3. Pulizia
Pulire a secco per rimuovere tutte le polveri. In uno secondo tempo, pulire con acqua, asciugare queste parti con speciali strumenti di ventilazione e deumidificazione.
4. Finitura
Intonacare di nuovo dov'è necessario e verniciare.

Manutenzione.
Un controllo dovrebbe essere fatto frequentemente per monitorare le condizioni delle pareti. Quando si ritiene necessario si può fare lo stesso intervento.

Note.
Tutto il nuovo materiale aggiunto deve essere simile e adatto al materiale del sottostrato.

2.14. SAV 12. Umidità di risalita d'acqua

Fig. IV-54.Fotografia interrato ©UNESCO

Localizzazione

Unita tecnologia interessata - Chiusura verticale

Casa 8	Casa 9	Casa 10
R1: muri nord, sud e est	Interrato 1: tutti muri	Interrato: tutti muri
R2: muri est e ovest		R1: muro sud
R3: muri est e ovest		R2: muro nord
Interrato: tutti muri		
Corte: muro sud		

Definizione da Normal.
L'umidità di risalita d'acqua è un fenomeno che provoca un insieme di anomalia.
-Patina biologica: Strato sottile e omogeneo, aderente alla superficie e di evidente natura biologica di colore variabile
-Rigonfiamento: Sollevamento superficiale e localizzato del materiale che assuma forma e consistenza variabili.
- Esfoliazione: Degradazione che si manifesta con distacco spesso seguito di caduta di uno o piu strati superficiali sub paralleli fra loro

Descrizione.
La zona concerna è una banda larga circa 80 centimetri in basso del muro, delimitata da una colorazione di patina biologica. Danneggia particolarmente gli stati superficiali della parete.

Cause.
Scelta di materiale non appropriato
Risalita capillare dell'umidità del suolo
Mancanza di ventilazione
Mancanza di manutenzione

INTERVENTO POSSIBILE

Obbietivo.
Ripristinare l'aspetto originale ed evitare che questa situazione si ripeta.

Protocollo operativo.
1. Pulizia
Pulizia con l'uso della spazzola di setola: prima di utilizzare qualsiasi stucco, assicurarsi che non vi siano oli o sporcizia sulla superficie.
2. Verifica di danni sottostanti
Verifica dell'area indagata per verificare se ci sono problemi di struttura con l'utilizzo di specifici strumenti come martelli di legno o termocamere.
3. Ridurre la risalita capillare dell'acqua
Se possibile, intervenire sulla parete per ridurre la risalita: taglio meccanico, barriera chimica, vespaio aerato...
4. Sostituzione
Rimuovere le parte strutturale troppo colpite. Con un avviso esperto, ricostruire la struttura con un attento particolare alla giuntatura con le parte rimanente.
5. Intonaco nuovo
Applicare un nuovo gesso dove il precedente era danneggiato.
6. Finitura
Aggiungere strati di vernice per raggiungere il colore dell'intonaco originale.

Manutenzione.
Un controllo dovrebbe essere fatto frequentemente per monitorare le condizioni delle pareti. Quando si ritiene necessario si può fare lo stesso intervento.

Note.
Tutto il nuovo materiale aggiunto deve essere simile e adatto al materiale del sottostrato. Scegliere dei materiali traspirante con una permeabilità al vapore alta. Prevedere una strategia basata sulla ventilazione.

DEEPENING ON THE HOUSE N°8

1. MOTIVATION

The decision to deepen the recovery study of the house No. 8 comes from the development of the architectural project that follows in the next chapters. In fact, this house will be a central element of the project.

2. MATERIAL ANALYSIS

2.1. Material survey

5.2.a. Global view

All external and internal walls are covered with a layer of plaster with the exception of the inner sides of the walls in the kitchen. Thanks to the detachment of the plaster, we notice a structure entirely made of limestone. All floors are covered with modern ceramic tiles. The windows are almost all missing, or at most without glass. The peculiarity is the use of alabaster marble for the profiles of the doors and windows on the east side of the courtyard.

5.2.b. Notable places

The court is the place where we notice the most material composition.

2.2. The different materials

5.2.a. Stones

The stone used for the construction of the house is a stone of gypsum and limestone cut summarily. They are very common sedimentary stones thanks to the proximity of the Kurdish mountains. Unfortunately, the lack of information on the constructive culture in Iraq and the lack of on-site analysis does not allow

Fig. IV-56.Pietre usate in prospetto est. @UNESCO

5.2.b. Mosul Marble

Alabaster is a very common microcrystalline variety of the mineral chalk is distinguished from other rocks that if it resembles marble. There are two types, based on gypsum and calcareous type. They are distinguished by their hardness: alabaster gypsum is so soft with Mohs hardness from 1.5 to 2, while calcite has a Mohs hardness from 3. Alabaster is only used for interior cladding or sculpture work due to its low resistance to

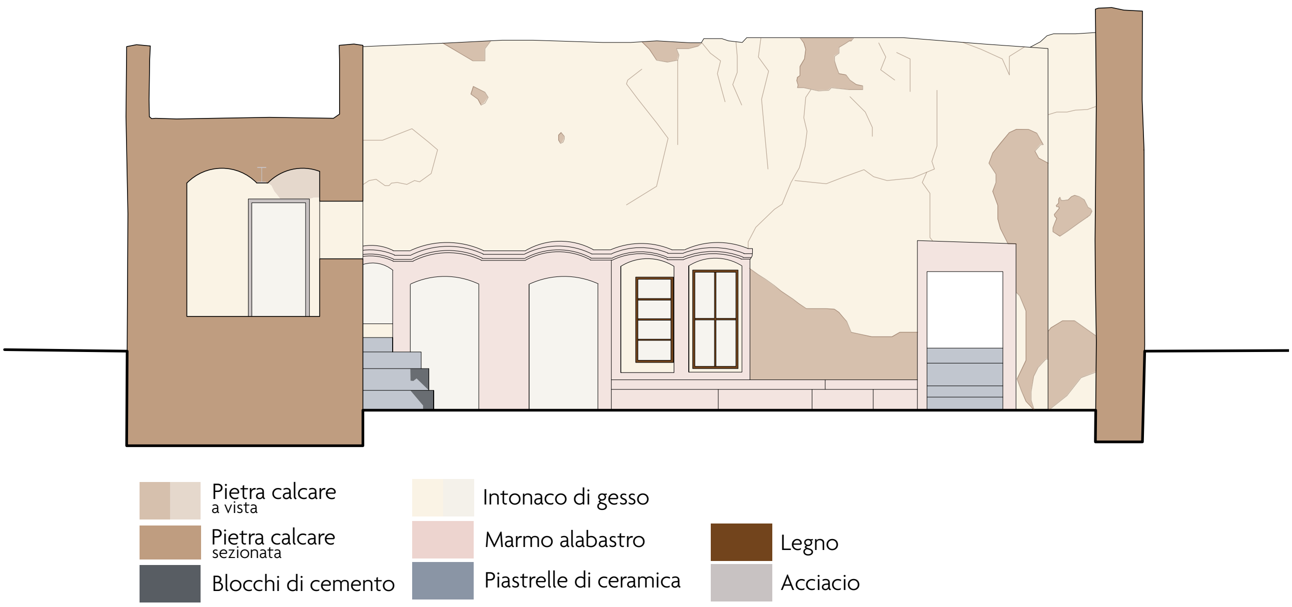


Fig. IV-55.Sezione A-A della casa 8- Materico. Scala 1/100 atmospheric agents. The court remains a protective environment because it is semi-closed.

Unlike marble, alabaster is much easier to work with because it is soft. In addition, it is a poor conductor of heat.

"Mosul marble" is a gypsum alabaster found in northern Iraq. Historically, it was used for the reliefs of Assyrian palaces from the ninth to the seventh century BC.C.

Fig. IV-60.Stele della vittoria di Nasiriyah, Naram Sin@ WikipediaCommons

3. CONSTRUCTION TECHNIQUES

3.1. Wall

5.3.a. Description

The walls are simple. They are wall of stones and mortar very often, without insulation. All the house is

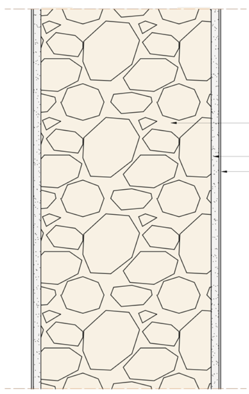


Fig. IV-57.Chiusura verticale. Scala 1/20

covered with plaster.

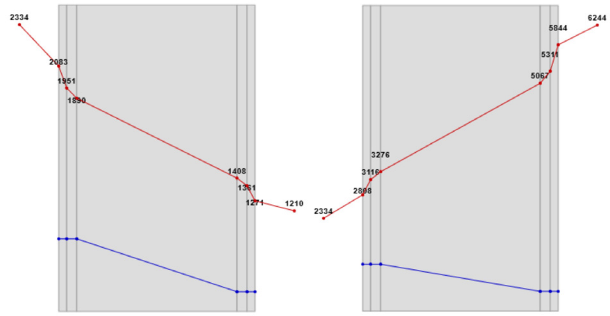


Fig. IV-58.Diagrammi di Glazer a gennaio (sinistra) e ad agosto (destra)

5.3.b. Performance

- Conductivity: 1.48 W/m²K
- Phase shift : 13.74 hours
- Interstitial condensation: never

3.2. Floor

5.3.a. Description

The current floors have been redone with a modern technique. They probably consist of a concrete floor

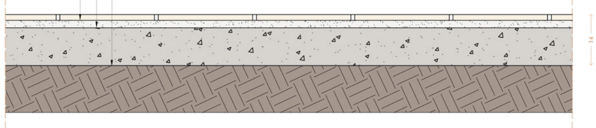


Fig. IV-59.Chiusura orrizontale a terra. Scala 1/20

between 10-20cm thick cast directly on the ground covered with ceramic tiles.

5.3.b. Performance

- Conductivity: 2.40 to 3.20 W/m²K
- Phase shift: 5.31 to 8.44 hours

3.3. Roof

5.3.a. Description

The current roof is made from Jack's arches reinforced with a concrete slab cast over the initial roof. And a technique widespread in Mosul, called Ekadahv.

5.3.b. Jack's arches

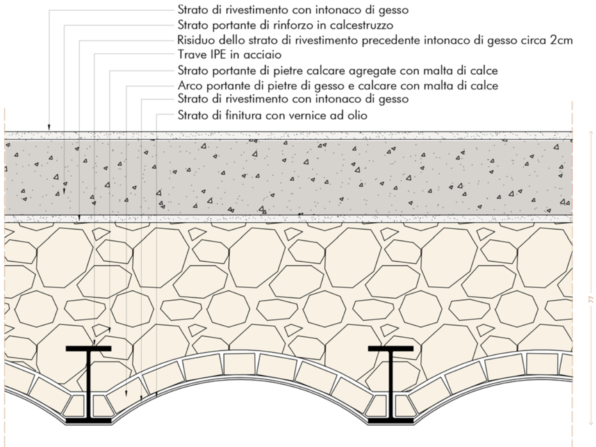


Fig. IV-63.Chiusura orrizontale superiore. Scala 1/20

Jack's arches are a structural configuration at times. They distinguish us with their shape that unlike traditional arches is not semicircular. The advantage lies in the construction, with small pieces, at low cost that is feasible by a single person.

Jack's first bows were used in ancient Turkey. The proximity of northern Iraq may explain the spread of this technique in Mosul.

5.3.c. Performance

- Conductivity: 1.18 W/m²K
- Phase shift: 20.14 hours

4. DEGRADATION

The house is fairly complete in a satisfactory general state by all appearances. However, appearances can be wrong and a study of the above pathologies can reveal serious problems.

4.1. Visible pathologies

On the surface, the house shows frequent pathologies. The big danger is moisture, which creates discolouration, disintegration and cracks. The dampness is probably due to the riverside location of the Old City of Mosul. The water from the river impregnates the subsoil of the city.

Fig. IV-61.Riassunto spaziale delle patologie |Scala 1/250

5.4.a. Storage area

And the most damaged room in the house. The ceiling has sometimes collapsed at the top. The plaster of the walls is covered with discolouration spots due to rising damp.

Fig. IV-62.Zona di stoccaggio @UNESCO

5.4.b. Kitchen

The walls of the kitchen are entirely covered with ceramic tiles. Unfortunately, they are damaged with fractures. The ceiling is the victim of rainwater infiltration that has degraded the plaster and its paint.

Fig. IV-64. Pareti ovest e sud in cucina @UNESCO

5.4.c. Room R2

Except for the moisture that colors the bottom of the walls, they are some fracturing. The situation is critical in the upper corner to the southwest. Jack's first bow would need to be reinforced.

Fig. IV-65.Soffito della Stanza R2 @UNESCO

5.4.d. Bath

The bathroom is apparently degraded with a lot of discoloration and fracturing. However, they are superficial degradations, they only alter the plaster.

Fig. IV-66.Bagno @UNESCO

5.4.e. Room R1

The ceiling towards the entrance to the house has partially collapsed. Almost a whole Jack arc is missing. Moisture affects the lower half of the walls.

Fig. IV-67.Parete est della Stanza R1 @UNESCO

5.4.f. Room R3

Fig. IV-68.Soffito della stanza R3 @UNESCO

The room is particularly degraded to the south. The already reinforced wall is weak. The roof of the house above the room has been perforated, from there are rainwater infiltration.

5.4.g. Court

The entrance remains the most damaged place in the house. The walls and ceiling are critically fractured.

The external bathroom under the staircase, is in a critical state, fractured, with infiltration. Its localization under scale fragiles the lift of the ladder.

The rest of the court shows a great diversity in pathologies by degrading the building.

Fig. IV-69.Corridoio d'ingresso @UNESCO

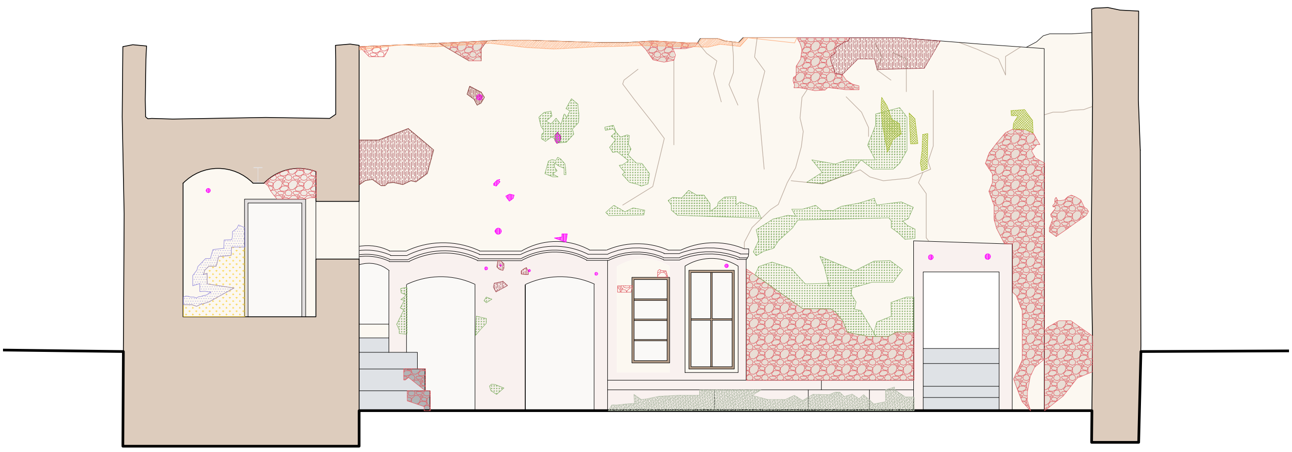
Fig. IV-70.Corte, lato ovest @UNESCO

Fig. IV-71.Bagno esterno @UNESCO

4.2. Degradation survey

For a scale survey, the study was done on section A-A of the house. It corresponds to the internal east façade of the courtyard and the bathroom. The choice is related to the fact that it is the place with the widest diversity of materials and anomalies.

Like all the exteriors of the house, it was hit by perforation due to armed conflicts. The aging of the building is noticeable thanks to the presence of exfoliation of the coatings and biological patina. The rise of water has caused a presence of moisture inside the walls. Hit the bottom of the walls. Resolution of the areas of pulverization, efflorescensa, crusts up to the lack of some constructive layers of the walls.



Crosta
Disgregazione differenziale
Distacco
Efflorescenza
Esfoliazione
Mancanza
Patina biologica
Perforazione
Polverizazzione

Fig. IV-72.Sezione A-A della casa 8- Degradi principali in facciata. Scala 1/100

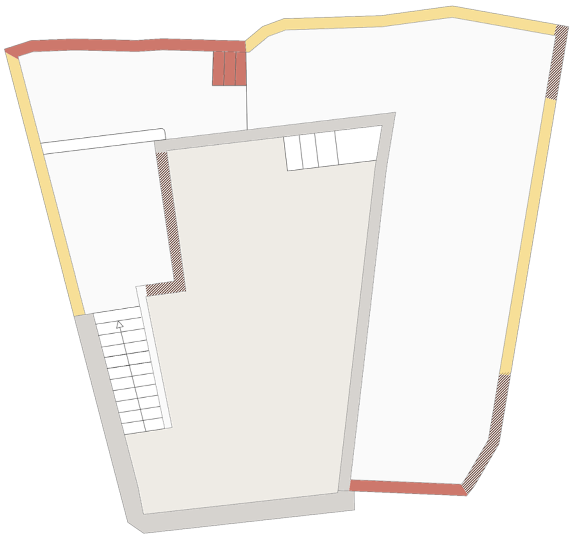


Fig. IV-73.Stato strutturale delle pareti in terrazza |Scala 1/200

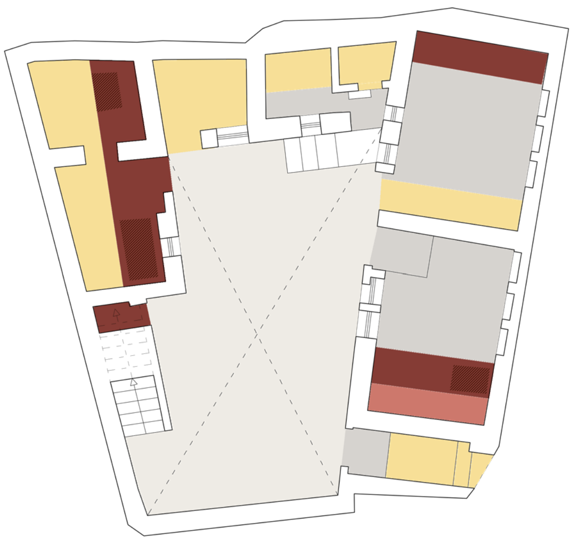


Fig. IV-75.Stato strutturale degli soffiti |Scala 1/200

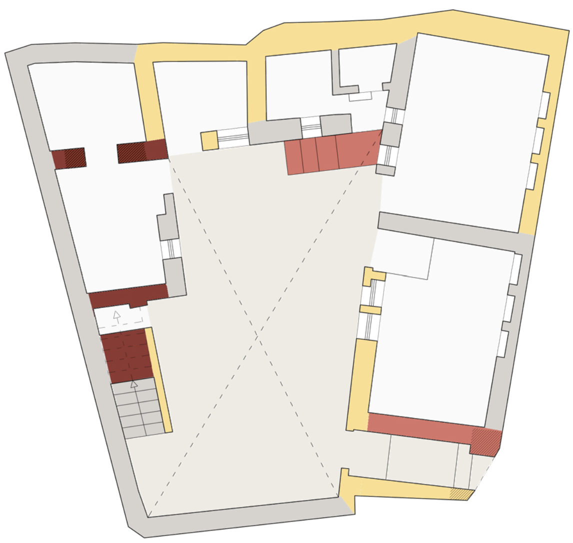


Fig. IV-74.Stato strutturale delle pareti in piano terra |Scala 1/200

Solo da invecchiamento
Gravemente, non critico
Superficialmente
Criticamente
Crollato

4.3. Structural diagnostics

The structural diagnostic made it possible to account for the true state of the building. Determine the habitable zones without intervention and the reinforcement work to be done. For the house n°8, there are three critical areas:

- the entrance
- the external bathroom
- the ceilings of the kitchen and storage area. In fact, the collapsed areas belong to the same Jack arch as the structure. He allowed not to have to intervene on the entire structure of the ceiling.
- the ceilings of rooms R1 and R2 are victims of punctual drilling. In the same intention that before, punctual intervention should be enough.

4.4. Conclusion

All previous news was made thanks to UNESCO photographic documents. They allowed to have a first knowledge of the building without needing to go to the field. The health of the building affects both the feasible work and therefore the composition of the project.

In the case of a real project, a diagnostic from specialists, structural engineer would be done to know what the exact bearing capacity of the building, and what are the reinforcement works.

RIABILITATION STRATEGY

1. STRATEGY

1.1. Concept

For the recovery work, the idea is to preserve the value of the house, while making interventions allowing the union of the new project.

In the whole of the concept of the global project, having a building to recover underlines the presence of the past. The post-war situation offers the past an unfortunately negative value. One of the consequences of a war is to put the country into decline due to forget. For this reason, a will in the project will be to show that to move forward and develop we do not blindly turn the page. The project will try to exploit the traditional architecture in accordance with the modern culture of the city.

1.2. Guidelines

6.1.a. Cure

The house presents many flaws. These damages will be treated before intervening. In addition, the design will take into account the damage in the composition of the project of the Al-Nuri school.

6.1.b. Minimal intervention

The first will of UNESCO is the slightest intervention. This will arises from the condom character of the organism. It makes sense when it comes to buildings of high historical value. For example, the ruins of the Al-Nuri Mosque will be preserved and integrated into the new mosque. In addition, the new mosque will be built to the identical of the previous mosque. In the school project, taking into account the change in function and the very low value of the houses, the freedom regarding interventions expands.

In addition, UNESCO asks not to build over the house. Not knowing the reason behind this request, a structural weakness was hypothesized.

6.1.c. Value

For the evaluation of the building, the project will try not to hide it and to preserve its identity.

2. INTERVENTIONS

The interventions are from two types, the destruction by the existing part of the building and the construction of new elements in the framework in the new project. Thus, the building transforms us and changes our lives. With respect to the building all interventions are justified.

2.1. Reasons

The interventions are the result of different reasons: architectural, aesthetic, structural. Here are some examples.

6.2.a. Aesthetic motif

The internal façade of the eastern part is the element with the strongest architectural value, it seems to be the identity card of the house. For this reason, it was a choice to preserve it from interventions of destruction.

6.2.b. Functional motif

The logic of recovery lies in accordance with the design of a school. Small rooms are difficult to convert with new public functions adequately. Rooms R1 and R2 are more advantageous than the kitchen, storage.

6.2.c. Structural motifs

The situation of room R3 is really worrying. In the south wall, there is a single critical fissuration in the center of the wall. Apparently, this fissuring is connected with the collapse of the arc above. The wall has been reinforced in the past without a favorable outcome. The wall in front is collapsing with the casing of the storage area. For these reasons, the structural recovery being annoying, the architectural recovery of room R3 was abandoned.

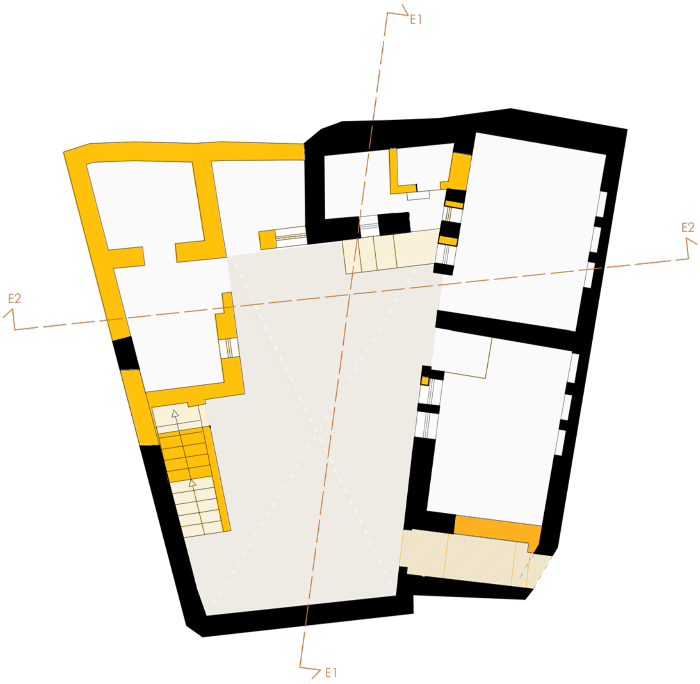


Fig. IV-76.Interventi di distruzione al piano terra |Scala 1/200

Fig. IV-77.Interventi di costruzione al piano terra|Scala 1/200

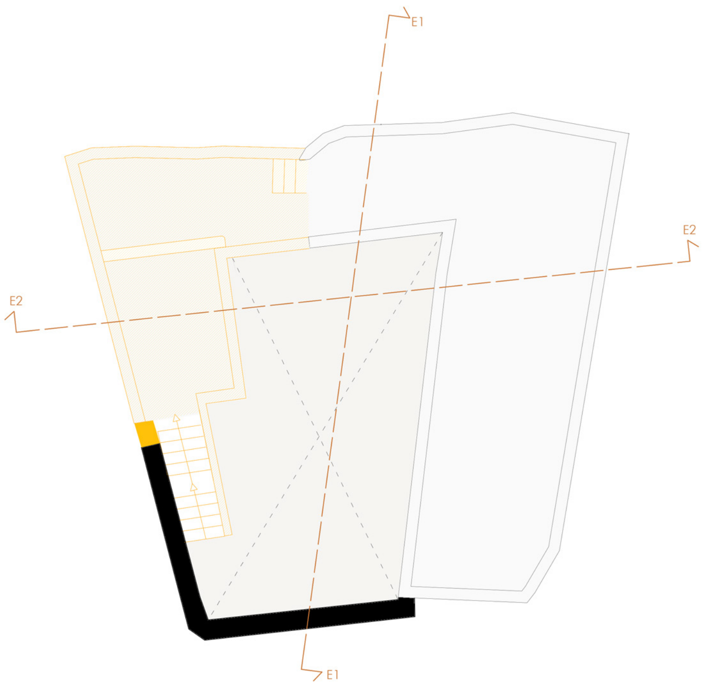


Fig. IV-78.Interventi di distruzione al primo piano | Scala 1/200

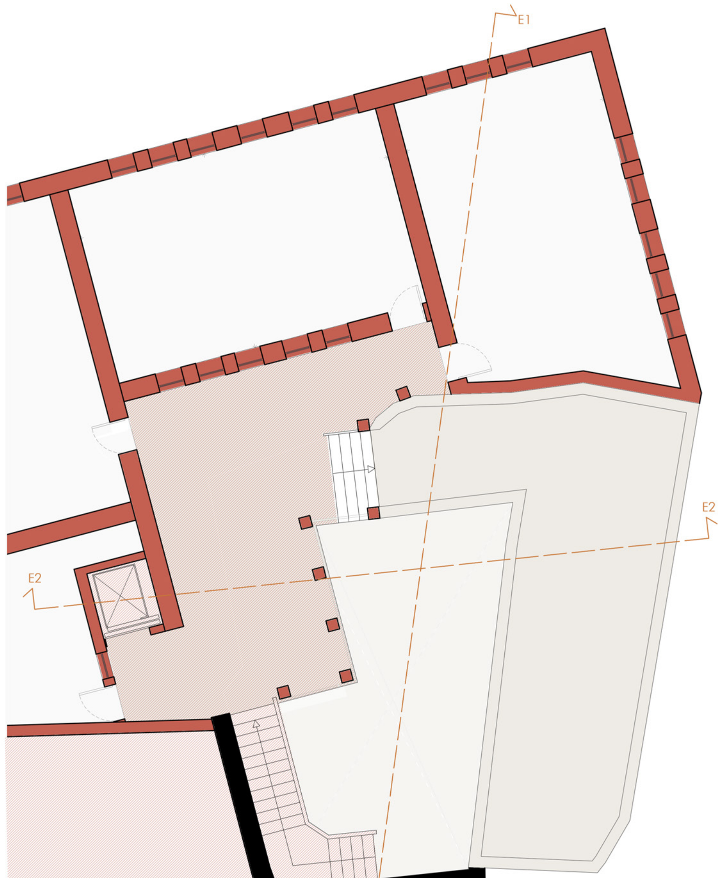


Fig. IV-79.Interventi di costruzione al primo piano| Scala 1/200

2.2. Notable interventions

6.2.a. Destruction of the western part

Between the smallness of the rooms and their structural state, the west area of the house was conducive to its destruction. This major intervention allowed, among other things, to truly unite the house with the new building.

6.2.b. Preservation of the eastern part

In the opposite case the eastern part is the part that remains the least changed. It arises from several factors. First of all, the impossibility due to UNESCO's plan to expand further eastwards stops the composition at the borders of the house. The size of the two rooms allows to accommodate the secondary functions of the school. In addition, it presents the façade with more value to preserve.

6.2.c. Scale management

The staircase has been redone in their previous place. In the unity of the house and the new project the place was adequate to the accessibility of the upper floor. It was not possible to maintain the scale of origin taking into account its structural state. In addition, it would have been necessary to stretch it to reach the correct height.

6.2.d. Closing the entrance

Closing the entrance to the house is a strong choice. In a traditional house, the entrance makes the aesthetic identity of the casing. However, this entrance both due to its place (at the end of the lot), and its fairly narrow shape, was not suitable for the new school project.

3. RECOVERY FROM RISING HUMIDITY

3.1. Study of solutions

Among all the techniques to restore the walls, some are not recommended.

Mechanical cutting can be a significant disturbance to the stability for the walls of stones from uncertain stones.

Dehumidification with draining siphons that consists of inserting pipes from another material into the wall does not work in a hot climate. This causes additional condensation in the wall. The process of dehumidification with active electrosmosis requires a constant current. It goes against the principles of not relying too much on the city's service networks. In addition, it is oversized about the situation of the building. The passive way that exploits the principle of polarity reversal would have to be studied carefully.

3.2. Possible solution

6.3.a. The chemical barrier

Installing a chemical barrier is one of the possible processes. It consists of drilling a series of holes and inserting silicone resins, epoxy resins... The addition of chemicals reduce the absorption power of the wall. However, this solution requires a wall with a coherent binder, without too many cracks or voids. The chemical barrier is not suitable for too old masonry. The absence of consistency in the mortar leads to a heterogeneity of the process. From consequences, before choosing this intervention a tomographic verification will be made to ensure the absence of gaps in the wall where the intervention will be done.

6.3.b. Dehumidification with a plaster

Dehumidification thanks to a macroporous cellular plaster according to the walls increases the evaporation of water. Thanks to the arid climate, the presence of moisture above the ground level is not so important. For this, smart coating the wall can be a sufficient solution. This solution limits the phenomenon of efflorescence.

The wall covering is made with a dehumidifying plaster layer of 2cm at a minimum under the finish of 3mm and painting. Two others will need to be highly vapor permeable. And the least intrusive intervention.

4. CONSOLIDATION

The elements preserved in the composition of the project are consolidated to ensure the stability of the project and the safety of the users. The goal is to ensure the durability of the building for all the hardness of its second life.

4.1. Ceilings of rooms R1 and R2

6.4.a. Diagnostic

The ceilings of rooms R1 and R2 are made with jack arches made of terracotta brick and concrete and steel beam. The beams form the primary order of the structure that resume all the charges. No stability issues are detected at this level. Despite some of Jack's bows have partially collapsed.

6.4.b. Consolidation

Where the arches are still stable but with possible weaknesses, the mortar is consolidated. One technique is to pour an expansive cementing mixture that penetrates inside the ceiling and its weaknesses. To increase the effectiveness of the process, the injection is made by pressure. In this way, the mechanical characteristics are improved.

Fig. IV-80.Soffito della stanza R1 @UNESCO

Fig. IV-81.Soffito della stanza R2 @UNESCO

6.4.c. Reconstruction of the arch:

Thanks to the stability of the beams, the collapsed parts of the arch are simply to be rebuilt with a similar and unfortunately compatible technique. The intervention consists in replacing the portions at the boundaries of the holes and the arch is rebuilt.

4.2. South wall of room R1

6.4.a. Diagnostic

The south wall of room R1 has a critical fissuring that endangers the stability of the building.

6.4.b. Consolidation

The presence of cracking attests to the structural weakness of the wall. Need one consolidation.

The solution is the modification of the static scheme thanks to an external armature. The system is double. For one side from which the structure is not exposed, the wall is covered with a 5-10cm thick reinforced concrete slab. On the one hand, where the previous process is not suitable, the system consists of a continuous mesh made of high-strength steel ropes, inserted into the mortar joints. The ropes are fastened with galvanized steel eyebolts. The two structures are connected to each other by passing wounds. This technique remains less invasive to the wall than other techniques such as concrete injection etc. and an inexpensive, removable and durable system. It creates a structural envelope that is compatible with the preservation of the material from which the building is made.

Fig. IV-82.Parete della stanza R1 @UNESCO

6.4.c. Reconstruction of the wall

The main crack is too worrisome to simply be sealed. It is necessary to rebuild the wall. For this, a local wall substructure is feasible. The intervention proceeds with

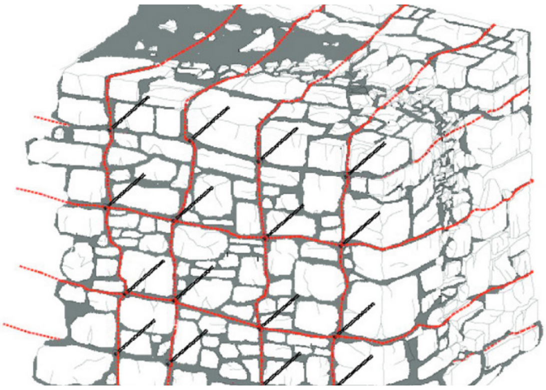


Fig. IV-83.Armatura di consolidamento @A. Borri

demolitions and gradual reconstructions first on one side of the wall and later on the other side. Proceeding in this way, preserves the structural stability of the wall.

4.3. Entrance

6.4.a. Diagnostic

The vault of the entrance is not stable is the opening to the outside to the destroyed goal.

6.4.b. Vault consolidation

The first intervention focuses on the consolidation of the vault. And the critical point of the entrance. The danger would be the collapse of the vault during the

Fig. IV-84.Corridoio d'ingresso @UNESCO

Fig. IV-85.Soffito a volta dell'ingresso @UNESCO

other interventions.

The first intervention focuses on the consolidation of the vault. And the critical point of the entrance. The danger would be the collapse of the vault during the other interventions.

Consolidation consists of two phases. For the air with critical fractures and the beginning of collapse, a reconstruction is required. The surgery is a gradual sewing scuci to eliminate the injury.

In a second time, the other cracks show the static weakness of the structure. Structural support is needed. The insertion of chain tie rods remains one of the most effective traditional solutions. It consists in inserting bars on the outer sides of the load-bearing walls of the arch. Inside the vault is pulled a hollow pretensions that keeps the vault well compressed. The innovative alternative of this system are the alleged cables anchored to the intrados of the vault. It acts as one under reinforcing arch.

A repair of the concrete casting that stands above

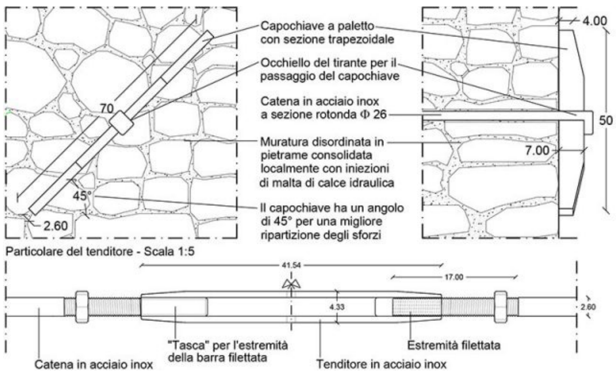


Fig. IV-86.Ancoraggio della catena @TekNoring

Fig. IV-87.Rinfozo con cavi pretesi @P.Napoli the vault is a possible solution considering that it helps the stability of the arch

6.4.c. Closure of the façade

The entrance is closed by the method of wall substruction at the boundaries of the opening. The filling of the entrance opening is best done with a load-bearing technique to be able to support the vault. In addition, the closure helps to redistribute the loads and thus lighten the loads borne by the other walls.

6.4.d. Transformation of the wall

The goal is to open the wall. However, it requires redistribution of compression loads due at a time.

One solution is to change the structure of the building from a massive structure to a structure with beams and pillars. The new structure is anchored on both sides of the wall. The beam reinforces the resumption of loads that are transmitted to the pillars. The wall is less loaded and open it, less dangerous.

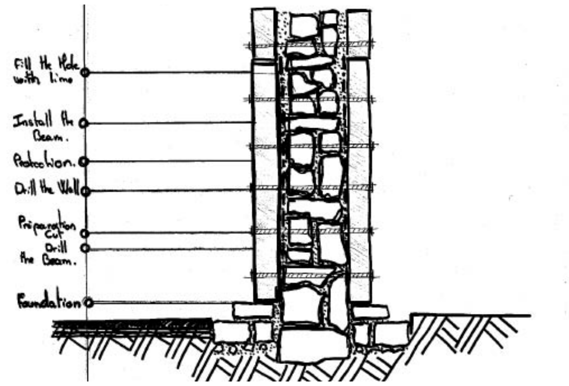


Fig. IV-88.Ancoraggio dei pilastri @CConcrete

6.4.e. Creating Openings

To open a compartment, the side bands of the compartment to be opened are consolidated and an architrave is inserted. Consolidation is done with cement injections with steel bars. Thus a counter-frame is created that resumes loads.

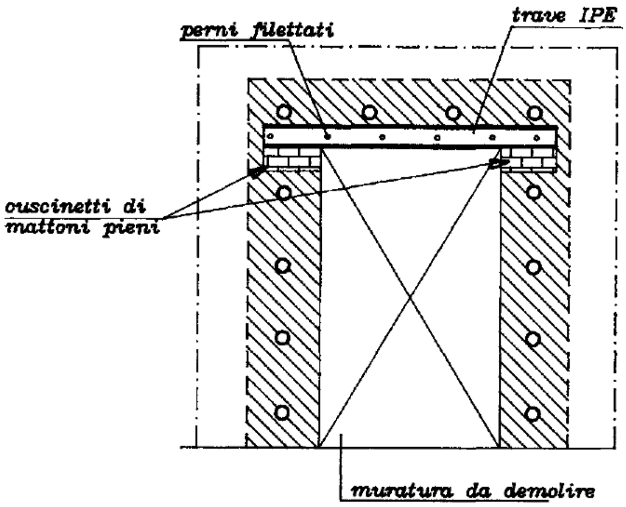


Fig. IV-89.Sistema di consolidamento per vani

V. Architectural Design

INDICE DEL CAPITOLO

THE CONCEPTUAL VOID

1. INTRODUCTION

In front of an Arab city the viewer is struck by its density: the roofs of the houses are side by side and merge, hiding the streets and the people. Paroxysm is reached in the city of Gadames in Libya, where from the sky the streets are invisible and the houses can only be delimited by the lines of the parapets.

If the streets do not trace the city, the facades cannot define the architecture of urban buildings; it is therefore difficult to conceive of the unity of each building from its envelope. The Arab city would be a single volume, there are several full.

Under these conditions, how are the buildings designed? Inside. We can therefore see that the Arab building is introverted, facing the essential element that will define its architecture: the void.

Fig. V-01.Gadames vista alto

Fig. V-02.Disegno di Marrakech

2. THOUGHTS ON VOID FIELDS

2.1. The physical vacuum

The vacuum is broken down into a space delimited by a maximum of six physical limits. It is defined by its content. According to the dictionary, something is empty who does not contain anything perceptible, where there is nothing solid or liquid. The void constitutes a state of physical absence, a place where there is no studied matter.

However, in any field of science it has been shown that vacuum is never empty, at least on the human scale, but always contains matter. This process leads to the incoherence of emptiness understood as nothing.

2.2. The void in plastic art

In the twentieth century, there was an intense desire to research the void. In France, Albert Camus writes to Yves Klein: ‘’With emptiness, full powers’’.

The void is found connected to the immaterial, often to the sky and air. In the fifties Yves Klein practiced creating the vacuum in two dimensions in his “Aventure monochrome” but also in three dimensions, trying to imprison it in a box. The avant-garde experiences emptiness and its feelings in an often extreme way. Ad Reinhart's Ultimate paintings, a series of identical black works, will be described as a provocative void.

Mark Rothko (1903-1970) paints huge monochromatic rectangles with floating contours that touch each other in the same canvas. The Spanish architect Carlos Marti Aris finds in Rothko's works a religious silence, an emptiness that invites

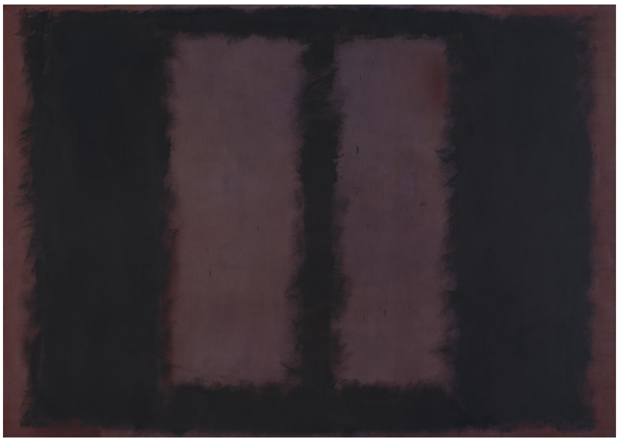


Fig. V-03.Black on Maroon, 1958, ROTHKO @Tate

contemplation.

Kasimir Malevitch's work entitled "White on White" (1918) is a white monochrome. A void within a void that should represent the aerial vision of an infinite space. But the square is not entirely square and the white is not entirely white, suggesting that the whole is not entirely empty. Malevitch's paintings, because of his ascination with aviation, often represent built spaces or non-places seen from the sky, yet nothing indicates what the squares he painted are, are they people, buildings, parks or empty? In abstract art, paintings show the absence

Fig. V-04.White on White, MALEVITCH

of real things, leaving uncertainty about the nature of things visible.

It should be noted that in these artistic

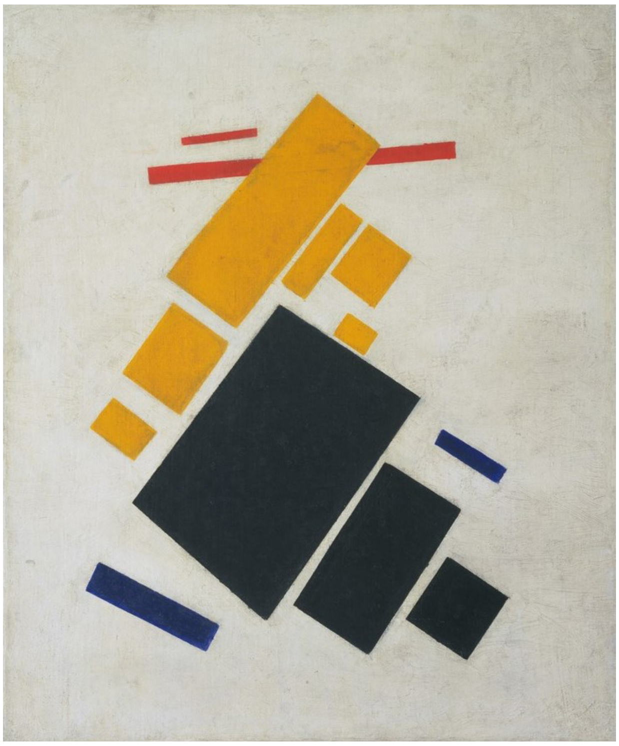


Fig. V-05.Air plane Flying 1915 ©MoMA

representations stands out the physical use of rectangular forms, a simple form and yet brings within these limits its corners, endowed with strong power.

2.3. The religious void

If in Western culture emptiness is anxiety-inducing and associated with death, Islam faces it with more positivity. The prohibition of strict representation, for example, is justified by the desire to leave an artistic as well as a spiritual void. If nothing can be truly empty, it is a matter of leaving a place free from what is human. The void is therefore the ideal and transcendental place. Facing a void in Islam brings serenity and allows man to return to the essentials.

2.4. The architectural void

1.2.a. The urban space

In the urban scale, the full considered are the buildings, while the study of the void is in the discontinuity of the full. So, they are the spaces of movement and urban life considered as empty, of which the first of all is the square. Italian cities have been physically and socially organized around this urban void since Roman times.

1.2.b. The Asian void

In Japan, vacuum has a greater importance, its presence brings fluidity and purity to construction. It is considered pure and does not accept interference to achieve the desired mental effect of serenity and intimacy. In Asian architecture the composition of the vacuum is strictly regulated. In the composition of a Taoist garden voids are classified and created in precise places. To symbolize the presence of the void understood as an inaccessible area is the gravel, whose presence is never accidental.

1.2.c. Free space and clarity

The void created in ludwig Mies Van Der Rohe's architecture is based on spatial transparency with its free plants and glass facades that ensure that spaces have no precise limit. There is also a conceptual transparency with the use of elementary elements whose whole forms the general work. Mies was looking for clarity, in front of that there are no explanations to give but he appreciates the silence.

1.2.d. Extrude and dig

Like the works of the sculptor Oteiza, architecture plays with matter, with full volumes or voids. A process of architectural creation seems to be based on the addition and subtraction of volumes between them.

Steven Holl designed on this principle two buildings for the Normal University of Hangzhou in 2011. One

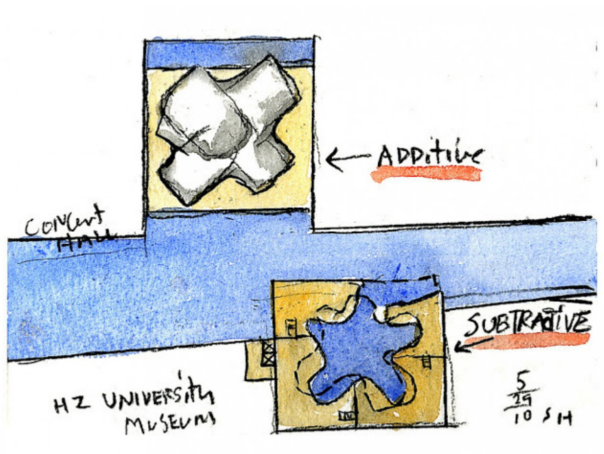


Fig. V-06. Concetto del università di Hangzhou ©StevenHOLL

building is made from pieces dug into the volume of the other building while the other is defined by voids. Full and empty are highlighted by each other.

The Aires Mateus brothers work a lot with materiality: the full volume with its relationship with the outside.

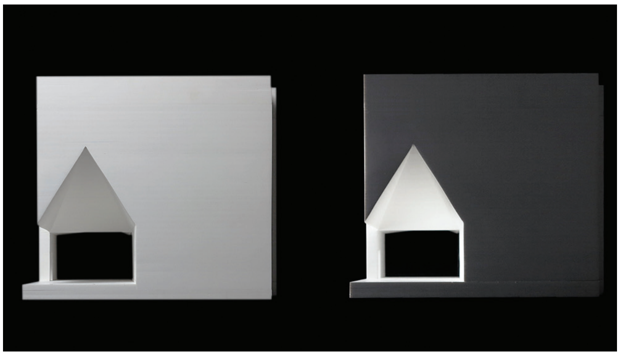


Fig. V-07. Modello per la facciata dell'università di Tournai ©AIRES MATEUS

Their white facades are distinguished by the rare openings, voids that open up in all built volumes. On the façade of the extension of the University of Tournai, the emptiness of the passage to the front courtyard is highlighted.

3. URBAN VOIDS OF MOSUL

1.3.a. In 1958

The District of the lot, presents in 1958 a dense layout interrupted only by small voids, except for the large voids composed of the two main streets. It is a traditional layout, a result of Muslim urban architecture, with narrow streets and courtyard houses.

At the urban level, there is an abnormally large void around the Al-Nuri mosque that highlights its social, cultural and religious importance. It is not a mosque like any other, its wide irradiation is filled every Friday by the entire population.

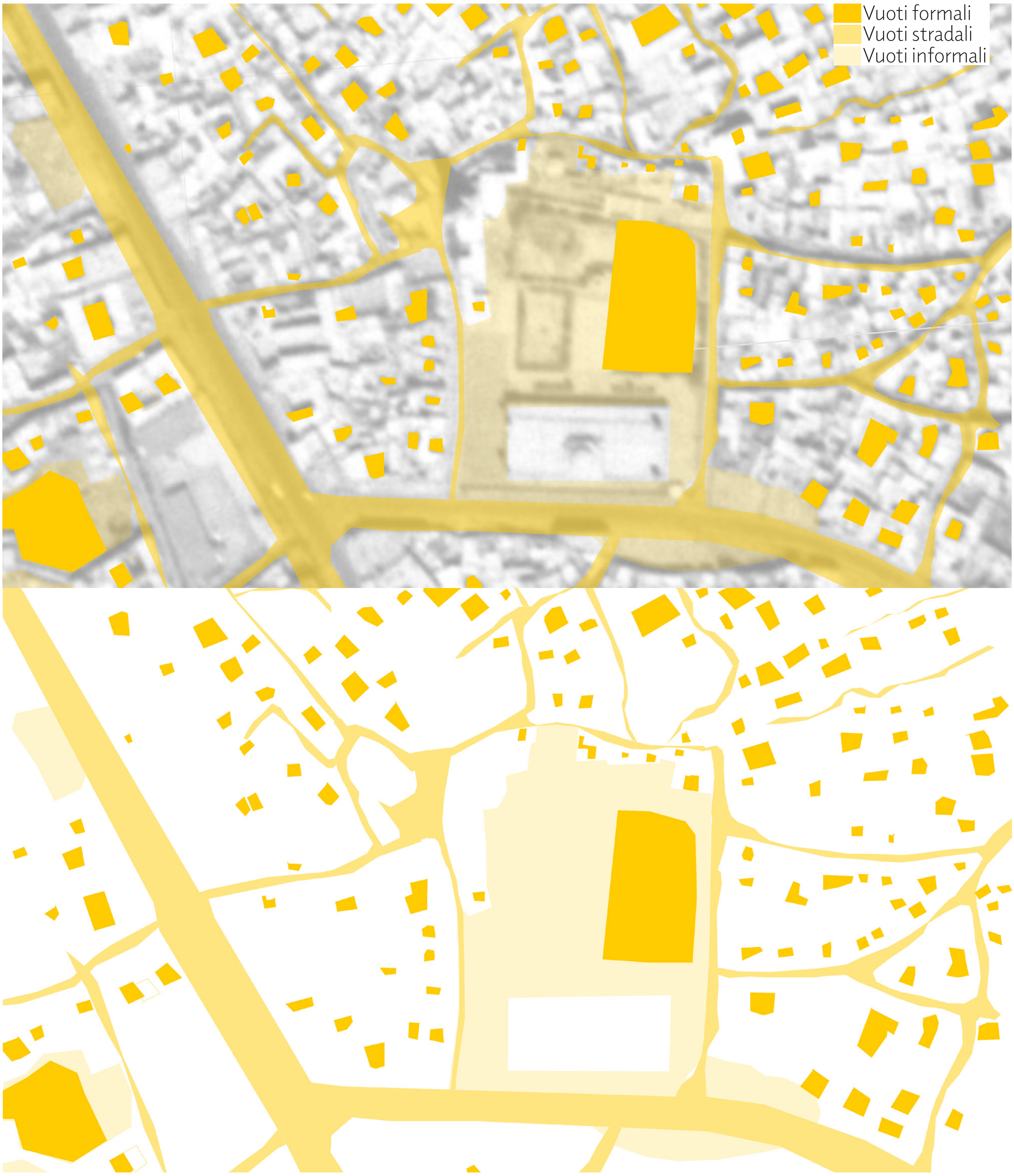


Fig. V-08.Vuoti urbani nel quartiere di Al-Nuri in 1958

3.1. In 2017

Because of the war it came to transform the layout of the city and the mechanism of urbanvoids, distorting what was a classic plant of Muslim urban architecture. In parallel with a widening of the roads due to the deterioration of the buildings at the edge of the roads, the city records the creation of informal voids, of non-places due to the destruction of buildings. In the first instance, the flight of the population did not allow the functional reconversion of these voids. Secondly, the return established a chaotic use of urban spaces, with temporary light construction.

Throughout this scenario, UNESCO has envisaged the extension of the void on the Al-Nuri lotus, increasing its importance.

Fig. V-09. Vuoti urbani nel quartiere di Al-Nuri in 2017

DESIGNING WITH VOIDS

1. FUNCTION AND TRAINING

Emptiness is not a space emphasized by absence. With the same consideration of the full, a vacuum is created from a required performance objective, in addition to the volumetric aesthetics.

1.1. void function

2.1.a. Light

The first function that comes to mind is to create a vacuum to give light. The void packs the full element that makes up the building from a layer permeable to natural light. Sculpting new facades, it offers the possibility of developing openings to the outside to accommodate the light inside.

2.1.b. Ventilation

The reasoning is similar with regard to ventilation. Air permeability allows you to create a chimney for drafts. Driving and producing air flows is of greater importance in passive energy design, especially in the desert area where ventilation is the main way of cooling the building, so as to achieve an acceptable level of comfort.

2.1.c. Accessibility

The arrangement of voids manages the flows of people. Transitive spaces are secondary empty spaces for the circulation and distribution of other spaces. On a large scale, both the physical and functional layout of a city is heavily dependent on street voids.

2.1.d. Social life

The informal and flexible character of a void is particularly suited to the development of social life. Create a space to fill with activities and social reports according to the start of the users.

2.1.e. Privacy

Unlike before, the vacuum gives a privacy when it is not closed and protected from external eyes. And the image of the courtyard that allow you to be outdoors although hidden.

1.2. Different types of voids

With a simple reasoning related to its possible functions, different types of voids that help the composition were highlighted.

2.1.a. Private vacuum

Completely surrounded by the full, the private void arises from an internal need to open us, it is an introverted opening that creates an intimate and private space. The needs at the origin of the composition of this vacuum can be energy reasons to insert light, ventilation in the project or create a distributive intersection.

An essential example is the private courtyard of an Arab house.

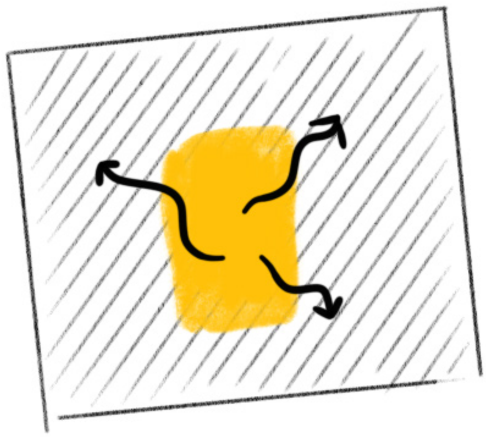


Fig. V-10. Disegno concettuale - vuoto privato

2.1.b. Monumental void

In contrast to the previous case, the monumental

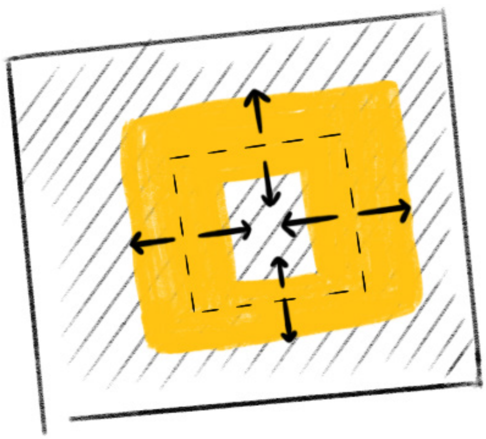


Fig. V-11. Disegno concettuale -Vuoto monumentale void arises from an almost proud need for extroversion. It consists of isolating a full element to highlight it.

It creates a private space in the public sphere due to its proximity to a particular building. This is the case of the square in front of the Al-Nuri Mosque, where it corresponds to a space of contemplative waiting before entering.

2.1.c. Intrusive void

The emptiness seems to dig into the full volume creating an impression of welcome. Manufacture a public space that is at the service of the volume in front, the user has entered before entering. Of course, the function of a vacuum like that is distributive, it is a way of signaling the entrance or accessibility of a space.

2.1.d. Social void

An empty space is a way of connecting the outside and the inside as a previous view. It is also a way to combine

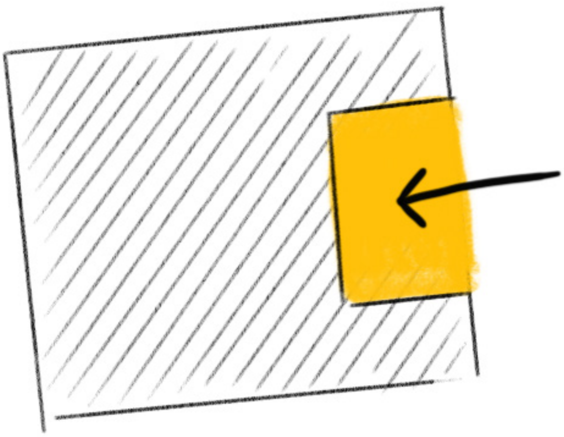


Fig. V-12.Disegno concettuale - Vuoto intrusivo

different full elements for a social interchange., being in the middle or intrusive to the different buildings.

It comes from an energetic or distributive need for social life or privacy. Its peculiarity is to be semi-private, the object of a reserved sociality.

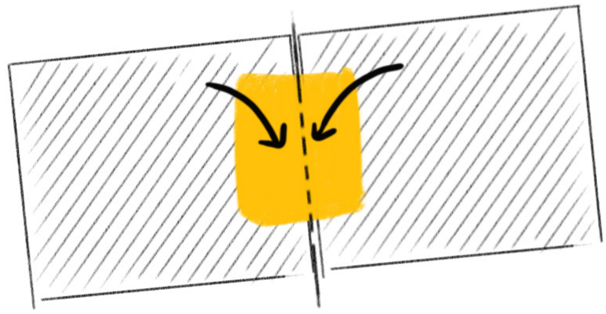


Fig. V-13.Disegno concettuale - Vuoto sociale

2. MASTERPLAN

The structure of the complex has been reasoned giving value to the empty spaces, while the full elements have been designed starting from the building zones defined by UNESCO.

2.1. Main Route

The Al-Shaziani Street on the west edge of the lot imposes the main entrance of the complex on this side as it seemed appropriate to set a direct route to the mosque. The clarity of the path comes from the absence of obstacles. The road void will be pedestrian, wide enough to contain the flow of believers. A narrowing helps drive the flow. This fireplace has a cultural value, it is linked to the traditional path that believers made to go to the mosque. The slowness of the path prepared for a state of meditation and spiritual calm. So the cars were banned and removed from the main entrance requiring you to go back to walking.

2.2. Feature Localization

2.2.a. Administration

At the entrance there is the administration of the complex, the natural place to install the administrative reception.

2.2.b. Institute and auditorium

The southwest corner is formed by two widely used roads. As a result, they define a social environment full of life. It is the ideal place for adults and public functions. The art institute with its dining space open to all takes advantage of this space. Adjacent to it is the auditorium that can be used both by the institute and by any community organization. The connection between the two function accessible to all is made with a shared intrusive void.

2.2.c. Secondary school

The northern part of the complex is facing residential areas and secondary roads. Access is privileged for a neighborhood school.

At the center, the freedom was taken to make a social assistance space consisting of an adult training center and a sports space for all

2.3. Public voids values

The northern part of the complex is facing residential areas and secondary roads. Access is privileged for a neighborhood school.

At the center, the freedom was taken to make a social assistance space consisting of an adult training center and a sports space for all.

2.4. Access to the different buildings

Access to a building is done in the Arab tradition indirectly. Therefore, a mixed space that behaves like an intrusive void marks the different entrances: that of the school is integrated into the building, as well as the one in front of the administration a waiting square develops.

2.5. Monumentality

The monumentality of the Al-Nuri Mosque is preserved. Another monumentality appears towards the recovered building of the school, no adjacent construction is planned. The urban isolation of the element highlights the will and desire to live with the past.

2.6. Private court

Every building in Arab thought has its own private sphere. The principle of the court has been used paroxysm considering that each social group gets its own space. In the Al-Nuri school the separation between girls and boys is set. In the interest of equality, three shorts were created: one for girls, one for boys and one for adults. At university, gender boundaries are more blurred, users tend to be one community. For this reason there is only one private courtyard.

3. COMPOSITION

3.1. General considerations

The urban composition is the summary of all the intentions described above. Faced with the huge strange void created by the war, the project seeks to restructure in a more common way. Under Mosul’s arid climate, a gigantic open space is not livable.

The buildings were first considered with footprints on the ground using the constraints given by UNESCO also with regard to the maximum building height.

The result is the conceptual masterplan shown in Figure 15 on the following page.

3.2. Architectural references

In their compositional aspect, the empty spaces present a remarkable diversity. The following projects are references in the composition of the project. The instruments that give the value are mainly based on the play of light, volumetric games of the surroundings and the boundary between open and closed.

01

Funerario Tangassi|Tatiana BILBAO

02

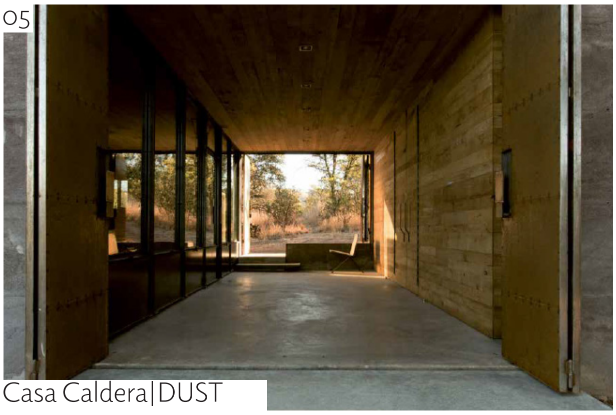
Learning Garden |Carlos RATTI

03

Chapel of Reconciliation |Martin RAUCH

04

Vila Nova da Barquinha |AIRES MATEUS

05

Casa Caldera|DUST

06

AISN extension|Mariam KAMARA

06

Tribunale di Patzcuaro|ROCHAS + CARRILLO

07

Casa in Betera|QUADRAT

Fig. V-14.Insieme di fotografiche di progetti riferimenti @ArchDaily

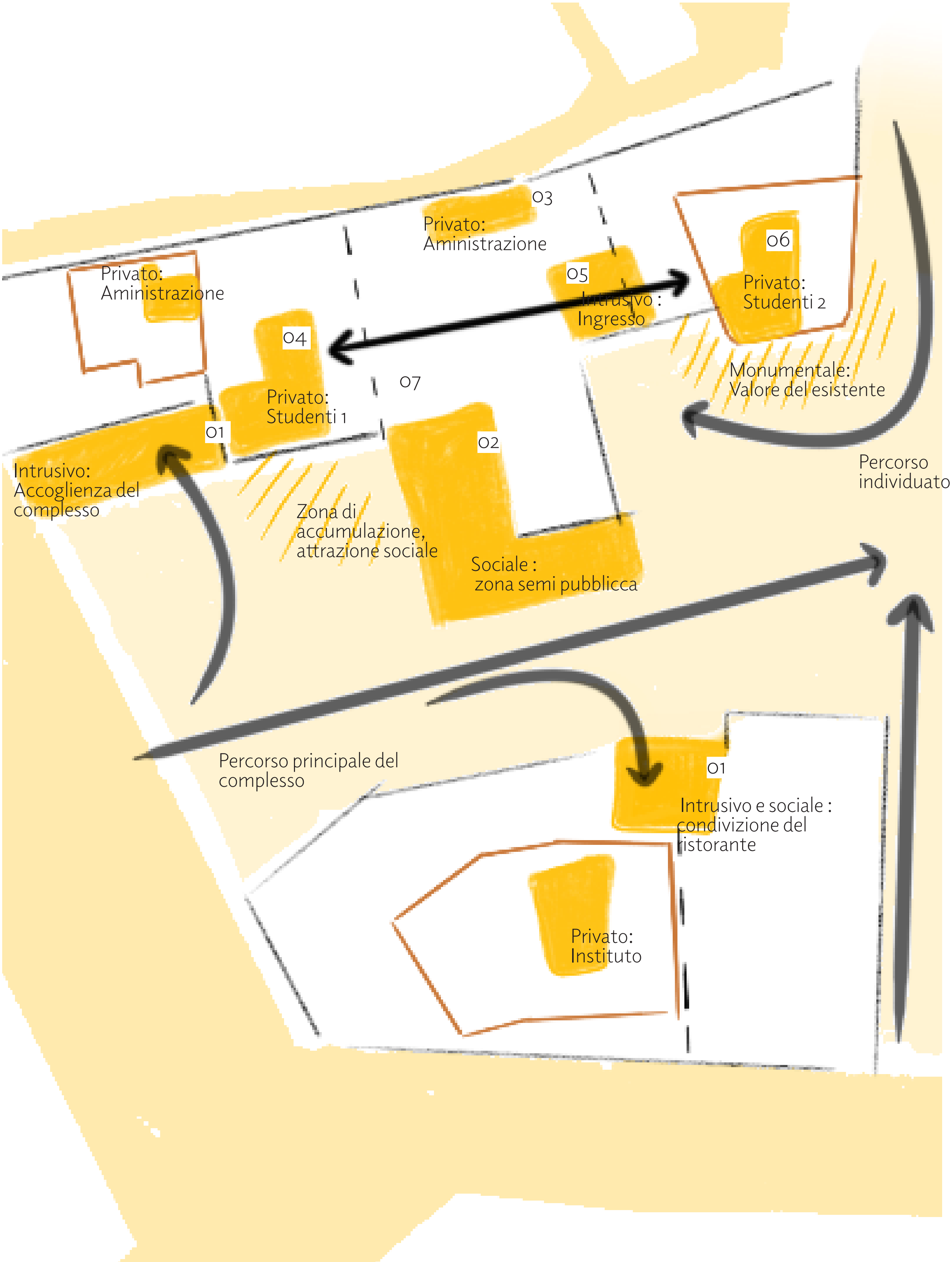


Fig. V-15.Masterplan concettuale

FUNCTIONAL APPROACH

In the compositional process, the organization of the lot was a work on an urban scale. He planned to consider the various buildings from their general function. Inside the full volumes there is another functional system.

1. OTHER BUILDINGS OF THE LOT

Before focusing on the school, the point of the thesis, a functional approach was made inside the other buildings, to dominate the ground and be aware of the world surrounding the main project.

1.1. Administration

3.1.a. Localization

As previously written, due to its main function, by arrangement of the administration is provided near the main entrance of the complex.

3.1.b. Spatial functionality

The block consists of two functional bodies: an administrative space in the strict sense and a space for security.

The public face is that of the administrative offices, for this reason the administrative block looks towards the interior of the complex. It was the will to compact this building taking into account its secondary importance in the urban layout. To this end, it is spread over two floors with a division of the floors according to their accessibility to the public. For example, the Iman office and dining space will be on the first floor

Security is a private function, it is programmed that the entire complex is under video surveillance. The confidential nature of the supervisory system remains an assurance of its effectiveness. Of course, you need public access to the security lock, granting access to it in case someone is looking for help.

3.1.c. Existing management

House 9 has several advantages to be recovered for the administration: it is the tallest existing building, with a roof terrace with a high parapet and has a convenient watchtower. In addition, its entrance to the street constitutes a discreet service entrance. Moreover, the administration requires an archive space that the basement of the house offers.

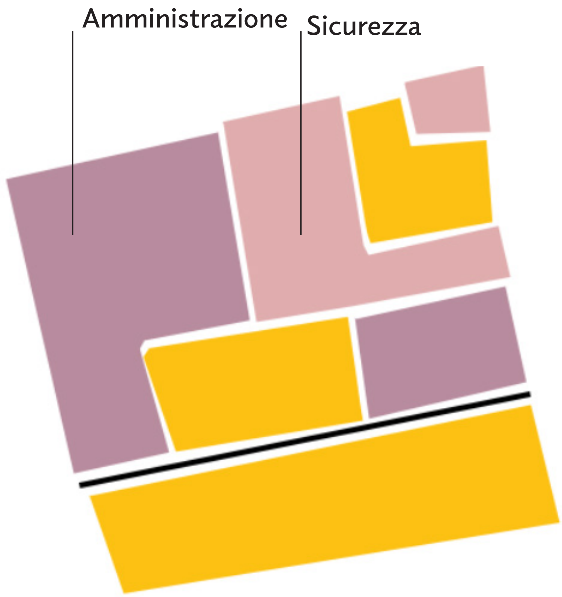


Fig. V-16.Fuzionalità dell'amministrazione

Function	Area/Unit (sqm)	No. of Units	Total Area (sqm)	Notes
Offices	**130**	**1**	**130**	
Entrance with seats	16	1	16	1 receptionist at the entrance
Office for Imam	12	1	12	
Offices for administration personnel	15	2	30	Each office able to host 3 persons
Meeting room	30	1	30	Room able to host up to 10 persons
WCs for employees	4	3	12	1 WC per gender and 1 for disabled
Pantry	14	1	14	Space equipped for dinning
Storage	16	1	16	For mosque's archives
Security	**42**	**1**	**42**	
Office for security and CCTV	15	1	15	
Rooms for guards	12.5	2	25	Each room for 2 guards (1 room equipped with 2 beds)
Corridors and circulations	**43**	**1**	**43**	Around 25% of the total
TOTAL			215 sqm	

Tab. V-01.Programma funzionale per l'amministrazione @UNESCO

1.2. Auditorium

Localization

The location of the auditorium is mainly due to the building area designated by UNESCO. Taking into account the required surface, the place to the west of the mosque was the most comfortable free space.

3.1.a. Existing management

The auditorium is not a space that is performing well the integration of an existing building and its rehabilitation, because it requires large free spaces.

3.1.b. Feature

The auditorium is a space dedicated to conferences or various events, it consists of two spaces: a multi-purpose entrance space and a conference space. The entrance space is sized to accommodate small stands of shops. The two functions of the building will not work together, so they have been separated on two floors.

Function	Area/Unit (sqm)	No. of Units	Total Area (sqm)	Notes
Entrance lobby with shop	**200**	**1**	**200**	Able to host 200 pers. standing. Calculated 1,00sqm/p.
Main space – Hall	**300**	**1**	**300**	Able to host 200 pers. Calculated at 1,50sqm/person Area includes the circulations and the stage
Rooms for performers	**5**	**4**	**20**	4 rooms equipped with WC
Storage and maintenance rooms	**30**	**2**	**60**	
Corridors and circulations backstage			**20**	Around 25% of the backstage area
TOTAL			**600 sqm**	

Tab. V-02.Programma funzionale per l'auditorium @UNESCO

1.3. Art Institute

3.1.a. Localization

The location of the art institute comes from two reasons. First, proximity to the auditorium was desired, so that it would be used for conferences or other events of the institute. In this way we would make up for the lack of spaces capable of accommodating all students, not included in the UNESCO program. Secondly, house 10 with its large courtyard seemed suitable for creating a school environment.

3.1.b. Existing management

As evoked before, house 10 offers a large central courtyard that can accommodate numerous people and be a pleasant area of passage. In addition, the interior facades of this house are the most beautiful in terms of traditional aesthetics. All this creates a thematic link between the art institute and the existing architecture that offers the potential to give inspiration.

Function	Area/Unit (sqm)	No. of Units	Total Area (sqm)	Notes
Classrooms	**42**	**8**	**336**	8 classrooms, each class for 25 students maximum
Entrance lobby	**15**	**1**	**15**	
Cafeteria/ Tea House	**107**	**1**	**107**	
Open space	60	1	60	For 50 persons
Kitchen	20	1	20	For 2-3 staff
WCs for customers	4	3	12	1WC for disabled
Storage	15	1	15	
Library	**100**	**1**	**100**	
Open space	60	1	60	1 staff and 20 students
Quiet rooms	20	2	40	Each room able to host 6 persons
Administration	**210**	**1**	**210**	
Offices for management	12.5	2	25	1 office for director and 1 office for deputy director
Cubicles for teachers	6	10	60	Individual cubicle-type space for 10 teachers
Offices for administration staff	15	2	30	Each office able to host 3 persons
Meeting room	75	1	75	Space able to host up to 25 persons
Pantry (communal area)	20	1	20	
WCs for students and staff	**4**	**10**	**40**	With 2 cubicles for disabled, 1 per gender
Corridors and circulations			**325**	Around 40% of the total
TOTAL			**1.133 sqm**	

Tab. V-03.Programma funzionale per l'istituto d'arte @UNESCO

3.1.c. Feature

The institute consists of three spaces: the administration, the cafeteria and the teaching spaces. Cut in this way appeared the possibility of opening the cafeteria to the outside so that you can develop the social life of the complex. A double access is then created, from the void of the inner courtyard and from the intrusive square. Its openness to the outside creates an exchange with the auditorium, so as to draw a synergistic behavior. The functions in the Al-Nuri complex are not next to each other, without any relationship, but live together.

The administration is close to the entrance of the building following a logic similar to the administration of the complex.

The classrooms and the library, being reserved only for students, are removed from the entrance. For this reason the upper floors are dedicated to private educational functions

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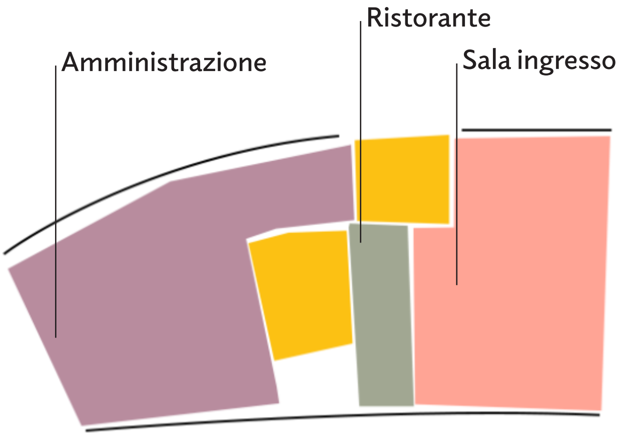


Fig. V-17.Fuzionalità del piano terra

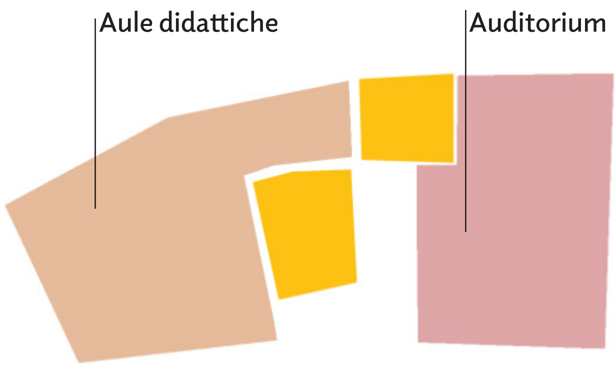


Fig. V-18.Fuzionalità dei piani superiori

2. AL-NURI SCHOOL

2.1. Localization

As explained above, the Al-Nuri school is located to the north, on the residential slab of the complex. It is a quiet place, between surveillance functions and religious services that are pillars in the sense of security.

2.2. Existing management

House 8 offers extensive rooms on the east side. In addition, being on a single floor it is adaptable for functionality on various floors. The most critical point lies in the exploitation of his court without being able to expand eastwards.

2.3. Feature

3.2.a. Generality

In the functionality imposed by UNESCO, a separation between girls and boys is required. They propose a vertical separation with the ground floor where the common functions and administration are, the first floor for boys and the second floor for girls. With this approach came out a compact volume from the first sketch that did not have a planimetric coherence, partly due to the heterogeneity of the surfaces. As a result, a horizontal separation is suitable for reducing the height of buildings.

Horizontal separation helps to create a community nucleus: shared functions are at the center, while reserved functions are in the boundaries. Each has its own path with a crossroads at the central courtyard, inclusive and accessible to all. In addition, to accentuate the exclusive and inclusive nature of the spaces, private workstations derived from the library are inserted into the teaching bodies.

Function	Area/unit (sqm)	No. of units	Total Area (sqm)	Notes
Classrooms	**45**	**12**	**540**	12 classrooms, each class for 30 students
Library	**40**	**1**	**40**	1 librarian; 15 students
Multi-functional classroom	**45**	**1**	**45**	Used for laboratory and/or projections
WCs for girls and boys	**4**	**12**	**48**	With 2WC for disabled students, 1 per gender
Indoors sports hall	**410**	**1**	**410**	
Main hall area	380	1	380	
Changing rooms with WC	15	2	30	Changing rooms separated by gender
Administration	**101**	**1**	**142**	
Office for the director	12	1	12	Space for 1 person
Offices for administration staff	15	2	30	Each office hosts 3 persons
Teachers rooms equipped with WCs	22	2	44	Each room for 6 persons (separated by gender)
Pantry/ Kitchenette for staff	12	1	12	
WC for staff	4	2	8	With one WC equipped for disabled use
Storage space	36	1	36	For furniture
Corridors and circulations			**490**	Around 40% of the total
TOTAL			**1.715** sqm	

Tab. V-04.Programma funzionale per la scuola @UNESCO

The decision to expand the common core towards the interior of the complex stems from the desire to combine the external and internal functions of the buildings. The addition of the social center in front of the school works in the same way, the Al-Nuri complex has the will to become a community place, between religion, education, sociality and the car with the aim of revitalizing the city.

3.2.b. Planimetric level

At the planimetric level, the school develops mainly on the ground floor. On the first floor, only the teaching bodies grow to form functional volumes.

For energy reasons, the northern orientation is privileged for the main functions, more private, consisting of offices and classrooms. So the south side constitutes the complex is social, with temporary spaces: circulations, shared functions etc ...

Funzione	Area /u m2	Unite	Area totale m2	Commenti
Scuola			**40**	
Sala studio	20	2	40	ogni per genere, 5-10 studenti
Centro sociale			**84**	
Ingresso polivalente	30	1	30	
Aula didattica	45	1	45	per accogliere circa 30 persone
Bagno	4	1	4	
Stoccaggio	5	1	5	

Tab. V-05.Programma addizionale

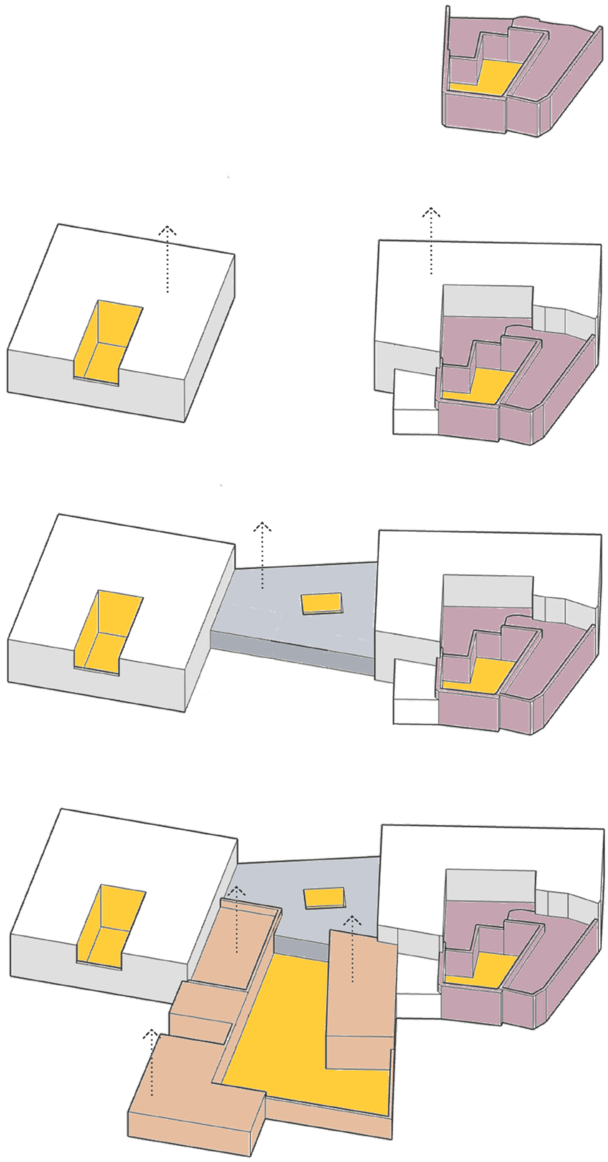


Fig. V-19.Fuzionalità volumetrica

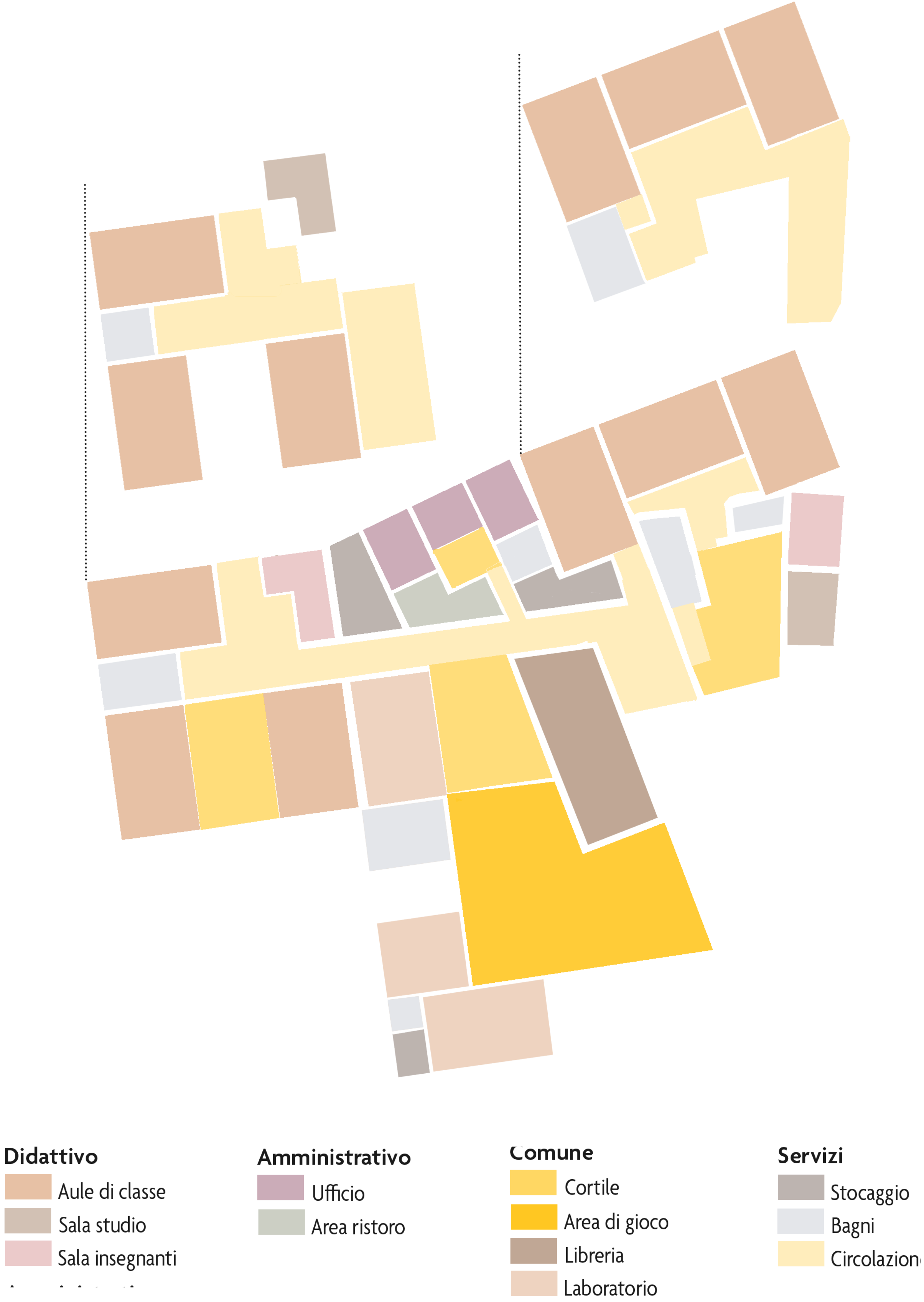


Fig. V-20.Fuzionalità planimetrica

ARCHITECTURAL DESIGN

1. CONCEPT

1.1. Reconstruct

The concept behind the Al-Nuri School project is strongly linked to the problem of rebuilding after the war.

- Rebuilding an urban space
- Rebuilding buildings with few means
- Rebuilding a community
- Reconstructing his mental state

1.2. With the past

In this theme of general reconstruction appears the theme of the management of the past. Mosul's near past has been chaotic and full of violence, insecurity and little hope. However, in the distant past, ancient Mosul was a powerful city in the Arab world. Consequently, the axis of work chosen is to recall that the past is looked at in its generality, under the layers of war, between two layers of negative elements are beauties to be protected.

The Al-Nuri school seeks to revitalize the roots of Arab composition in an accessible way. It is about changing the landscape without the feeling of disorientation; the population must recognize itself in the project without assimilating it to the traumatic period it has just gone through. As a result, the project tries not to brutally transform the urban landscape and goes against a composition consisting of huge unique blocks.

In the composition, the translation of the concept passes through the use of vernacular architecture in compliance with modern requirements. The building has the desire to have even minimal educational value.

1.3. A sense of community

In addition, creating a sense of community is central to the construction of the Al-Nuri complex, the functional approach and urban reasoning go in this direction. The community remains a central pillar in the restoration of mentalities, and is even more effective when it comes to people who have lost their family and therefore are not supported.

In this regard comes the symbol of the court that stops people to bring them together.

1.4. Honest

In order to be able to claim to touch the population quickly, in the face of the emergency of reconstruction, simplicity is used. The goal is to be accessible both physically and mentally: try to be unpretentious in the possibility of approaching people. Modus operandi cannot be complex. It is a passive building, which functions from its envelope, it does not need anyone except its community as a user who connects the building to people and helps in independence related to the weak services of the city. This is the most challenging part of the concept, but it is the essential goal.

2. PROJECT

2.1. Generality

4.2.a. Decentralization at court

The building consists of an organization under different arrangements centered on the courts to form a set of houses. The idea was born from the New Gourna project made by Hassan Fathy. For the relocation of the city of Gourna, the architect studied the interactions and structures of the city for his design. It grouped the families that belonged to the same social subgroup together and the subgroups of a larger social group together. The management was done thanks to a system of shared courts. In the Al-Nuri school it works in the same way with individual courts, while maintaining the existence of a central court.

4.2.b. Equality

Despite the separation imposed between girls and boys, the idea of collective value has been cultivated. The two teaching bodies are the same and it has not been decided what it is for whom. The unwanted separation complete with common areas in the center.

It is noted that the classrooms are not separated according to the level of training. It was a desire to remain neutral and therefore flexible. The many years of war and dysfunction have changed the distribution of children in educational levels. Therefore, the school system will change strongly in its early years. In addition, the diversity in age results from the complicated past of the city. Bringing all children together helps not to have an age-based discriminating system.

4.2.c. Social circulation

With the exception of a main corridor, the school does not have corridors in the strict sense. It was a choice to distribute the spaces thanks to the crossroads where people meet automatically. They are visual spaces that complete the courts during the break times. In addition, the courts are used as distribution spaces for the circulation of users

2.2. Plants

4.2.a. Entrance

The route starts from the entrance located on the east side to the south. Stairs go down to reach the level of the school, at the same level as the existing house. The entrance takes advantage of the bare wall of the existing house. On the other side of the wall there is a first didactic body.

4.2.b. East School

This teaching body to the east takes advantage of the existing house. It's centered on a casual-playing courtyard with direct access to the bathrooms. On the east side, in the old rooms of the house there are the common room of the professors and a study room. The study room is a space where some students have access to computers or can study in groups. It is a more intimate space than the large library, a place where some students may be more comfortable. The classrooms are arranged adjacent to the house to the north, this arrangement creates a more private area. Access to the first floor of the body is made by a staircase in the courtyard, it comes in a transitional space that looks like an iwan. The classrooms are arranged in the same way as on the ground floor. The circulation space is large, has a double value as a circulation space and is livable in the same way as a terrace.

4.2.c. Transverse corridor

Transversely the building is crossed by a wide corridor that goes from one teaching body to another. The corridor resembles a road connecting the different houses. To emphasize the value of the space, the ceiling is vaulted..

4.2.d. West School

At the west end of the corridor there is the second teaching body, it works like the first, despite having a more classic form. The staircase is at the bottom of it, in front of the court. The classrooms overlap on the two floors. The study room is on the second floor. An access on the roof widens the terrace of the first floor. This space is sized to accommodate an extra class if you need it.

4.2.e. Administration

In the middle of the main corridor, to the north is the administration of the school. The layout is structured around a small courtyard. On the north façade are the offices with the main office in the center, while on both sides there are service spaces. The west welcomes a dining break space open to the courtyard to widen the view. The inspiration of this space is called Eyvan in traditional architecture; it was an elevated space on the courtyard used by the elderly to rest and chat in the shade looking at the inner courtyard.

The administration is isolated from the two teaching bodies with two storage spaces through functional and acoustic infills.

4.2.f. Shared spaces

In front of the administrative space, on the other side of the central corridor, is the main courtyard. It is a space shared with everyone, it is framed on both sides of two shared spaces: a laboratory room and the library. The library has a particular state, arranged immediately after the entrance is a space of personal culture. Of centralized layout, it accentuates its accessibility and requires the possibility of opening it to the public. Similar to the corridor, it is turned below linear its nature. From the main courtyard, it is a direct access to the sports space in front of the school.

4.2.g. Sports area

This space remains first of all for the use of school children. Being not used so much by children it is optimized with a public access. The sports space is of mixed use but the southern part is designed for a volleyball court, the national sport in Iraq. Although it seems adequate for a social renewal, sport, as a novelty, favors moving forward. The size of the camp is much more convenient to implement in the old city where space is lacking. Psychological studies have shown an increase in violence among children in schools who have to fight. In this sense, volleyball does not present violence, but it is a collective sport that gives the possibility of creating social bonds and an impression of belonging to a group.

4.2.h. Social Center

At the end of the sports area, there is a small public building of a humanitarian nature. The social center aims to give lessons to people who no longer went to school despite having educational gaps. They can be adults who try to change jobs and consequently need training, or even for teenagers who left school during the war. Numerous children have been forced to work and do not have complete education. In order not to have a life of random jobs, the center offers the possibility of recovering the school.

2.3. Accessibility

First of all it was an unspoken request to have a school accessible to all. War leaves physical wounds that incapacitate some people to live normally.

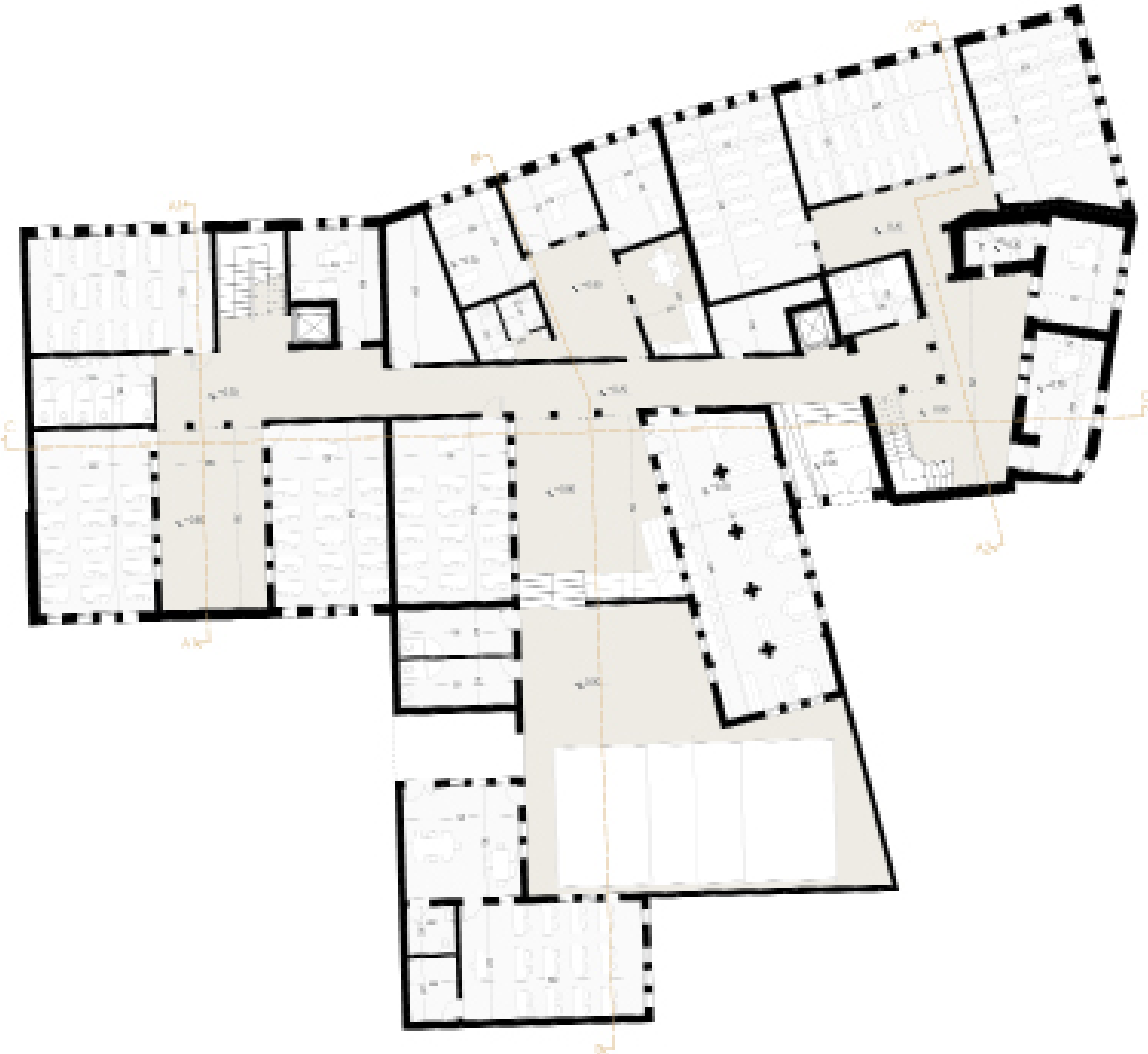


Fig. V-21.Pianta del piano terra. Scala 1/300

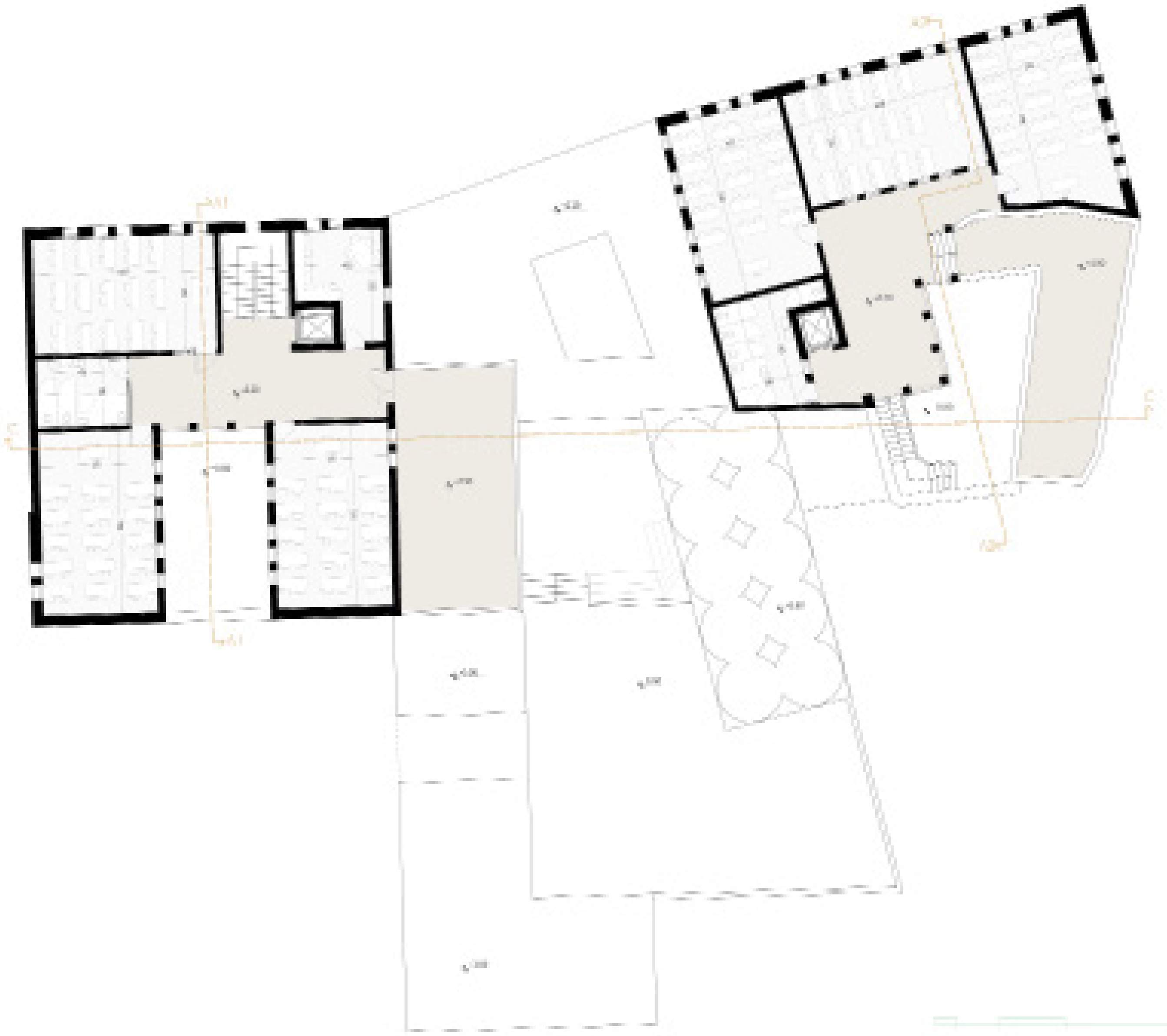


Fig. V-22.Pianta del piano primo. Scala 1/300

Funzione	Area/u	Unite	Area totale
Nucleo commune			**224.41 m²**
Foyer d'ingresso	17.42 m²	1	
Aula di laboratorio	44.71 m²	1	
Libreria	70.34 m²	1	
Corte	56.67 m²	1	
Circolazione			49.20 m²
Area sportiva			**185.08 m²**
Spogliatoi	11.17 m²	1	
Campo	172.94 m²	1	
Centro sociale			**85.81 m²**
Foyer	27.39 m²	1	
Aula diddattica	44.79 m²	1	
Area di stoccaggio	6.58 m²	1	
Bagno	4.80 m²	1	

Funzione	Area/u	Unite	Area totale
Amministrazione			**127.21 m²**
Ufficio del direttore	12.55 m²	1	
Ufficio secondario est	16.12 m²	1	
Ufficio secondario ovest	15.95 m²	1	
Area ristoro	15.79 m²	1	
Area di stoccaggio est	10.68 m²	1	
Area di stoccaggio ovest	19.20 m²	1	
Bagno	9.99 m²	2	
Corte	21.20 m²	1	
Circolazione			0 m²

Funzione	Area/u	Unite	Area totale
Scuola Ovest			**496.95 m²**
Aula	44.71 m²	6	
Sala insegnanti	15.27 m²	1	
Bagno per insegnanti	2.00 m²	1	
Sala studio	17.27 m²	1	
Bagni per studenti PT	17.65 m²	1	
Bagni per studenti P1	13.38 m²	1	
Corte	40.33m²	1	
Terrazza	61.01 m²	1	
Circolazione			70.76m²
Scuola Est			**498.97 m²**
Aula	44.71 m²	4	
Aula	43.31 m²	2	
Sala studio	15.27 m²	1	
Sala insegnanti	16.73 m²	1	
Bagno per insegnanti	5.67 m²	1	
Bagni per studenti PT	10.55 m²	1	
Bagni per studenti P1	19.01 m²	1	
Terrazza	55.01 m²	1	
Corte	51.32 m²	1	
Circolazione			60.04 m²

Tab. V-06.Superficie

Fig. V-23.Pianta dell'accessibilità ai disabili. Scala 1/400

3. SECTION

3.1. Section A1

Fig. V-24.Sezione trasversale A1. Scala 1/200

3.2. Section A2

Fig. V-25.Sezione trasversale A2. Scala 1/200

3.3. Section B

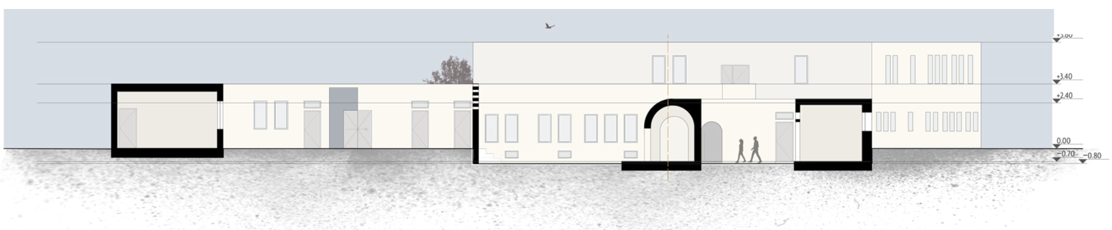


Fig. V-26.Sezione longitudinale B. Scala 1/400

3.4. Section C

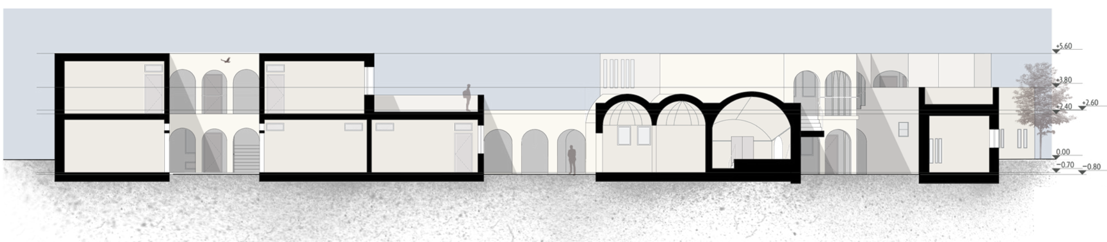


Fig. V-27.Sezione longitudinale C. Scala 1/400

4. PROSPECTS

4.1. Concept

Traditional Arab buildings have a special relationship with the outside. They are introverted buildings. Therefore, the facades were quite closed. The reasons are varied. A closed façade allows you to attach buildings and form a dense urban layout. The density was sought after and the streets were narrow for energetic reasons. Density is a way of maintaining a microclimate. The oasis of Ghadames is a beautiful example of a microclimate created thanks to urban density. Located deep in the desert, people live in tightly grouped traditional houses, made of mud brick and palm wood. The protruding structures of the houses cover the alleys between the houses creating an almost underground network of passages. The temperature in the city remains comfortable being hidden from the sun. The streets disappear and the unity of the city rises. In the case of the Al-Nuri project, the density is difficult to maintain given the island where the project develops. So, closing the facades is a critical protection against the Iraqi desert sun.

In addition, the closure of the facades works for the sense of privacy and security: if you are not seen, you are not exposed to violence. For children it is a not insignificant topic, especially for girls who during the last few years have not been allowed to leave the house.

In spite of everything, there remained a desire to open the building to the outside. Natural light is an important comfort condition and lowers the electricity requirement. In addition, extroversion helps sociality and moving forward. Establishing a visual connection is a way of reconnecting to the world.

From all this comes the problem of being closed and opening up. What is analyzed translates into a system of fixed shading on the façade. The south side remains quite closed, open only to ensure a minimum of light for secondary functions. Circulations are open to public spaces.

4.2. Realization

4.4.a. Generality

The building is covered with uniform plaster. The casing is structured by differences in heights. The two school bodies develop its two floor in the middle is highlighted the administration and behind the common core. The variations in height create a legible envelope that along the road to the north leaves the impression of later buildings.

All exterior windows are hidden behind modern mashrabiya. The height of the mashrabiya is chosen in order to rebalance the façade between the two floors. The building being semi-underground from the outside the ground floor appears less high than the first floor. To erase, the appearance of a stocky building the mashrabiya of the two floors are of equal heights.

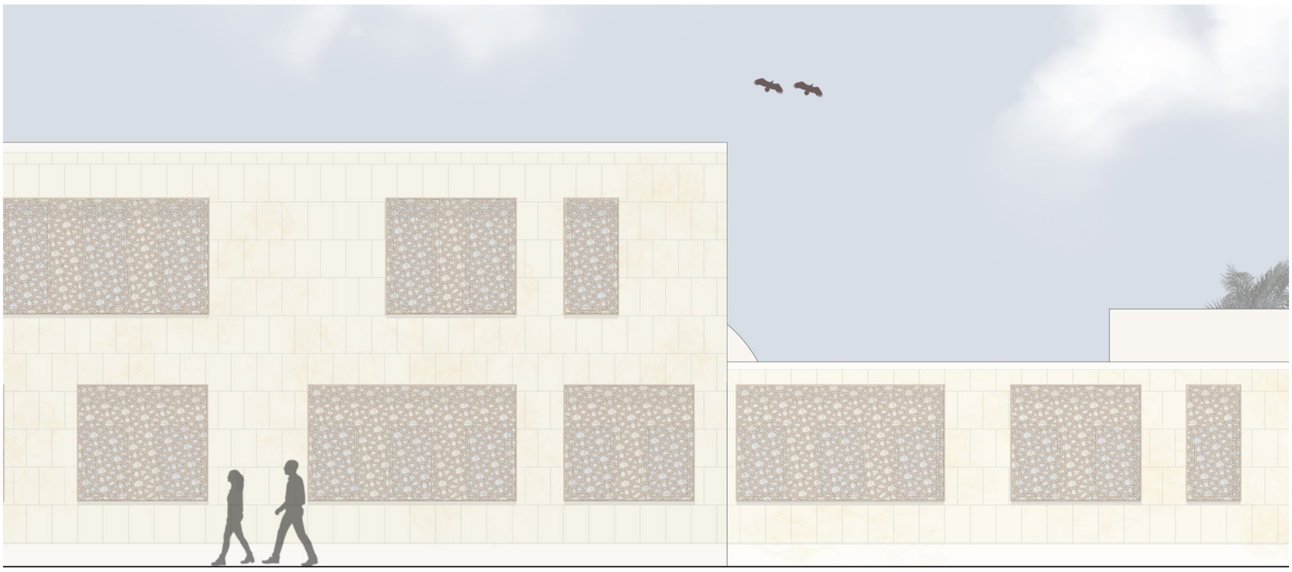


Fig. V-28.Dettaglio architettonico del prospetto Nord. Scala 1/100

4.4.b. North Elevation

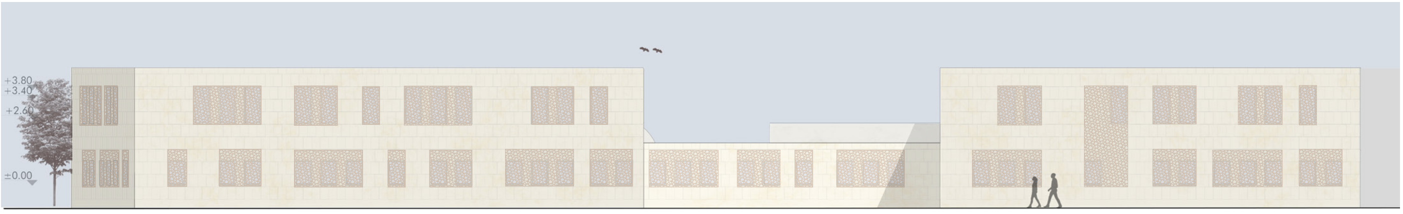


Fig. V-30.Prospetto Nord. Scala 1/400

4.4.c. South Elevation

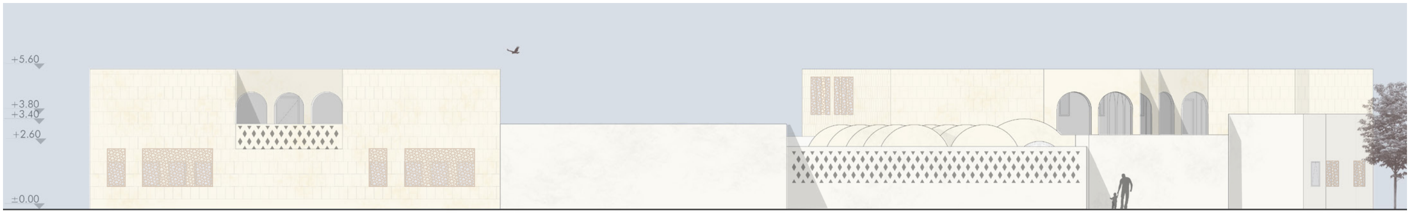


Fig. V-31.Prospetto Sud. Scala 1/400

4.4.d. East Elevation

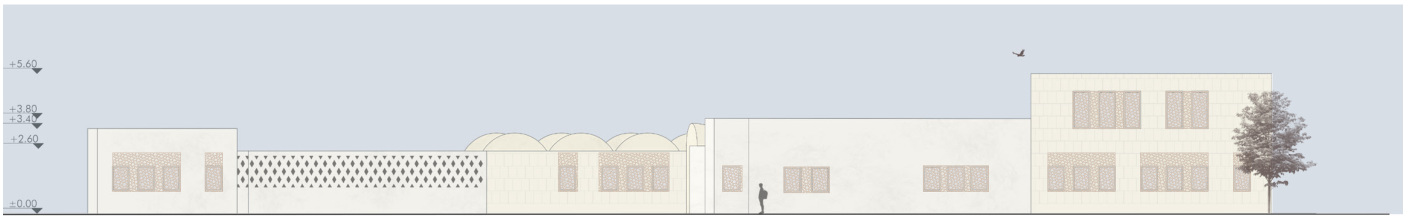


Fig. V-32.Prospetto Est. Scala 1/400

4.4.e. West Elevation

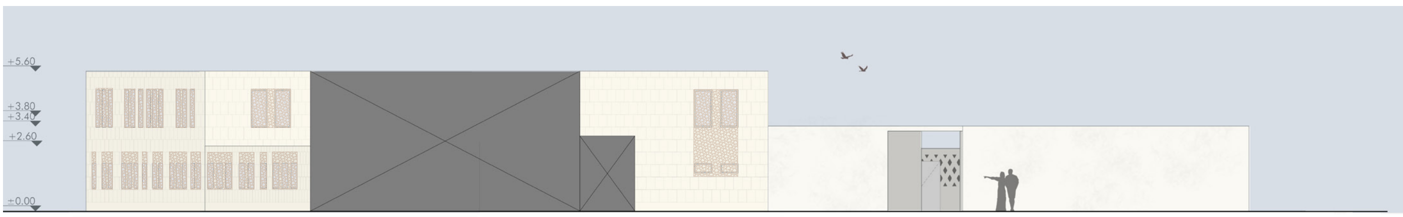


Fig. V-33.Prospetto Ovest. Scala 1/400

VI. BUILDING WITH EARTH

INDICE DEL CAPITOLO

INDICE DEL CAPITOLO

CHARACTERISATION

1. THE EARTH MATERIAL

Fig. VI-01.Terra naturale @BuildGreen

1.1. Composition

The earth is a three-phase material: solid with the sand it contains, liquid thanks to the water it contains, gaseous with oxygen. On a physical level, the earth is composed of clay with grains with a diameter of less than 0.002mm, silt with grains between 0.002mm and 0.06 mm in diameter, sand with grains up to 2mm and wider granules. Being a mixture, the physical performance of the earth depends on its composition.

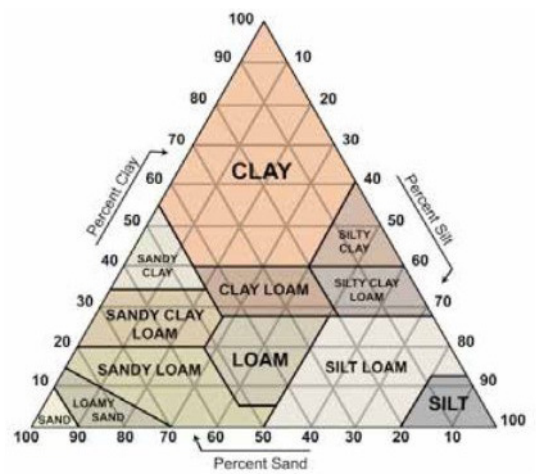


Fig. VI-02. Nominazione delle terre @Wikipedia

1.2. Cohesion

The cohesion and strength of the mixture is due to three types of cohesive forces. Friction forces are created by grains of sand and gravel that give roughness to the earth. The capillary cohesion with water makes the sand (dry being a powder) plastic. The cohesion given by electrical forces is a peculiarity of clay that has a multilayer structure. When the environment is dry, the layers of clay are bound by electrical forces.

The appearance of the earth is therefore due to the internal cohesion forces and also to the external action suffered. The Carazas test, conceived by Wilfredo Carazas Aedo, highlights the states of the earth according to the action suffered and highlights how water helps up to a certain point to cohesion, since an excessive amount of water cancels the forces of capillarity. Minimizing the presence of air in the earth mix increases mechanical strength, hence the use of compression in the most common construction techniques.

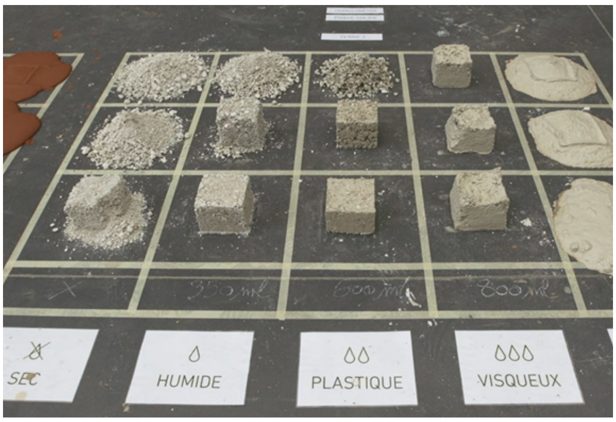


Fig. VI-03. Fotografia di una matrice di Carazas

1.3. Preparation of the dough

Traditionally, extracted clods of earth are put in water. After two or four days, the earth has become plastic and is processed with the feet or with the support of an animal. In case necessary, more sand, fibers and additives are added.

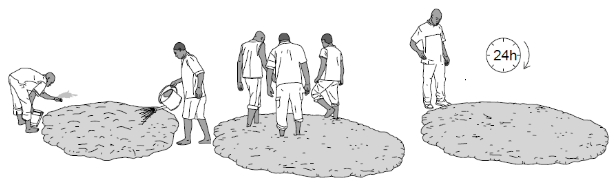


Fig. VI-04.Preparazione tradizionale ©Voute Nubienne

With the use of machines, water curing is reduced to a maximum of two days. The earth, being fragmented thanks to a machine after extraction, is easily humidified.

2. INFLUENCE OF WATER

2.1. Water resistance

The ability of an element made of earth to withstand rain is linked to its ability to absorb water: the less it absorbs, the more it resists. To quantify, a cube of earth is immersed in 3mm of water.

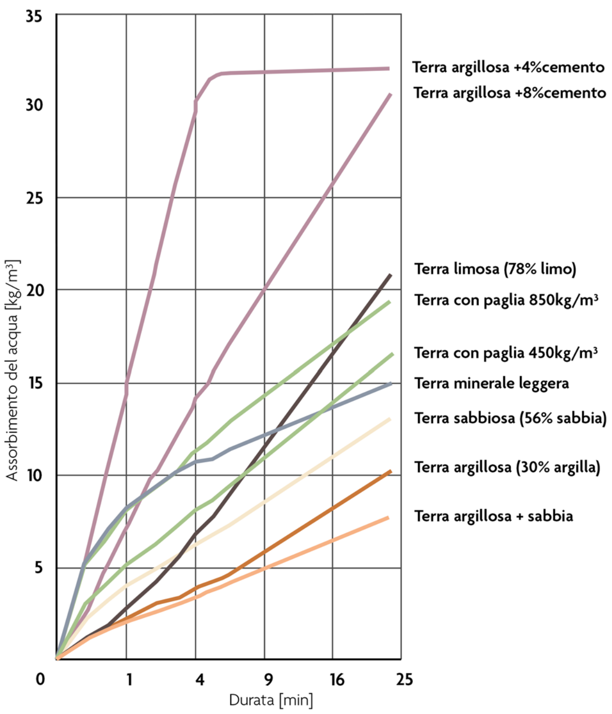


Fig. VI-05. Grafico comparativo dell'assorbimento

2.2. Vapor permeability

If the earth is required to withstand the rains, instead its permeability to water vapor is to be preserved, giving the walls the ability to regulate the internal humidity of the rooms. In addition, it is important not to have condensation inside the wall. The vapor permeability of the earth is from 5 to 20.

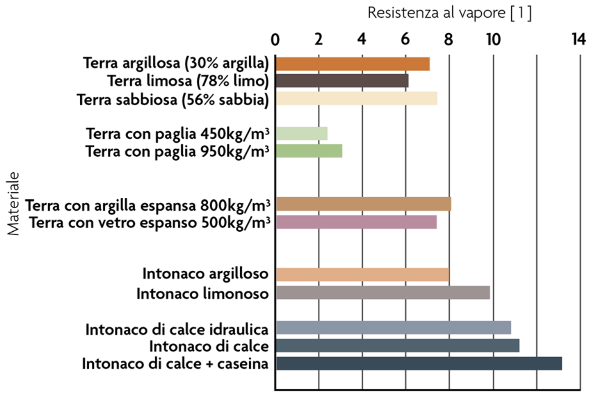


Fig. VI-06. Resistenze al vapore

3. INFLUENCE OF HEAT

According to popular belief the earth is a good thermal insulator, in reality the earth being massive is not the best thermal insulator but its inertia allows to have a good thermal phase shift. Its massive heat capacity is about 1 kJ/kgK, its thermal conductivity is from 0.2 up to 1.5 W/mK, and increases with its density.

4. MECHANICAL PERFORMANCE

4.1. Elasticity

The dynamic modulus of elasticity of raw earth is compressed between 600 and 350 kg/mm².

4.2. Compression

The compressive strength of the earth depends a lot on the construction technique adopted. It is compressed between 1 and 6 Mpa.

4.3. Tension

The earth has a very bad traction behavior. Its voltage resistance is about 10% of the compressive strength. In the design, therefore, structures that work in tension are avoided. For this reason in Islamic architecture the vaults are numerous, so all the blocks that make up the structure work in compression.

5. PERFORMANCE OPTIMIZATION

Optimization is done in accordance with the specific requirements of the construction site. The proportions in the mixture that makes up the earth can be changed so as to change the different properties.

5.1. Influence of sand

Increase the amount of sand in the mixture, decreases the shrinkage that is required during drying.

5.2. Influence of fibers

Adding fibers increases tensile strength and decreases thermal conductivity.

5.3. Influence of compression

The compression of the earth element increases its density, thus also increasing the heat capacity, for example, from 1 500 kg/m3 can go up to 2 200 kg/m3.

5.4. Influence of additives

Cement is added to the earth mixture especially for compressed blocks and allows to increase the compressive strength, while decreasing its vapor permeability.

Some bituminous additives help to improve the resistance of the material to water.

The addition of industrial additives is not convenient for restoration work going against the rule of reversibility. Some additives make the soil mixture unusable.

ADVANTAGES AND LIMITATION

In regions such as Iraq, where climate and geography do not allow for much diversity of building materials, land has emerged as the best choice in the country's vernacular architecture. Today, new developments in the construction sector allow raw earth to be used again. Raw earth has numerous advantages that unfortunately are often held back by the mentality of the cultural substrate.

1. ADVANTAGES

1.1. Low cost availability

Raw earth is a material available in infinite quantities. Although not all types of land are ideal for construction, different techniques have been developed to adapt to a wide range of lands. Generally, a rather clayey land is preferred.

An important point for the development of construction in Kurdish land is that the land used is not the earth of the surface layer. The construction activity does not conflict with agriculture.

First of all, it is a low-cost material, even free in some situations.

1.2. Ecology

The life cycle of the earth as a building material is environmentally friendly. It releases less CO_2 than other materials such as cement and, thanks to the few changes it is undergoing, extraction is simple. It is used only with the addition of natural material : water and fiber. The drying of the elements made requires an ambient temperature at least that is above 20 ° C. The process is not chemical.

In addition, during the life of the building it was shown that the elements in the earth helped to absorb pollutants.

1.3. Recyclability

The earth is naturally durable. Building in earth allows you to recycle the excavated earth. In addition, after the demolition of the earthen building, it is possible to reuse it if it has not been mixed with synthetic additives.

This aspect makes it possible to facilitate the maintenance and repair of earthen buildings, thus extending the life span.

1.4. Bearing capacity

Earth is a load-bearing material. With different techniques, from the sixteenth century, buildings up to seven floors were built. The addition of natural adjuvant such as straw or synthetics such as cement, reinforces the bearing capacity of the earth elements.

1.5. Aesthetics

From an aesthetic point of view, the use of land is appreciated. The color panel is varied. Warm colors give a simple and cozy ecstatic.

1.6. Comfort

The earth is a hygrometric regulator: its power to absorb water regulates the humidity of the rooms. So, the relative humidity lies to a comfort level. In addition, absorbing moisture allows other materials such as wood to absorb less, preserving its durability by reducing the development of mold and driving away insects.

Another quality that improves internal comfort is the earth's ability to store heat, thus offering a phase shift that helps to passively reach a good temperature.

1.7. Conviviality

A construction site is not so mechanized, it requires a lot of labor without a strong know-how. For this reason the earth construction sites are cooperative, they become a social experience where the construction of land is relearned.

2. DETRIMENTS

2.1. Water resistance

The worst enemy of constructions made of raw earth is water. Rain and rising damp destroy the buildings. The design must take into account this weakness, especially for external use.

In addition, water permeability makes it difficult to manage the drying of elements in raw earth, when drying, the earth shrinks.

2.2. Psychological block

Earth, being an ancient material, is not included when it comes to innovation. Especially in emerging countries, for those it is important to show their technical advancement, the land has been banned. This mentality is a real brake on the use of raw earth. But in the face of its advantages, some architects such as Hassan Fathy have worked and are still working to rehabilitate his public image.

2.3. Ingratitude

Today the raw earth construction has been lost because of its image in the common mentality. As a result, it is difficult to acquire the necessary knowledge to master this material. Especially it is unknown in the legal institution, the land is not included in the legal standard process of building construction.

3. CONCLUSION

Raw earth is the oldest building material used worldwide. Today, raw earth represents a new perspective for a reasoned and sustainable construction. In the case of construction projects in post-war contexts, land is an interesting material.

CONSTRUCTIVE LOGICS

Through its vernacular use, the construction of raw earth has developed in a different way throughout the whole world between the different soils, climates and available materials. Twelve ways of working the land were characterized, leading to six main techniques.

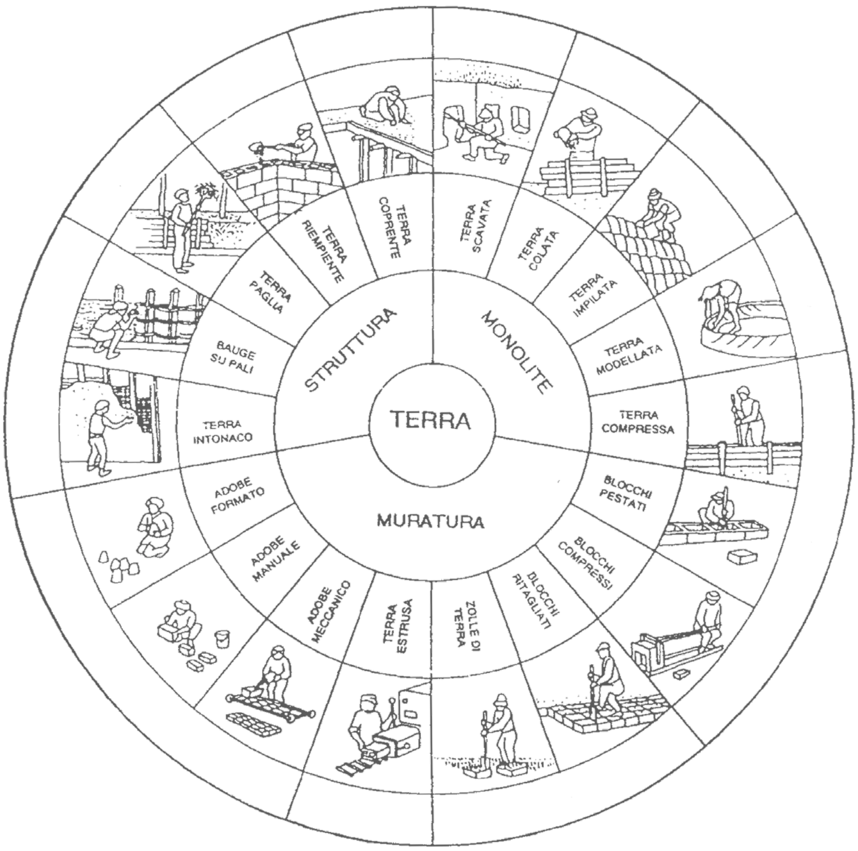


Fig. VI-07. Ruota delle logiche costruttive

1. MONOLITHIC TECHNIQUES

Fig. VI-08.Qasr al amara, Najran

1.1. Freemason

3.1.a. History

Freemason is an ancient technique widespread in the vernacular architecture of sub-Saharan Africa. There is evidence of its use also in Asia, Arabia and Europe. It presents the of being able to easily make curved shapes.

3.1.b. Earth

The Mason needs a fine, clayey earth mixed with water, straw, herbs or thin branches.

3.1.c. Methodology

A Mason wall is made in layers. Each layer consists of piled up clods of earth. The thickness is between 40 and 60 centimeters (it does not exceed 80 centimeters). The layer is left to dry partially before starting the top layer. The wall is sanded with stones, hit to densify the construction. It is not necessary to interlay a layer of mortar between the layers. Mason walls are after finishing from 45 to 60 cm thick.

3.1.d. Paraphernalia

The Mason technique does not require special tools, however, over time variants with formwork or prefabrication have developed.

Fig. VI-09. Abitazione Tulou, Cina

1.2. Pise

3.1.a. History

The Pise technique dates from 5000 BC in Assyria. In Europe, it was spread with the work of the architect and mason François Cointreaux in the 1790s. We find it particularly in France, Spain and Morocco. In 1986, the French Nicolas Meunier developed a prefabricated method of pise panels. Today, the pise is the construction technique with earth the most appreciated, especially because of its aesthetics.

3.1.b. Earth

The land used is a gravelly earth, with a small amount of sand and sticky clay. Considering the way of doing, the soil mixture does not need to be stabilized with lime or cement to be load-bearing enough.

3.1.c. Methodology

Pise is a compressed earth technique. Layers of slightly moist earth 12 or 15 centimeters thick are put in a formwork. Then, the layer is compressed by a pestle and covered with the next layer. The difference in moisture between the two layers can result in cracks during compression of the top layer. To reduce this phenomenon, the Pise technique French adds a layer of lime mortar between the layers of earth. Pise walls are 40 to 60 centimeters thick and are not made to be plastered.

3.1.d. Paraphernalia

Traditionally the pestle was made of wood, but with modern techniques it is mechanized, pneumatic. The traditional formwork is made of wood, about 40 centimeters high. It had to be moved up every time it made us a new layer. Formwork management is the most critical point of this technique. Wrong management causes up to 30% of working time to be lost. Today, formwork designed for concrete constructions is used. If the wall is less than three meters high, the formwork can be removed immediately after the last complete layer, or, to avoid collapse, the earth must be partially

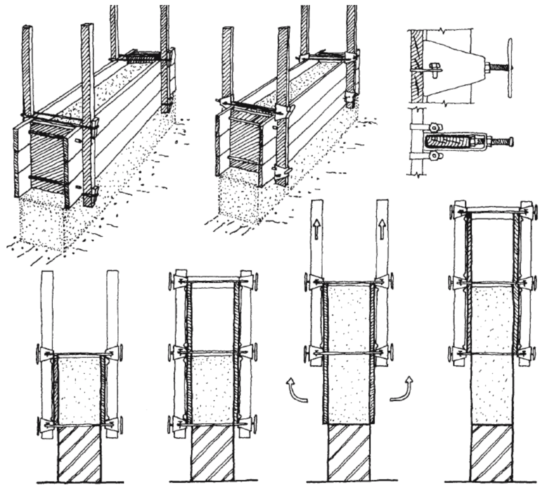


Fig. VI-10. Gestione della cassaforma per il pise

dry before removal.

3.1.e. Durations

It remains faster to build with pise than concrete. The withdrawal due to drying disappears after a few days allowing the work. A wall is completely dry after three weeks, compared to a concrete wall that dries in about 28 days before being workable.

With the traditional method, the implementation speed is from 20 to 30 hours/m3 of pise element, instead, with modern techniques it drops to 2 hours/m3.

1.3. Other techniques

Other monolithic techniques are used as that of the land thrown developed in the XXI century. This technique is based on that of concrete. The element made in the formwork can be armed to raise the mechanical performance and facilitate the removal of the formwork. The addition of cement helps drying.

2. TECHNIQUES IN SMALL ELEMENTS

Techniques in small elements are prefabrication techniques.

2.1. Mud bricks

Fig. VI-11.Huaca del sol, Peru

3.2.a. History

The mud brick technique was born in Mesopotamia eleven millennia ago. This technique is especially adapted to hot and dry climates. Bricks have experienced many evolutions with the industrial revolution. Compared to the others, this technique has the advantage of not being bound to seasonality. Bricks can be produced at a time of year and stored.

3.2.b. Earth

A fine earth with a lot of sand and clay is used, without gravel, mixed with some animal or vegetable fibers. The mix contains less water than that of the Freemason. For example, a mixture that is convenient is: 14% clay, 22% silt, 62% sand and 2% gravel.

3.2.c. Methodology

And a molded earth technique, to make bricks the earth is shaped according to the shape that is convenient. Wet bricks dry at room temperature. It requires two drying phases, one on each side to ensure a complete and uniform drying. Once the bricks are completely can be used. The brick wall is assembled using a mortar of a composition similar to those used to make bricks.

3.2.d. Paraphernalia

Making mud bricks does not require so many tools. At the beginning the bricks were made entirely by hand, then to ensure regularity in the shape the bricks were shaped with wooden formwork.

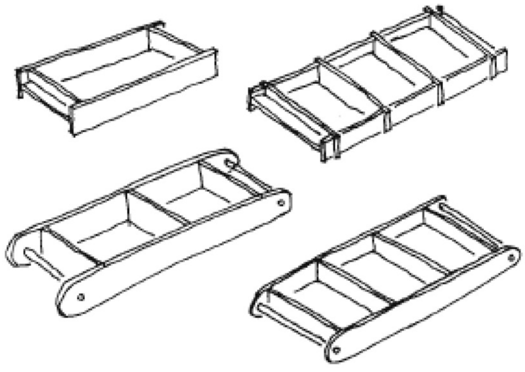


Fig. VI-12. Cassaforma di legno per mattoni

3.2.e. Durations

Traditionally, a person can produce between 300 and 500 bricks per day.

2.2. Other techniques

Compressed earth block (BTC) is a variant of brick. It was invented in 1952 by the Colombian engineer Raul RAMIREZ. The brick is made with a mechanical press. This technique allowed to use less water, reduce the drying time. However, the presence of less water makes the blocks less durable. So, in general the earth is mixed with cement to achieve the requirements.

The extruded brick is produced without interruption by an automated process at the factory. Panels are also manufactured with the same technique. The production of blocks in this way rises from 1500 to 4000 blocks per day.

3. FILLING TECHNIQUES

3.1. Torchis

3.3.a. History

Torchis has been used in all tropical, subtropical and moderate climates. And perhaps the oldest of the techniques.

Fig. VI-13.Maison ecopaysanne Francia ©I.Lemaître

3.3.b. Earth

The earth used for the torchis technique is practically the same as for the Mason, it is a fine, clayey earth with an important amount of fiber.

3.3.c. Methodology

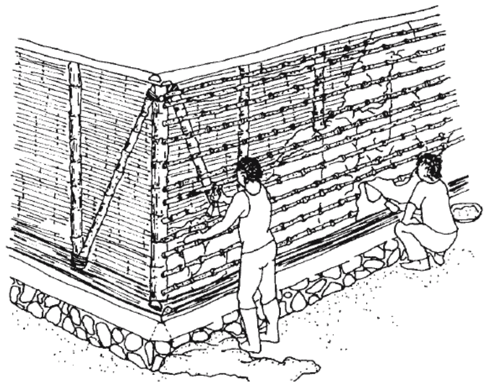
Torchis is a coating earth technique. The earth is not a load-bearing element of the structure. In fact, the earth is used as a filling of the supporting structure, in general made of fairly flexible wood, for example bamboo, making the structure anti-seismic.

There are several methodologies that depend on the mesh of the supporting structure. If the supporting structure is a fine straight, the earth is thrown or pressed and must cover with at least 2cm thickness on each piece of the structure. If the structure were a three-dimensional network with internal spaces, the cavity would be filled with clods of earth. Or, the filler may contain gravel or stones. The coating is always made of at least two centimeters of earth.

The wall of torchis is both vertical and horizontal, its thickness depends on the supporting structure.

3.3.d. Paraphernalia

This technique does not require special tools. Traditionally, it is implemented all by hand. Today, the earth is sometimes projected mechanically.



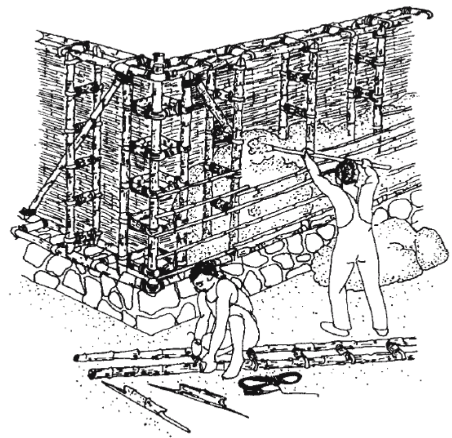


Fig. VI-14. Tecniche di torchis

3.3.e. Durations

Drying of the earth, being used as a coating, does not slow down the construction site

3.2. Other techniques

There are developed other techniques of filling with earth. The torchis is mainly used with a lightweight structure. With a massive structure, the Colombage technique was created in France during the medieval period.

Lightened land is another innovation. It allowed to have a superior thermal and acoustic insulation. Use a land with a density of less than 800 kg/m3.

COATINGS

A building built with earth is often left with exposed earth, especially with pise. For a uniform finish, the surface of the Mason structure is smoothed to the point that the layers are undeferrable. There are several ways of cladding buildings in earth. Painting them is simple and allows you to express your artistic imagination. Plastering them remains the most widespread and durable technique. In the following paragraphs the focus will be on three most common techniques.

1. EARTH PLASTERS

Fig. VI-15. Intonacatura della moschea di Djenne, Mali ©Thomas Martinez

With earth, you can plaster the walls of a building. A plaster consists of three layers, a layer of adhesion, a layer of body, a layer of finish.

1.1. Blend

Earth plaster is composed of fine earth, clayey, with sand, fibers and water. Clay is the binder of the mixture, the amount is to be minimized about 5% to 12%. The mixture contains a lot of sand, which helps to decrease shrinkage during drying. The finishing layer is made with a finer sand. The plaster does not contain as much fiber, but enough to decrease the risk of breakage, and at the same time to keep the dough fine and uniform. For internal use, sometimes the fibers are sawdust and cellulose. The water is washed, pure; a polluted water creates stains on the plaster after drying.

Laying condition

A temperature above 0°C is needed to avoid the risk of frost. In addition, laying is possible in hot weather or with strong winds. Drying is faster than that of a plaster with hydraulic binders.

Inside, good ventilation must be ensured. Outside, it is necessary to protect the elements of raw earth against rain. The support must be stable, without moisture problems and resistant to impacts.

1.2. Laying methodology

First of all, to ensure the adhesion of the plaster, the laying surface is properly prepared by removing all the loose material is removed. The surface is made wrinkled to facilitate the grip of the plaster.

The plaster is both single-layer (at least 5mm thick on wrinkled surfaci) and multilayer. In addition, for the reinforcement of plaster, a synthetic reinforcement can be added to the first layer of plaster. But it does not have a shortening function. The plaster is placed by hand or projected mechanically.

Depending on the type of surface the methodology is different. On the stone, you need a layer of body and a layer of finishing. Gypsum is smooth so you need a layer of adhesion and a layer of finish. Straw is not a smooth, or flat surface. The plaster system is then composed of a layer of adhesion, a layer of body with an armor and a layer of finishing. Instead, on concrete a single layer is enough.

Buildings made of earth are the most sensitive to plaster. The surface of earth to be plastered must be sufficiently rough, possibly grooved with beveled mortar joints. It must be dry enough so that there is no need for additional shrinkage with drying of the plaster. However, at the same time, sufficiently moist so that it softens. Plaster permeates the soft layer, so the connection is created.

Plaster is thrown with a strong impact so as to permeate the outer layers. If the plaster is to be more than 10-15 mm thick, it should be applied in two or even three layers with partial drying intervals to avoid shrinkage cracks.

Protection of the edges and corners is not mandatory, they can be plastered. However, care should be taken about the connection with other materials. The lower part of the wall is subject to risk of degradation due to rising damp. The coating dries between two to four days.

1.3. Advantages and limitation

The earth plaster without additive does not react chemically with the earth support. Not being dangerous for the operator there are no precautions to be taken. Plaster gives air tightness, protection against fire and moisture control.

Reversible drying of plaster makes it complex to use outside. Despite this weakness, laying in humid rooms is possible except for very humid rooms with large water spills such as collective showers, kitchens with pressure, swimming pools, etc ...

1.4. Optimization

In order to have a resistance to abrasion to water, the surface is eventually finished with a coat of paint.

To improve surface hardness, cow dung, lime, casein or other additives can be added to the top layer. The addition of additives changes the physical properties of materials, especially vapor tightness, lowering the permeability of the wall.

2. PLASTER WITH LIME

Lime plaster is more durable than earthen plaster and is recognizable by its light color.

2.1. Blend

Lime-based plaster contains lime obtained by firing a limestone (quicklime) and rehydrated (slaked lime), sand and water. There are two used kicks. With aerial lime, the obtained plaster dries slowly and is permeable to water vapor. With natural hydraulic lime the plaster contains clay that gives better mechanical strength at the expense of worse vapor permeability.

2.2. Laying condition

The gripping of the plaster is made in dry scope if it

Fig. VI-16. Città di Shibam, Yemen

is based on aerial lime. While, with a hydraulic lime, it is feasible in both dry and wet areas.

2.3. Laying methodology

Surface preparation is as sensitive as for an earthen plaster. It is necessary to bring less roughness considering that the lime reacts chemically with the earth. Before plastering, the operator wears protections, gloves and glasses against the corrosive effect of lime.

Lime plaster is never single-layered, generally on an inner surface you need two layers, while on the outside, you need three.

2.4. Advantages and limitation

The color of the plaster comes from the type of sand used that gives the lime plaster a varied colorimetry. The color lightens with drying.

Lime plaster is more durable and less complex to design than an earth-based plaster.

The limits are given by lime: it is corrosive, it is not easy to obtain, it is less environmentally friendly and more expensive.

2.5. Optimization

There are variants with additives. For example, adding linseed oil to the mixture increases abrasion resistance. Casein is also one of the most popular additives.

3. OTHER PLASTERS

With plasters, both with lime and with earth, the coating comes clear. To obtain a dark color it is better to use a plaster with borax and casein.

4. VARNISH

To bring colors, paint is a simple solution and suitable for all smooth supports. It has been used for centuries especially in Africa.

4.1. Traditional paint

4.4.a. Soninke Culture

In the town of Oulalat in Mauritania the buildings are decorated with white symbols. The decoration surrounded the openings with chain patterns to emphasize the relationship between inside and outside.

Fig. VI-17.L'artista Silla Camara in Mauritania

Traditionally women used a lime paint laid on top of an earthen plaster. They came decorated especially the interior of the houses and in the courtyards. The different colors were produced from local natural pigments.

4.2. Kassena Culture

In Burkina Faso, in Tiebele the Kassena people paint the outer walls of buildings using white from chalk, black from coal and red from laterite, a local stone. Pigments are mixed with water and clay. They prepared the walls before painting, then smoothed them using stones.

To extend its service life, they painted the wall with a transparent varnish obtained from a local fruit.

4.3. Modern paint

Today, industrial paint is used more.

An environmentally friendly alternative is clay paint. This paint is composed of natural white clay, marble

Fig. VI-18. Villagio Tiebele ©Paronamico

powder, vegetable casein, lye, cellulose fiber and mineral pigments. It dries in about four to five hours. If the support has been well smoothed and light enough, the paint is applied in a single layer.

Clay paint costs more than ordinary paint, but it is more environmentally friendly and does not cause any allergies, as well as helping thermal well-being thanks to its clay component.

DESIGN BASICS

1. MANAGING WATER

As has been pointed out, water remains the most critical problem for land construction. However, it is continuous exposure to water that poses a danger. To overcome this danger it is advisable to design "good shoes and good hat", that is, paying attention to the foundations and the roof of the building.

1.1. Foundations

The village of New Gourna designed by the Egyptian architect Hassan Fathy, is disintegrating because of the water due to a groundwater dwarf is less than 50 centimeters below the feet of the inhabitants. The rise of water is consuming the bricks. This situation proves that it only takes a little water to endanger an entire building. For this reason the foundations of a building designed with raw earth can not be made from raw earth.

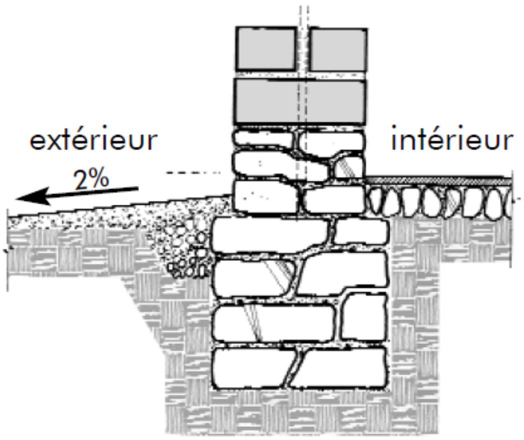


Fig. VI-19. Esempio di fondazione adeguata ©CRATerre

In the ground attachment of the walls serve external skirting boards, ideally of 30cm in case of heavy rains. The joint between the skirting board to the wall is a critical point. Another solution is to make a plinth made of stone or baked brick.

In addition, in areas with a risk of flooding, the building's water protection must be reinforced. Ground floor coverings must be durable with skirting boards, for example, floors can be covered with ceramics, exposed concrete and in other methods. The situation is the same for wet rooms. However, a waterproof coating amplifies the rise of water by capillarity along the walls. The waterproof part of the foundations can be raised so as to ensure that the walls are not wet. Obviously, in the design of plants, a water discharge system is required.

1.2. The roof

To protect the whole building from rain, the roof is the only barrier. Generally, evaluating the characteristics of the wind that directs the rain, the roof provided a protrusion. Earth is not a convenient material for making a protruding roof.

In the case of a flat earth roof, made to avoid water storage with a slope and downpipes or even if the roof is not accessible, parapets are useful to protect the walls below.

2. MECHANICAL BEHAVIOR

The earth works weakly in tension, so the design of the structure must favor compression behavior. In addition, the openings create lateral forces in the wall, so it is recommended to move away from each other and from the corners. A modern solution are the ''trumeaux'' walls where the opening cuts the wall along its entire height.

The earth does not react well to the association with rigid materials. The difference in stiffness amplifies the forces inside the wall, raising the risk of splitting.

2.1. Anti-seismic construction

Earth is not an anti-seismic construction material, it is heavy and crumbly. The 2003 earthquake in Iran destroyed a large part of the citadel of Bam and killed thirty thousand people. It was built in 250 BC.C. mud brick on about twenty hectares. In Peru and Chile, where earth construction is still part of culture today, they began to look for how to minimize the damage of an earthquake.

There are two types of forces involved during an earthquake. The horizontal forces from the earthquake cause vertical oscillations on the building, damaging the heavy elements more. Lateral forces that cause torsional oscillations with ground movement are associated with the shape of the building. Taking into account these phenomena, there are several baselines to follow to have a minimum of resistance to earthquakes.


Fig. VI-20. Armature di canna in angolo ©ASF

2.2. Architectural principles

A regular and compact plant with symmetrical walls is the best configuration. In addition, with the ground it is preferable a building that develops only on the ground floor. In some regions of the world the construction of a two-storey building on earth is prohibited by law. It is recommended to have small openings centered in the wall. The distance between the walls does not have to be too large to ensure stability (Craterre recommends a maximum of 20 times the thickness of the wall). The length of the total open surface should not exceed one third of the length of the wall.

2.3. The anti-seismic brick

The comfortable anti-seismic brick is square in shape with dimensions close to 30x30x10cm, or it is convenient to put it. A wall thickness of at least thirty centimeters is recommended. One proposed mixture contains ten clay unites, thirty sand joins, one straw unit and three water units.

2.4. Implementation

The construction uses vertical reinforcements every about 65 centimeters, and horizontal every three or five layers. The Reinforcements are about 2 centimeters in diameter to be hidden in the mortar; they can be bamboo or reeds.

The reinforcement of the structure begins in the foundations. The corners are weak points, where the lateral forces are concentrated, so they must be reinforced for example with the exposure of the walls.

DEEPENING ON THE TECHNIQUE OF COMPRESSED EARTH BLOCKS

1. GENERALITY

For the elaboration of the project of the Al-Nuri school it was decided to use the compressed block technique. This decision stems from the desire to optimize traditional techniques. The goal is to lighten the building so as not to stray too far from the current aesthetics of lightness. The compressed blocks allow much more architectural freedom and high thermal and structural performance.

Fig. VI-21. Centre de l'Architecture de Terre @ FrancisKERE

1.1. Description

As summarized above the compressed block is derived from the mud brick. The technique consists of forming the blocks with a press in order to compact them. At first, the blocks were formed by manual beating of the earth into wooden formwork. The technique is democratized in Europe and South America with the development of mechanical presses. Since the 80s, BTC have been favorably used in humanitarian construction sites in Africa and South America.

1.2. Evaluation

Like other techniques in small elements, the technique with compressed blocks has the advantages of having a low cost and simplicity of manual processing. Unlike mud bricks, compressed blocks show a smoother finish, greater compressive strength. In addition, the compression in the production drives away the water contained in the earth, so the blocks do not require any drying time before assembly. Finally, the presses make it possible to make a wide variety of shapes.

However, this mechanical drying weakens the dough of the blocks against cutting and punching. Blocks need to be stabilized, often with the addition of cement, deteriorating the ecological impact and recyclability.

Fig. VI-22. Blocchi compressi@FuturaScience

1.3. Property

Compressed blocks have specific performance. Their density is between 1500 and 2000 kg/m3. Their compressive strength is by the regulations higher than 2MPa. Without stabilization, their resistance is about 4MPa when stabilization helps to reach 15-20 MPa. Thermal conductivity is also a parameter affected by stabilization. If not stabilized, a block will have a conductivity of 0.6W/mK compared to 1W/mK when stabilized.

2. EARTH DOUGH

2.1. Terra addata

In this chapter it is noted that the profile of the characteristics of raw earth is very variable, each construction technique has its own requirements related to the nature of the earth dough.

To make BTC (compressed earth blocks) of good quality, the main selection criteria are granularity and plasticity. The particle size examination consists in filtering the soil in various sieves and characterizing

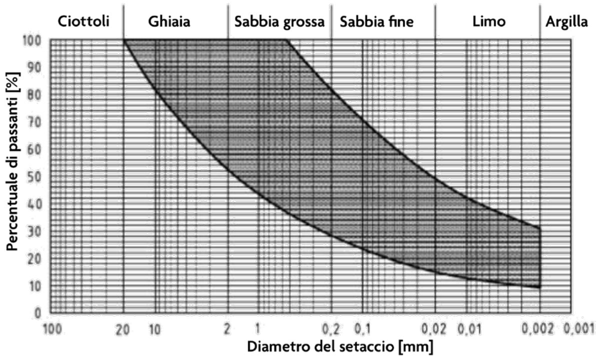


Fig. VI-23. Profilo granulare per una terra di BTC @Norma XP P13-901

the diameters of the grains present in its particle size profile.

To specify plasticity is used the index of plasticity which is directly related to the amount of clay contained in the earth. It is compared to the limit of liquidity that

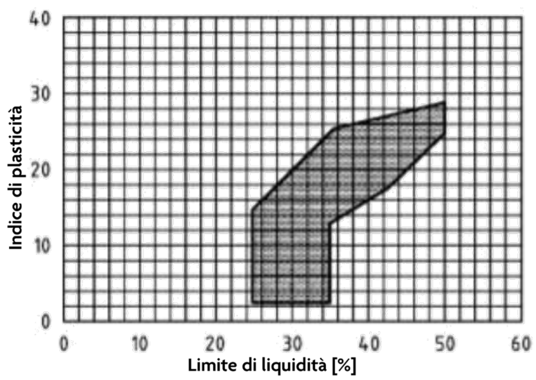


Fig. VI-24. Diagramma di plasticità per una terra di BTC @Norma XP P13-901

is the water content to be incorporated into the land in the specific Atterberg test.

Thus, a soil that contains between 10-30% clay, 10-25% silt, 15-35% raw sand, 15-35% fine sand and 0-40% gravel is more suitable for the manufacture of blocks.

2.2. Stabilization

Dough stabilization consists of adding a material to improve the performance and behavior of the blocks.

6.2.a. Sand

The addition of sand is made to improve the compactness of the block and proportionally reduce the clay content. And a minor stabilization, in the sense that it consists more in the change of the grain size profile of the earth, the sand is not a foreign body.

6.2.b. Cement

Cement is the most common stabilizer for the use of compressed blocks. It is a binder whose presence decreases porosity, so it makes a more homogeneous block. It is used more to raise compressive strength and waterproofing. The addition of cement to the dough decreases the quality of the thermal behavior of the block.

Stabilization with cement is recommended more for sandy or weakly clayey soils. As a result, it is widespread in desert countries such as Francis Kere's Burkina Faso.

The dosage provides a minimum amount of 5% cement in the dough, while 8% allows a good climatic resistance outdoors. Consequently, common dosages are between 6% and 12% cement.

After addition, the dough needs quick processing, before the cement solidifies.

6.2.c. Lime

Stabilization with lime consists of the addition of hydraulic lime and aerial lime. The use of hydraulic lime is similar to that of cement.

Aerial lime reacts with clays, so it is used with soils that contain at least 20% clay. Decreases plastic and swelling and increases mechanical strength. The advantage over cement is more than anything else its ecological impact.

Usually, between 6% and 12% lime is added, in the case of a non-industrial lime a larger dosage is needed. The minimum percentage is the percentage that allows you to improve endurance. Minus 6% a decrease in the compressive strength of the mixture is observed.

To heal the effectiveness, the dough matures at least 2 hours before being compact

2.3. Case of Mosul

Stabilization depends on the type of land used. Gravelly clay soils, sandy clays and loamy clays, require the addition of sand, and stabilization with lime is preferred.

Instead, a particularly sandy soil is stabilized with cement. The geology of Mosul shows a tug of about 20 m of sandy clay soil. The hard layer of limestone that originates from Kurdistan is buried about 90m deep. For this reason, lime will be used as a stabilizer.

3. MALTA

For the joints of the masonry, a mortar with a similar composition to the dough of the blocks is used. However, it must be more sandy with grains of diameters from 2 to 5mm. In addition, a quantity of stabilizer twice as large is added. In masonry, joints are made up to 1 or 1.5cm thick.

4. PRESSES

4.1. Generality

The presses are the tools that allow the compaction of the earth blocks. In compression lies the essential point of difference between mud bricks and compressed mouthpieces.

Except for the effect sought to raise the mechanical strength of the bricks, the use of presses allows to pass from a dry density that varies between 1000 and 14000 kg / m3 before compression to a dry density that varies between 1700 and 2300 kg / m3 after compression.

4.2. Types of press

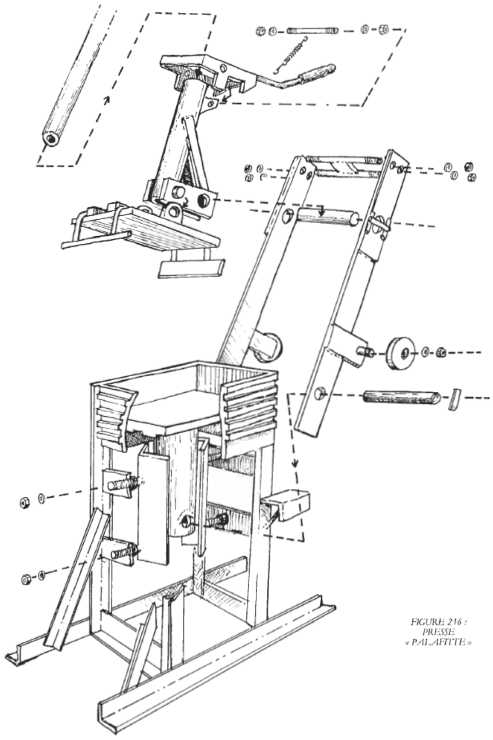


Fig. VI-25.Pressa Palafitte @CraTerre

They may be the same as those used for terracotta bricks, but presses dedicated to raw earth have been developed. Today they are of four types: manual presses, motorized presses, towable units and industrial units. The production units are reserved for the manufacture and marketing of the blocks. They are not sized for a single construction site.

6.4.a. Manual press

Fig. VI-26.Pressa CINVA @WikipediaCommons

The manual press works thanks to a lever system and is operated by a person. This is the press with the lowest cost and is the lightest. Its production capacity is 300 to 1200 blocks per day with a compressive force of 1-2MPa.

The best known example of a manual press is the CINVA-RAM, invented by Raul Ramirez in 1952. It remains a widely used press because it is a simple and inexpensive system that can be manufactured by small craftsmen.

Fig. VI-27.Pressa idraulica © Caroline Grellier

6.4.b. Hydraulic

Hydraulic presses are manual presses improved with a hydraulic system. They are able to increase the compressive force up to 20Mpa

6.4.c. Mechanized manual presses

The mechanized press includes a hinged lid that provides pre-compaction. With a force similar to the simple manual press of 2-4 MPa improves the organization of work

For example, the TEK-BLOCK invented in Ghana is an improvement of ramirez's press with an automatic opening and closing of the lid that facilitates production.

6.4.d. Motorized presses

With motorized presses, human strength is not required. With a compression of about 2-6Mpa it is possible to produce up to 3000 blocks per day. And one system much more expensive than the previous presses

.

5. PROCESS

5.1. Dough

The process begins with the preparation of the dough. First of all, the earth is cleaned and sifted to comply, then it is mixed (possibly) with sand and with the stabilizer. The mixture is gradually moistened until it forms a paste that can be held in the hand. On the construction site, the suitable state of humidity is verified by taking a ball of 5cm of earth, when left from 1.10 m in height, the ball must break into 4 or 5 parts.

The production of the dough is done gradually at the same time as the production of the blocks. Due to the presence of stabilizers, the dough should be used quickly, about an hour later.

5.2. Compaction

A portion of the dough produced is placed in the drawer of the press. With a manual press it is the strength of the user during the action of the mold that compresses the dough into a block, then, the action of the lever helps to extract the block out of the press. If the appearance of the block is not regular, it is destroyed and its dough is reused for other blocks.

The blocks are stored overlapping in a dry place and safe from wind and rain until they are used in construction. The seasoning lasts at least three weeks.

5.3. Implementation

When mounting on the construction site, the blocks are laid along a wall on a protective plinth. The process is similar to a common masonry: you start from a corner by arranging the blocks along the entire perimeter below

.

THE CURRENT PIONEERS

1. DIEBEDO FRANCIS KERE

FFrancis Kere is an architect born in 1965 in Burkina Faso. Thanks to a scholarship and the help of his community, he studied architecture in Germany where he prepares his life project. After graduation he returned to his village called Gando to build public buildings, mainly schools with the help of the community. His works are made of local earth bricks, cheap steel and concrete, the roofs are raised and vast. All construction sites involve the participation of the inhabitants of the neighboring village. This is followed by the adage ''Do more with menò'.

1.1. Primary school, Gando, 2001, 520 m²

A mixture of clay and cement was mainly used. Clay is abundantly available and is traditionally used. These traditional clay construction techniques have been modified and modernized to create a structurally more robust construction in the form of bricks.

1.2. School size, Gando, 2008, 560 m²

The expansion of the school was also built with blocks of stabilized compressed earth made by hand. The roof was designed as a singular vault. Instead of leaving revelations between the surface of the ceiling and the elements of the beams, the monumental vault was built with cavities inside the brick texture of the ceiling. This "breathing" surface sucks fresh air from the windows into the interior space and allows hot air to escape through the ventilations, all while remaining shaded and protected from harmful rains by the cantilevered roof. The steel used in the roof is an inexpensive steel normally used for concrete reinforcement.

Fig. VI-28. Scuola di Gando ©FrancisKERE

Fig. VI-29. Interno della scuola ©FrancisKERE

Fig. VI-30. Facciata principale ©FrancisKERE

Fig. VI-31. Vista laterale ©FrancisKERE

Fig. VI-34. Scuola Naaba Belem ©FrancisKERE

1.3. Naaba Belem Goumma School, Gando,Under construction,4800m²

The project includes classrooms, offices, a resource center, an assembly classroom, a sports field and a covered parking for bicycles and motorcycles. In addition to offering resources to students, the secondary school will also serve as a meeting point for the community, providing facilities for assemblies, gatherings and events. The walls are cast in local clay mixed with concrete and aggregates.

2. WANG SHU AND LU WENYU

Wang Shu and Lu Wenyu are two Chinese architects, seeking cultural revitalization from China. They won the Global Award for Sustainable Architecture in 2007 and the Pritzker Prize in 2012.

They militate for the development of craftsmanship and the preservation of old materials. Earth is an environmentally friendly material that was part of Chinese vernacular architecture, for this reason, Whang Shu and Lu Wenyu became interested in this material.

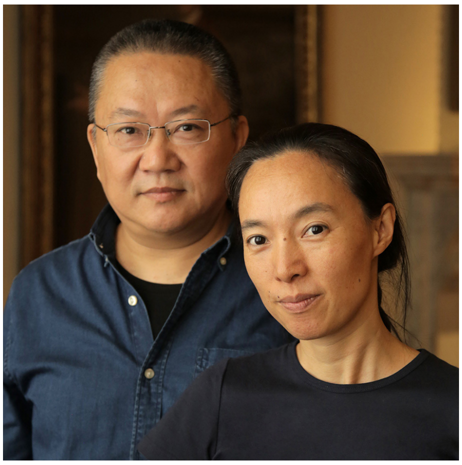


Fig. VI-32.WANG Shu e LU Wenyu @Dezeen

2.1. Wa shan, Hangzhou, 2011, 5 000m2

Among the 22 buildings designed by Wang Shu in Lu Wenyu that make up the Xiangshan campus, one in particular stands out. Finished in 2011, the building is spread over three floors fifteen meters high.

Along the river, the building assembles meeting places, study rooms, restaurants and twenty rooms into a set that recalls a labyrinth. Twenty walls of parallel pise impose the organization of the building. The structure was reinforced with concrete elements. The whole is covered with a single ventilated roof with a diffuse self-supporting structure in poor wood.

The design results from a cooperation with the body French Craterre for scientific expertise, having lost the knowledge of earth construction.

Fig. VI-33.Fotografia della Wa Shan ©CNC

GERNOT MINKE

Beginning in the 1970s, architect Gernot Minke worked for the return of earth architecture to Germany. Among other things, he proposed the first German educational training on earth construction at the University of Kassel. He uses the assembly of earth, straw and wood in his works. It favors curved structures, domes and plant roofs.

In 1978, Gernot Minke invented a new construction technique for emergency architecture by stacking bags of earth to make the walls of buildings.

Fig. VI-35.Sala centrale ©GernotMINKE

2.2. Waldorf kindergarten, Sorsum,1997,600m2

The plan is polygonal with a multipurpose hall in its center covered with a dome of 10 meters of brick light. Mainly the walls are also made of brick. Bricks are extruded mud bricks with a round shape to reduce acoustic reverberation time. As for the domed shape of the rooms, it allowed a uniform distribution of sounds. The corridors are made of a wooden structure.

Everything is covered with 15cm of vegetable earth to fit into the surrounding landscape. In conclusion, it is an energy-efficient building.

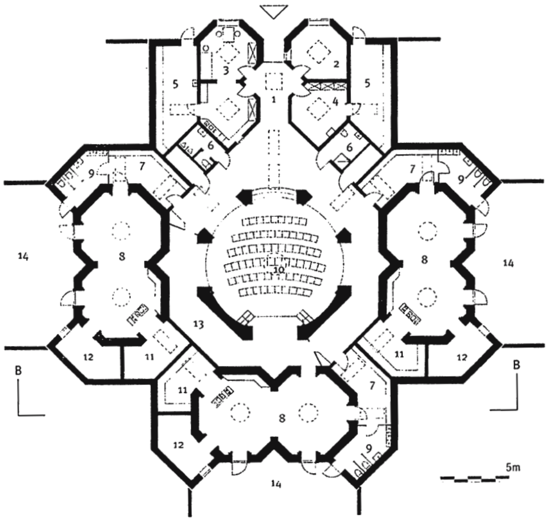


Fig. VI-36.Pianta ©GernotMINKE

Fig. VI-37.Asilo Waldorf ©GernotMINKE

EARTH SCHOOL

1. MUYINGA LIBRARY

Architetto.	BC architects
Anno.	2012
Luogo.	Muyinga, Burundi
Superficie.	$104m^2$
Materiale.	Terra cruda, legno

This library is part of a future inclusive school for deaf children. Its architecture is based on Burundi's raw earth vernacular architecture. We find a light protruding roof which protects the building. Small openings at the top provide ventilation as warm air rises.

2. AKNAIBICH SCHOOL

Architetto.	BC architects
Anno.	2014
Luogo.	Aknaibich, Marocco
Superficie.	$55m^2$
Materiale.	Terra cruda, legno

Inspired by local typologies, materials and techniques, the building has a high-performance bioclimatic operation and an anti-seismic design.

Fig. VI-38.Libreria di Muyinga ©BCarchitects

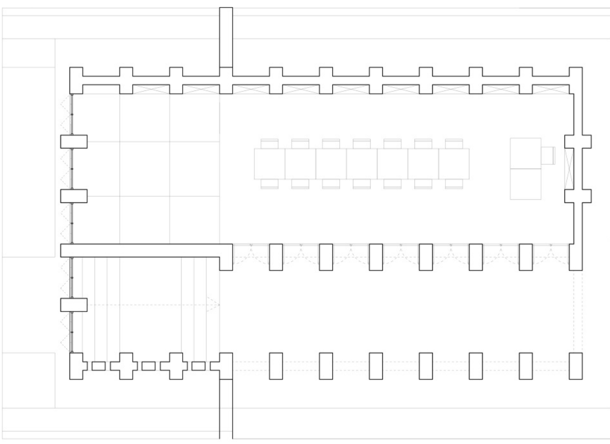


Fig. VI-39.Pianta della libreria di Muyinga ©BCarchitects

Fig. VI-40. Corte della scuola ©BCarchitects

Fig. VI-41. Scuola in costruzione ©BCarchitects

3. METI SCHOOL

Architetto.	Anna HERINGER
Anno.	2006
Luogo.	Rudrapur, Bangladesh
Superficie.	325m²
Materiale.	Terra cruda, bambù

Instead of doing a theoretical dissertation, this student chose to build a school in the village of Rudrapur with the help of architect Eike Roswag, the Meti association and a team of volunteers.

The two-storey building is made of solid walls and a bamboo roof. It was built in six months.

The school represents an educational innovation, inside its five classrooms the children sit in an egalitarian circle. Except for the classrooms, Anna Heringer has provided small spaces that seem to be dug into the earth where the children play.

Fig. VI-42.Facciata principale ©KurtHOERBUST

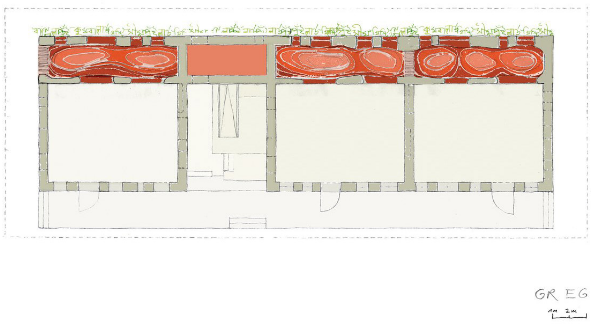


Fig. VI-43.Pianta del piano terra ©KurtHOERBUST

4. AISN EXTENSIONE

Architetto.	Mariam KAMARA
Anno.	2021
Luogo.	Niamey, Niger
Superficie.	1000⁺ m²
Materiale.	Terra, Acciaio

The American International School extension programme is divided into three phases and a set of small buildings positioned and shaped to maintain the maximum number of existing trees on the site.

Phase 1 of the project organises a set of small buildings to house new administrative offices, an infirmary and a nursery. The second phase includes a cafeteria, changing rooms and an indoor basketball court, while the third will see the creation of a leisure centre and swimming pool.

A welcome side effect of this approach is that it provides opportunities to design shaded communal spaces for students, while contributing to the thermal comfort of the buildings.

Fig. VI-44.Render della corte ©MariamKAMARA

Fig. VI-45.Corridoio principale©MariamKAMARA

VII. TECNOLOGY AND STRUCTURE

INDICE DEL CAPITOLO

STRUCTURAL STRATEGY

1. CONCEPT

As for the structural layout of the building, the concept comes from the past and from the relationship with the existing building. If the relationship with the existing architecture is not a perfect union, the structure tries to integrate the house into the modern building. The existence of the house impacts the new building.

1.1. Old-fashioned but trendy materials

The aim is to revitalize a traditional material to make it a modern use in architecture. Modern mixed structures with ancient influences and principles are born.

1.2. Structural coherence

A dialogue with the existing house is sought. One of the peculiarities of the house is the structure of the ceilings. Enhanced through the constructive method of the Mosul tradition called Ekadev. Its beauty and structural effectiveness are reasons to expand its use to the whole building. It forms a structural unit with regard to the recovery aspect in the project.

2. CHOICE OF MATERIALS

The building is built by combining traditional materials (raw earth) and fairly modern materials that are steel and concrete.

2.1. Raw earth

2.1.a. Use

Raw earth is used in the project to form the structure of the walls. It is also present in ceilings in two forms: compact for making adjustment under the floor and in the form of prestressed bricks for vault structures.

Taking into account all uses, it is the material used in greater quantities.

2.1.b. Reasons

The choice of raw earth as the main material stems from its advantages described in the previous chapter. In the post-war context in which the al-Nuri school finds itself, the low cost, its omnipresence and the ease of implementation are truly adequate.

On the emotional level, the adobe technique belonged to Iraqi heritage. It is a reminder of the past greatness of Mesopotamia.

2.1.c. Characterization

The mechanical behavior of raw earth is characterized by better compression performance than in other situations. However, it is still a material with average structural behavior. To ensure that you are able to support a two-story building with large classrooms, you use earth blocks and prestressed blocks. Compared to other construction forms they are performing. In addition, stabilizing the earth with cement is a possibility to raise performance.

Forma costruttiva	Compressione kg/cm²	Flessione kg/cm²	Punzonatura kg
Terra non stabilizzata			
Adobe	6.84	0.03	450
Pise	6.16	0.028	450
Terra stabilizzata			
Adobe	5.5	0.04	450
Pise	45.73	0.05	450
Blocchi precompressi	57.05	0.05	450

Tab. VII-01.Prestazioni per una parete sp 30cm @ CRATERRE

Mosul is a city located in a desert climate crossed by a river. The proximity of Kurdistan offers limestone and Mosul has all the advantageous characteristics to make a mixture of earth stabilized with lime. Lime has binding properties, it will help the soil mixture to maintain its compactness.

Not having the opportunity to make an inspection and to do the various tests to know the land available in Mosul, it is assumed that it was possible to find a land suitable for the technique of stabilized compressed blocks. This hypothesis is entirely plausible in the light of the ancient building culture. To make the bricks was considered a mixture with 62% of addate earth (mixture of clays, silts, sands and gravels), 33% of sand and 5% of lime. This composition has been obtained from the technical data sheets of the products on the market. The following mechanical capabilities result.

Caratteristiche	
Densità	2000 kg/m²
Resistenza alla trazione	0.3 MPa
Modulo di Young	2000 MPa
Resistenza alla compressione	3 MPa
Modulo di taglio	800 MPa
Rapporto di Poisson	0.2

Tab. VII-02.Prestazioni del impasto di terra

2.1.d. Behavior of masonry

The transmission of the load from block to block occurs mainly through the mortar of the masonry in the horizontal joint. In the event that the joints are not made well they cause tension points in the blocks. The situation is dangerous knowing the weakness of the raw earth when it works in tension. In addition, if the masonry is exposed to perpendicular compression loads, tensile behaviors appear to be avoided.

The settling of the blocks is necessary when the transverse tensile strength of the block is exceeded. The blockage forces the expansion of the mortar due to the very high level of lateral tension in the mortar. The joints resist, increasing the transverse tensile stresses in the blocks.

2.2. Steel

2.2.a. Use

Steel is used in the building for the primary and secondary beams of the ceilings and roof.

2.2.b. Reasons

Doing everything with raw earth would have been possible with a ceiling-vaulted structure. However, the vaults give the impression of a heavy structure and belong to an old style now used for mosques or other buildings of high public importance. For a classroom it is not considered adequate.

So, to lighten the building both in the weight of the structure and aesthetically, relatively flat ceilings with steel beams are used.

Steel, in addition to being light, reflects an image of modernity and technological progress. And the appropriate material to forget about the technological backwardness of the region during recent years.

Steel is known to be an expensive material and in a war-torn country, it can be worse than elsewhere. Iraq imported steel before the war to meet common needs. The proximity to Turkey and Iran is an advantage, they are respectively the eighth and fourteenth world producers. In addition, in the face of the increase in demand linked to reconstruction, numerous aids have been developed to promote local production. Numerous factories have been built in Iraq. For example, in May 2021 a new Med Stel factory was inaugurated about 80km from Mosul in the city of Erbil. Using steel in the project in reasonable quantities is a way of supporting local initiatives without overloading the market.

Caratteristiche	
Densità	7850 kg/m²
Tensione di snervamento	235 MPa
Tensione a rottura	360 MPa
Resistenza alla trazione	400 MPa
Modulo di Young	210 MPa
Modulo di taglio	82 GPa
Rapporto di Poisson	0.28

Tab. VII-03.Prestazioni dell'acciaio S235

2.2.c. Mechanical characteristics

The characteristics of steel are high compared to other materials. It works well in tension, and for this, it is a suitable material for beams. Taking into account the simplicity of the use of steel in the project, it is decided to use a common steel S235, designation of the European standard.

2.3. Concrete

2.3.a. Use

Concrete is used in the project to make the foundations and basements of the walls on the ground floor.

2.3.b. Motive

Concrete is used where raw earth for reasons of durability is not adequate because, unlike raw earth, it resists moisture better.

The use of concrete instead of stone in the project may seem too innovative compared to the use of raw earth and the techniques employed (described in the following section). But it was a desire for the project not to be completely inserted in the vernacular architecture and to have with steel, for example, an innovative character. And a break with the existing house made entirely of stone at the time of its construction.

In addition, concrete is part of the history of Mosul, the golden age entered the 1980s and 1990s and today the cement industry is one of the main sectors of the local economy. There are five cement factories in the city. Most of the cement was exported to Turkey, the Arabian Gulf, Yemen and Singapore. In conclusion, using it in this project enters the logic of supporting economic recovery after a crisis.

2.4. Wood

Wood is used in the project to make the load picking frames around the windows and for the curb for the distribution of loads at the top of the walls for the support of the steel beams. In some similar structural strategies, architects use concrete curbs, but it lengthens construction times and the presence of moisture endangers the earth structure. Wood allows a drier structure. In addition, it has a hygrometric behavior similar to earth. Thus, although its presence induces a heterogeneity, its characteristics make this material a choice compatible with raw earth.

In Iraq, the structural wood industry did not develop in part due to material insufficiency. For this reason, the project avoids the load-bearing use of wood. To cover the need, high-quality wood is not required.

3. PARTICULAR TECHNIQUES

3.1. Jack bow

3.1.a. Description

Unlike regular bows, Jack's bows do not have a semicircular shape. They are flat in the profile, this makes them get the alternative name of flat arches.

Fig. VII-01.Rec house. Guallart. 2020 @ArchDaily

Fig. VII-02.Casa en Batera. Quadrat. @Quadrat

It describes a roofing system that involves a series of vaults of small, but elongated size, supported by steel, wood or concrete beams.

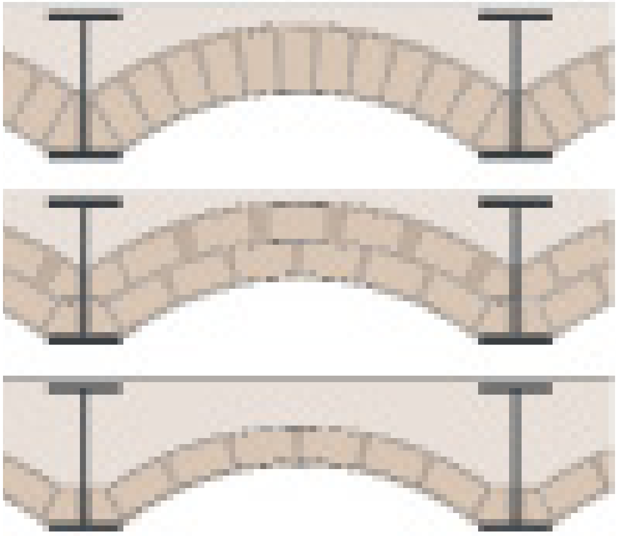


Fig. VII-03.Variazione dell'arco di Jack

The origin of these arches dates back to the 80s mainly in Europe. At first, this technique was reserved for industrial buildings but quickly spread. Hypothetically its use in the homes of the old city of Mosul seems to be the result of a Western trend adapted to local construction. In addition to their particular aesthetics their advantages are: an unlimited length and the economy of material compared to other techniques. As a result, they remain a structural technique used in today's world.

3.2. Nubian vault

3.2.a. Description

Presented in the chapter on raw earth, the Nubian vault has become a symbol of the revitalization of vernacular architecture in raw earth. It is a round barrel vault. In the manual of the Nubian vault written by the association French CRATERRE, a standardization of practices is put in place. Usually the vault is up to 3.3m wide and 8m long to ensure its stability when made of mud bricks.

3.2.b. Montage

The assembly begins with the side bearing wall of common mode up to about 1.75m in height and the transverse retaining wall up to the final height of the vault. From this wall is mounted the vault. The advantage is that it does not require any support structure during assembly. Mounting is done by laying brick arches one on top of the other inclined by about 45 degrees.

To lengthen the length of the vault it is necessary to make intermediate transverse walls that resume the loads or reinforce the bricks used. The closure is made by placing the bricks on a final transverse wall.

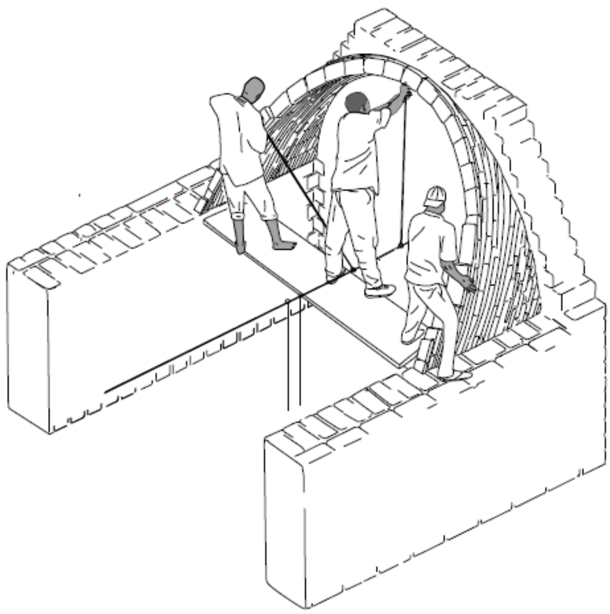


Fig. VII-04.Montaggio della volta @CRATerre

Structural behavior

3.3. Nubian dome

Following the same principle as the Nubian vault, a dome is feasible. It is sized in such a way that the dome and its plume are included in a sphere in diameter the diagonal of the base of the plume. Mounting is done with an inclined arrangement of bricks. Sometimes, to rebalance the shape, trapezoidal bricks are inserted into the assembly.

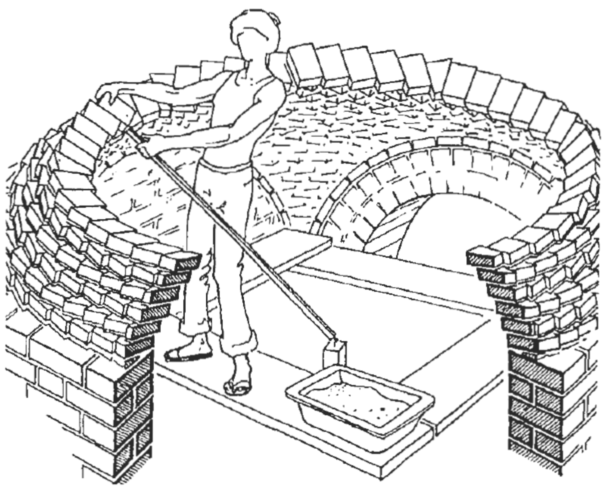


Fig. VII-05.Montaggio di una cupola @CRATerre

STRUCTURAL SIZING

1. GENERALITY

The fundamental elements of the structure are sized. The sizing of all structural elements is essential. Thus, the theoretical structure is confirmed or changed. In addition, structural principles affect the architectural and technological aspect of the project. The Al-Nuri school is a set of architectural, technological and energy values.

The sizing in this project remains elementary. This is a pre-sizing. The goal is to have a first idea about the well-being of the structure is not to evaluate the detailed structural behavior of the building: the study is static with some approximations.

1.1. The sizing of raw earth in regulations

Faced with the complexity of designing with raw earth, we wanted to understand what are the regulatory models that exist and the official recommendations from governments. Importantly, raw earth regulations do not exist in all countries or are not at the same level of development.

1.1.a. Lehmbau Regeln model

The method of "Lehmbau Regeln" can be translated from German into "clay construction rule". It is a calculation model used for pisé, Mason and brick techniques, and has been shown to be compatible with the use of the German standard DIN EN 1990. The compression sizing criteria of this model use a particularly high margin of safety.

Vertical and horizontal centric loads are hypothesized. The model takes into account the wind load and the non-permanent loads that result from the use of the building.

For ordinary bricks, a minimum thickness is expected for external structural walls of 36.5 cm, and 24 cm for internal structural walls. According to the shape of the building, the method gives various recommendations for the stability of structural elements (detailed in §4.2).

1.1.b. Middleton model

This second model is used by Australian legislation. Australia was one of the first countries to develop a national document for the design of adobe buildings, compressed blocks and rammed earth. It was first published in 1952 by the then Commonwealth Experimental Building Station.

It provides a ratio between the thickness at the base of the wall and its height of about 1/18 at a minimum. It is a restrictive model that takes into account the arrangement of the openings in the geometry of the building.

For the Al-Nuri school, this sizing requires not to have walls of less than 30cm at the base. Taking into account the length of the classrooms and the arrangement of windows in the project, Middleton's model recommends 40cm of thickness at a minimum.

Spessore della parete	40 cm	45 cm
Altezza della parete		
- piano unico	3-5 m	3-5.5 m
- due piani	5-6.7 m	5-7.3 m
Lunghezza tra due punti di rinforzo		
- per una parete con aperture centrale a 1.4m	12 m	13.75 m
- per una parete con uno gruppo di aperture	7.3 m	8 m

Tab. VII-04. Dimensionamento di Middleton

1.2. Sizing strategy adopted

1.2.a. Global strategy

For the Al-Nuri school, it was decided to study the structure of a block made ex-new of the building. In fact, there is not enough precise information to make an analysis of the existing house. It can only be seen that the walls and ceilings of the house did not have any structural defects: the damage was caused by bullets during the war.

The structural analysis therefore focuses on the following points:

- Dimensioning of the floors
- Typical attic of a classroom;
- Non-accessible roof
- Roof-terrace (at the most critical point)
- Sizing of the walls
- Typical perimeter load-bearing wall;
- Internal load-bearing wall (at the most critical point).

1.2.b. Strategy for floors and roofs

The floors are made with Jack arches and IPE beams, as in the existing house. More precisely, the ceilings of the existing house were made with IPE 200 beams spaced about 80cm apart, and the first hypothesis for the ex-new floors was to use IPE 270 beam spaced about 85cm apart (for reasons of practicality of assembly). While this true hypothesis analyzed (and lately changed), it is important to emphasize that the ceiling of the existing house is destined to become, on the way, a roof-terrace. Checks on the former new building can therefore be used to understand if the existing roofs are able to work with the new service loads.

In the sizing of the floors, we do not do analysis on jack's arches. They are made of small elements in compacted raw earth, and although the structural operation is well understood, the internal tensions due to the mortar joints and the mechanical characteristics of the bricks themselves make it a complex problem. Since this is a common construction practice, and we have chosen a step close to what is in the existing house, it is considered that there is no need to verify them. The structural verification of the floors and roofs therefore focuses on the IPE beams – in strength (SLU) and in deformation (SLE).

1.2.c. Strategy for walls

In the case of walls, the use of compacted raw earth bricks makes the analysis more complicated. The geometry due to calpining is not taken into account, the wall is considered as a continuous wall. The influence of mortar joints, however, is taken into account through the use of the Lehmbau Regeln method presented earlier. The structural verification therefore focuses on a test in resistance (similar to the SLU, but modified to take into account the structural behavior of the raw earth and the presence of the joints), and another in stability that uses more simplified criteria.

2. ACTIONS ON CONSTRUCTION

The theoretical framework adopted conforms to the Limit State Design used by eurocodes and Italian regulations (NTC-18). The structural checks will take place considering the ultimate structural limit state – STR: internal failure or excessive deformation of the structure or structural elements, including bases, piles, basement walls, etc., where the strength of the building materials of the structure governs.

2.1. Combination of carcuses

The following load combinations of the Italian legislation are those relevant for this study (worst-case scenario). Note that the is the variable action of primary consideration – for example, when assessing wind loads, it is the wind; for the general life of the building, it would be the service loads.

Combination of fundamental load, for SLU (Last Limit State) checks:

Characteristic load combination (rare), for irreversible SLE (Service Limit Status):

In our study, we would use the combination n°1 for the verification of the resistance of the design and n°2 for the deflection controls (since this combination is the most demanding of all the SLE combinations of the Italian legislation).

It is noted that vertical concentrated loads must be applied where their impact on the structure will produce the greatest load effects, on a square of 500 mm by 500 mm. They are never really perfectly punctual. Horizontal loads will not be used in the study of the Al-Nuri school because quantitative analysis of the effects of this type of load on raw earth walls cannot yet be done.

In addition, the partial factors for the SLU verifications will be chosen as per Table 2.6.1 of §2.6.1 in the Italian legislation, for the STR type checks, reported in table Table VII-05.

The combination coefficients were taken mainly for the buildings of the categories "C – Environments susceptible to crowding" which include the schools, but also "B – Offices" for the part intended for administration, "H – roofs accessible only for maintenance", and "I – Practicable roofs of environments of category of use between A and D". The values are shown in Table VII-06.

Tipo di carico	Coeff.	Valore	
Permanente, strutturale G_1	γ_{G1}	Favorabile	1.0
		Sfavorabile	1.3
Permanente, non-strutturale G_2	γ_{G2}	Favorabile	0.8
		Sfavorabile	1.5
Variabile Q	γ_Q	Favorabile	0.0
		Sfavorabile	1.5

Tab. VII-05.Coefficienti di combinazione parziali, per le verifiche SLU, senza azioni geotecniche.

Ambienti	ψ_{0j}	ψ_{1j}	ψ_{2j}
B - Uffici	0.7	0.7	0.3
C - Ambienti suscettibili di affollamento	0.7	0.7	0.6
H - Coperture accessibili per sola manutenzione/riparazione	0.0	0.0	0.0
I - Coperture praticabili (cat. C)	valutare caso per caso		

Tab. VII-06.Coefficienti per combinazioni di carico

2.2. Permanent loads

We proceed with the calculation of the permanent loads due to the structural and non-structural components obtained on the basis of the designed technological packages. The thicknesses of the structural brick walls are indicative (first hypothesis): they will be changed in the analyzes to find the most suitable thickness. The same applies to the IPE beams of floors and roofs.

NB: According to §3.1.2 of NTC-18, for, according to the value of the permanent (non-structural) load of the light partitions (on the floors), you can choose to model them with a uniformly distributed permanent load.

n°	Strato	Elementi / Materiale	Spessore s [mm]	Param. geometrico pertinente: nome	Param. geometrico pertinente: valore [mm o mm²]	Interasse i [mm]	Ratio di presenza $(per\ m)$ [%]	Densità ρ [kg/m³]	Densità di area: Totale σ [kg/m²]	Strutturale σ_{str} [kg/m²]	Non-str. $\sigma_{non-str}$ [kg/m²]
1	Intonaco	Argilla monostrato	10	spessore	10	-	1	1650	16.50		x
2	Muratura	Blocchi di terra cruda compressa con malta di sabbia	450	spessore	450	-	1	2000	900.00	x	
3	Finitura protettiva trasparente	A base di cera o resini naturale	2	spessore	2	-	1	800	1.60		x
	Totali		462						**918.10**	**900.00**	**18.10**

Altezza [cm]
280

	Totale D	Strutturale $G1$	Non-str. $G2$
Carico permanente [kN/m²]	9.00	8.83	0.18
Caricho perm. lineare [kN/m]	25.210	24.713	0.497

Tab. VII-07.Carichi permanenti per PV01 (muro interno, parte a due piani).

n°	Strato	Elementi / Materiale	Spessore s [mm]	Param. geometrico pertinente: nome	Param. geometrico pertinente: valore [mm o mm²]	Interasse i [mm]	Ratio di presenza (per m) [%]	Densità ρ [kg/m³]	Densità di area: Totale σ [kg/m²]	Strutturale σ_{str} [kg/m²]	Non-str. $\sigma_{non-str}$ [kg/m²]
1	Intonaco	Terra stabilizato con calce, doppio strato	30	spessore	30	-	1	1650	49.50		x
2	Muratura	Blocchi di terra cruda compressa con malta di sabbia	300	spessore	300	-	1	2000	600.00	x	
3	Finitura protettiva trasparente	A base di cera o resini naturale	2	spessore	2	-	1	800	1.60		x
	Totali		332						**651.10**	**600.00**	**51.10**

Altezza [cm]
280

	Totale D	Strutturale $G1$	Non-str. $G2$
Carico permanente [kN/m²]	6.39	5.88	0.50
Caricho perm. lineare [kN/m]	17.878	16.475	1.403

Tab. VII-08. Carichi permanenti per PV02 (muro interno, parte ad uno piano).

n°	Strato	Elementi / Materiale	Spessore* s [mm]	Param. geometrico pertinente: nome	Param. geometrico pertinente: valore [mm o mm²]	Interasse i [mm]	Ratio di presenza (per m) [%]	Densità ρ [kg/m³]	Densità di area: Totale σ [kg/m²]	Strutturale σ_{str} [kg/m²]	Non-str. $\sigma_{non-str}$ [kg/m²]
1	Rivestimento	Ghiaia chiara	50	spessore	50	-	1	1700	85.00		x
2	Schermo impermeabile bituminoso	Bitume	0.8	spessore	0.8	-	1	935	0.75		x
3	Assito di legno	Legno	15	spessore	15	-	1	700	10.50		x
4	Intercapedine d'aria ventilata	Listelli di legno	50	larghezza	50	500	0.1	700	3.50		x
5	Membrana traspirente riflettente impermeabile	Polipropilene	0.8	spessore	0.8	-	1	300	0.24		x
6	Isolante	Fibra di legno	200	spessore	200	-	1	140	28.00		x
7	Freno al vapore	Polipropilene	0.4	spessore	0.4	-	1	290	0.12		x
8	Strato di regolazione	Terra cruda compatta stabilizata con calce	62	area della sezione trasversale tra due IPE	9.3E+04	850	1.1765	2000	218.63		x
9	Strato di rinforzamento	Malta di sabbia/calce	20	area della sezione trasversale tra due IPE	1.9E+04	850	1.1765	1800	39.71		x
10	Arco in blocchi di terra cruda compressa con malta di sabbia	Blocchi di terra cruda compressa	110	area della sezione trasversale dei blocchi tra due IPE	7.9E+04	850	1.1765	2000	185.40		x
11		Malta interstiziale di sabbia/calce	interstiziale	area della sezione trasversale tra due IPE	3.9E+04	850	1.1765	1800	82.06		x
-	Trave IPE 270	Acciaio	inserite	area della sezione trasversale	4595	850	1.1765	8000	43.25	x	
12	Finitura protettiva trasparente	A base di cera o resini naturale	2	spessore	2	782.5	1	800	0.03		x
	Totali		511						**697.18**	**43.25**	**653.93**

Distanza tra IPE [cm]
85

	Totale D	Strutturale $G1$	Non-str. $G2$
Carico permanente [kN/m²]	6.84	0.42	6.41
Caricho perm. lineare [kN/m]	5.811	0.360	5.451

Tab. VII-09. Carichi permanenti per CO01 (tetto non-accessibile).

n°	Strato	Elementi / Materiale	Spessore* s [mm]	Param. geometrico pertinente: nome	Param. geometrico pertinente: valore [mm o mm²]	Interasse i [mm]	Ratio di presenza $(per\ m)$ [%]	Densità ρ [kg/m³]	Densità di area: Totale σ [kg/m²]	Densità di area: Strutturale σ_{str} [kg/m²]	Densità di area: Non-str. $\sigma_{non-str}$ [kg/m²]
1	Pavimentazione	Lastra di pietra	20	spessore	20	-	1	2600	52.00		x
2	Strato di supporto	Elementi in polipropilene	50	-	-	-	1		1.00		x
3	Membrana traspirente riflettente impermeabile	Polipropilene	0.8	spessore	0.8	-	1	300	0.24		x
4	Assito di legno	Legno	15	spessore	15	-	1	700	10.50		x
5	Isolante	Fibra di legno	200	spessore	200	-	1	140	28.00		x
6	Freno al vapore	Polipropilene	0.4	spessore	0.4	-	1	290	0.12		x
7	Strato di regolazione	Terra cruda compatta stabilizata con calce	62	area della sezione trasversale tra due IPE	9.3E+04	850	1.1765	2000	218.63		x
8	Strato di rinforzamento	Malta di sabbia/calce	20	area della sezione trasversale tra due IPE	1.9E+04	850	1.1765	1800	39.71		x
9	Arco in blocchi di terra cruda compressa con malta di sabbia	Blocchi di terra cruda compressa	110	area della sezione trasversale dei blocchi tra due IPE	7.9E+04	850	1.1765	2000	185.40		x
10		Malta interstiziale di sabbia/calce	interstiziale	area della sezione trasversale tra due IPE	3.9E+04	850	1.1765	1800	82.06		x
-	Trave IPE 270	Acciaio	inserite	area della sezione trasversale	4595	850	1.1765	8000	43.25	x	
11	Finitura protettiva trasparente	A base di cera o resini naturale	2	spessore	2	782.5	1	800	0.03		x
	Totali		480.2						**660.93**	**43.25**	**617.68**

Distanza tra IPE [cm]
85

	Totale D	Strutturale $G1$	Non-str. $G2$
Carico permanente [kN/m²]	6.48	0.42	6.06
Caricho perm. lineare [kN/m]	5.509	0.360	5.149

Tab. VII-10.Carichi permanenti per CO02 (tetto-terrazza).

n°	Strato	Elementi / Materiale	Spessore s [mm]	Param. geometrico pertinente nome	valore [mm o mm²]	Interasse i [mm]	Ratio di presenza (per m) [%]	Densità ρ [kg/m³]	Densità di area Totale σ [kg/m²]	Strutturale σ_{str} [kg/m²]	Non-str. $\sigma_{non-str}$ [kg/m²]
1	Finitura	Intonaco cementizio in doppia rasatura	12	spessore	12	-	1	1400	16.80		x
2	Rivestimento	Lastre in cemento fibrorinforzato	30	spessore	30	-	1	2500	75.00		x
3	Intercapedine ventilato	Orditura in acciaio zincato con profili T e staffe	40	spessore	40	-	-	2700	10.00		x
4	Membrana traspirente riflettente impermeabile	Polipropilene	0.8	spessore	0.8	-	1	200	0.16		x
5	Isolante incollato con malta adesiva	Fibra di legno	80	spessore	80	-	1	110	8.80		x
6	Muratura	Blocchi di terra cruda compressa con malta di sabbia	450	spessore	450	-	1	2000	900.00	x	
7	Intonaco	Argilla monostrato	10	spessore	10	-	1	1650	16.50		x
	Totali		622.8						**1027.26**	**900.00**	**127.26**

Altezza [cm]
280

	Totale D	Strutturale $G1$	Non-str. $G2$
Carico permanente [kN/m²]	10.07	8.83	1.25
Caricho perm. lineare [kN/m]	28.207	24.713	3.494

Tab. VII-11.Carichi permanenti per CV01 (muro perimetrale con facciata ventilata, parte a due piani).

n°	Strato	Elementi / Materiale	Spessore s [mm]	Param. geometrico pertinente nome	valore [mm o mm²]	Interasse i [mm]	Ratio di presenza (per m) [%]	Densità ρ [kg/m³]	Densità di area Totale σ [kg/m²]	Strutturale σ_{str} [kg/m²]	Non-str. $\sigma_{non-str}$ [kg/m²]
1	Mashrabiyya	Legno	12.5	spessore	12.5	-	0.25	500	1.56		x
2	Intercapedine ventilato	-	40	spessore	40	-	1	0	0.00		x
3	Membrana traspirente riflettente impermeabile	Polipropilene	0.8	spessore	0.8	-	1	200	0.16		x
4	Isolante incollato con malta adesiva	Fibra di legno	80	spessore	80	-	1	110	8.80		x
5	Muratura	Blocchi di terra cruda compressa con malta di sabbia	450	spessore	450	-	1	2000	900.00	x	
6	Intonaco	Argilla monostrato	10	spessore	10	-	1	1650	16.50		x
	Totali		593.3						**927.02**	**900.00**	**27.02**

Altezza [cm]
280

	Totale D	Strutturale $G1$	Non-str. $G2$
Carico permanente [kN/m²]	9.09	8.83	0.27
Caricho perm. lineare [kN/m]	25.455	24.713	0.742

Tab. VII-12.Carichi permanenti per CV01 bis (muro perimetrale con mashrabiyya).

n°	Strato	Elementi / Materiale	Spessore s [mm]	Param. geometrico pertinente: nome	Param. geometrico pertinente: valore [mm o mm^2]	Interasse i [mm]	Ratio di presenza $(per\ m)$ [%]	Densità ρ [kg/m^3]	Densità di area: Totale σ [kg/m^2]	Densità di area: Strutturale σ_{str} [kg/m^2]	Densità di area: Non-str. $\sigma_{non-str}$ [kg/m^2]
1	Finitura	Intonaco cementizio in doppia rasatura	12	spessore	12	-	1	1400	16.80		x
2	Rivestimento	Lastre in cemento fibrorinforzato	30	spessore	30	-	1	2500	75.00		x
3	Intercapedine ventilato	Orditura in acciaio zincato con profili T e staffe	40	spessore	40	-	-	2700	10.00		x
4	Membrana traspirente riflettente impermeabile	Polipropilene	0.8	spessore	0.8	-	1	200	0.16		x
5	Isolante incollato con malta adesiva	Fibra di legno	100	spessore	100	-	1	110	11.00		x
6	Muratura	Blocchi di terra cruda compressa con malta di sabbia	300	spessore	300	-	1	2000	600.00	x	
7	Intonaco	Argilla monostrato	10	spessore	10	-	1	1650	16.50		x
	Totali		492.8						**729.46**	**600.00**	**129.46**

Altezza [cm]
280

	Totale D	Strutturale $G1$	Non-str. $G2$
Carico permanente [kN/m^2]	7.15	5.88	1.27
Caricho perm. lineare [kN/m]	20.030	16.475	3.555

Tab. VII-13. Carichi permanenti per CV02 (muro perimetrale con facciata ventilata, parte ad uno piano).

n°	Strato	Elementi / Materiale	Spessore s [mm]	Param. geometrico pertinente: nome	Param. geometrico pertinente: valore [mm o mm^2]	Interasse i [mm]	Ratio di presenza $(per\ m)$ [%]	Densità ρ [kg/m^3]	Densità di area: Totale σ [kg/m^2]	Densità di area: Strutturale σ_{str} [kg/m^2]	Densità di area: Non-str. $\sigma_{non-str}$ [kg/m^2]
1	Cappoto	Intonaco di terra stabilizato con calce, doppio strato	30	spessore	30	-	1	1650	49.50		x
2	Isolante incollato con malta adesiva	Fibra di legno	80	spessore	80	-	1	110	8.80		x
3	Membrana traspirente riflettente impermeabile	Polipropilene	0.8	spessore	0.8	-	1	200	0.16		x
4	Muratura	Blocchi di terra cruda compressa con malta di sabbia	450	spessore	450	-	1	2000	900.00	x	
5	Intonaco	Argilla monostrato	10	spessore	10	-	1	1650	16.50		x
	Totali		570.8						**974.96**	**900.00**	**74.96**

Altezza [cm]
280

	Totale D	Strutturale $G1$	Non-str. $G2$
Carico permanente [kN/m^2]	9.56	8.83	0.74
Caricho perm. lineare [kN/m]	26.771	24.713	2.058

Tab. VII-14. Carichi permanenti per CV04 (muro perimetrale con capotto).

n°	Strato	Elementi / Materiale	Spes-sore* s [mm]	Param. geometrico pertinente: nome	Param. geometrico pertinente: valore [mm o mm²]	Inter-asse i [mm]	Ratio di presenza $(per\ m)$ [%]	Densità ρ [kg/m³]	Densità di area: Totale σ [kg/m²]	Densità di area: Strutturale σ_{str} [kg/m²]	Densità di area: Non-str. $\sigma_{non-str}$ [kg/m²]
1	Pavimentazione	Lastre di ceramica	10	spessore	10	-	1	2500	25.00		x
2		Adesivo cementizio	5	spessore	5	-	1	1500	7.50		x
3		Massetto cementizio ancorato	20	spessore	20	-	1	2050	41.00		x
4	Assito di legno	Legno	15	spessore	15	-	1	700	10.50		x
5	Anticalpestio robusto	Fibra di legno	7	spessore	7	-	1	250	1.75		x
6	Strato di regolazione	Terra cruda compatta stabilizata con calce	32	area sezione trasversale tra IPE	6.7E+04	850	1.1765	2000	158.63		x
7	Strato di rinforzamento	Malta di sabbia/calce	20	area sezione trasversale tra IPE	1.9E+04	850	1.1765	1800	39.71		x
8	Arco in blocchi di terra cruda compressa con malta di sabbia	Blocchi di terra cruda compressa	110	area sezione trasversale blocchi tra IPE	7.9E+04	850	1.1765	2000	185.40		x
9		Malta interstiziale di sabbia/calce	interstiziale	area sezione trasversale tra IPE	3.9E+04	850	1.1765	1800	82.06		x
-	Trave IPE 240	Acciaio	inserite	area sezione trasversale	3912	850	1.1765	8000	36.82	x	
10	Finitura protettiva trasparente	A base di cera o resini naturale	2	spessore	2	782.5	1	800	0.03		x
	Totali		221						**588.40**	**36.82**	**551.58**

Distanza tra IPE [cm]
85

		Totale D	Strutturale $G1$	Non-str. $G2$
Carico permanente	[kN/m²]	5.77	0.36	5.41
Caricho perm. lineare	[kN/m]	4.905	0.307	4.598

Tab. VII-15.Carichi permanenti per PO01 (solaio intermedio).

2.3. Variable actions

I carichi variabili comprendono i carichi legati alla destinazione d'uso dell'opera. I modelli di tali azioni possono essere costituiti da:

- Carichi verticali uniformemente distribuiti q_k (in kN/m^2)
- Carichi verticali concentrati Q_k (in kN)
- Carichi orizzontali lineari H_k (in kN/m)

Le varie aree del progetto della scuola entrano in varie categorie d'uso. Le parti scolastiche entrano nella categoria degli ambienti suscettibili ad affollamento, più precisamente C1 per le aree d'insegnamento (aule) e C3 per i corridoi. Le scale comuni sono considerate come tale. Uffici amministrativi, invece, entrano nella categoria B2 degli uffici non aperti al pubblico.

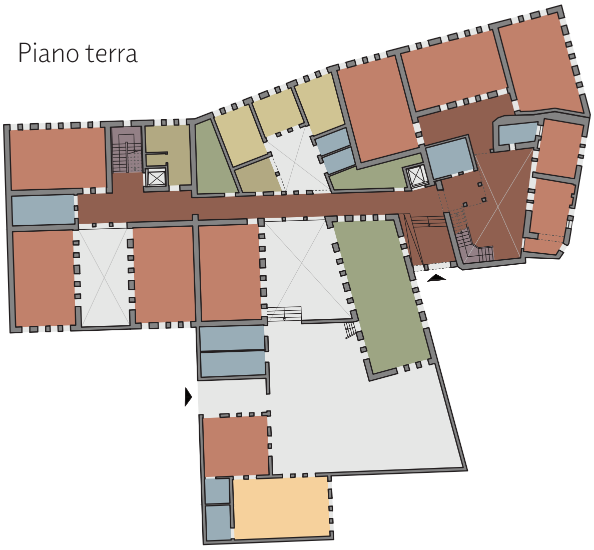
Categoria	Ambienti	q_k [kN/m²]	Q_k [kN]	H_k [kN/m]
A	Locali di servizi ad uso domestico (non suscettibili di affolamento)	2.00	2.00	1.00
B	**Uffici**			
	B1 - Uffici non aperti al pubblico	2.00	2.00	1.00
	B2 - Uffici aperti al pubblico	3.00	2.00	1.00
C	**Ambienti suscettibili di affollamento**			
	C1 - Aree con tavoli (sale di scuola e di studio)	3.00	3.00	1.00
	C2 - Aree con posti a sedere fissi (aule di laboratorio)	4.00	4.00	2.00
	C3 - Ambienti privi di ostacoli al movimento delle persone (corridoi)	5.00	5.00	3.00
	Scale comuni, balconi e ballatoi	4.00	4.00	2.00
H-I-K	H - Coperture accessibili per sola manutenzione e riparazione	0.50	1.20	1.00
	I - Coperture praticabili (→C3)	5.00	5.00	3.00

Tab. VII-16.Valori dei sovraccarichi per le diverse categorie d'uso delle costruzioni

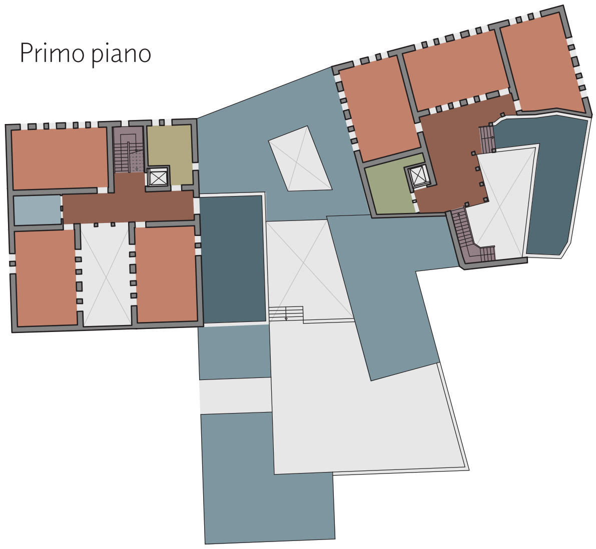
I tetti sono tutti piatti, però alcuni parti sono accessibile (terrazze), mentre le altre lo sono solo per manutenzione: le prime entrano nella categoria H, le seconde nella categoria I.

Gli spazi della scuola Al-Nuri sono associati alle categorie di uso, come sulle piante seguente (Fig. VII-06).

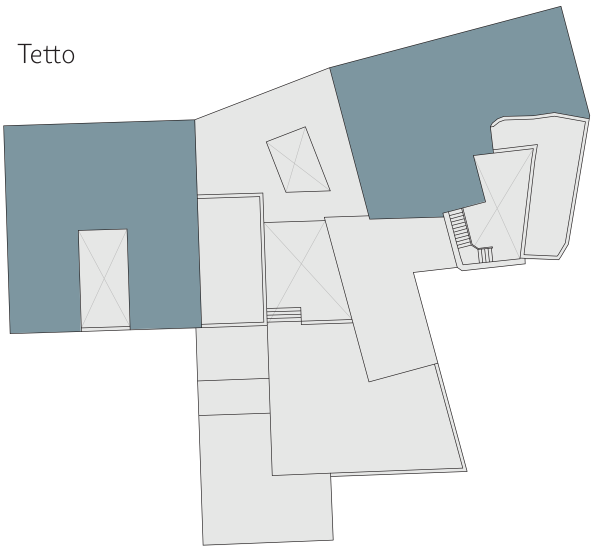
Piano terra



Primo piano



Tetto



Colore	Ambienti
	A - Serivizi (non suscettibili di affolamento)
	Uffici
	B1 - Uffici non aperti al pubblico
	B2 - Uffici aperti al pubblico
	Ambienti suscettibili di affollamento
	C1 - Aree con tavoli (scuola, caffè, ecc.)
	C2 - Aree con posti a sedere fissi (aule, laboratori)
	C3 - Ambienti privi di ostacoli al movimento delle persone
	Scale comuni, balconi e ballatoi
	E1 - Aree per accumulo di merci e relative aree d'accesso (biblioteche, archivi, magazzini, depositi, ecc.)
	H - Coperture accessibili per sola manutenzione e riparazione
	I - Coperture praticabili (→ C3)

Fig. VII-06.Categorie d'uso dei diversi ambienti della scuola Al-Nuri, secondo la normativa NTC-18.

2.4. Other actions

The climate of Mosul does not give rise to snow or rain. In addition, Mosul is not located in a seismic zone and therefore there is no need to evaluate seismic actions or take special measures to protect the building against earthquakes (raw earth does not work at all in seismic areas).

As for the wind actions, they will not be evaluated in our analysis. In fact, the wind produces horizontal loads and these actions cannot be evaluated quantitatively, in the case of raw earth walls, without a very advanced theoretical approach and modeling. It therefore goes beyond the scope of the thesis work. We will settle for more general criteria related to the geometry of the building.

3. PRE-SIZING OF THE IPE BEAMS OF THE FLOOR

For the pre-sizing of both the floors and the load-bearing walls, we consider in a first approach, the case of a typical classroom. In addition, it can already be assumed that the loads will be representative of the rest of the building at the level of the hall highlighted on the structural deck of the ground floor in learned:

The light L=5.30m and the wheelbase i=85cm of the IPE beams in the attic are the largest in the whole building, and are found in all the teaching rooms;

The areas of influence that define the loads taken from the walls are the widest of the building and involve both teaching rooms (cat. C1) that corridors (cat. C3) i.e. the environments with the highest service loads.

The area is located in the two-story part of the building, so with larger permanent loads at the base of the walls.

The closing wall that takes up the loads of the attic has several windows, like practically all the other teaching rooms. Their presence requires additional considerations for the structural system of the walls.

In the case of the attic, it is also necessary to analyze the situation of the highlighted roof-terrace. In fact, it enters the category of environments I and is aimed at a C3 environment, and is therefore the most critical case of the building.

3.1. System

There are two cases:

The classroom, category C1;

The roof-terrace, category I and using service loads of category C3.

Each is analyzed below, the first because it is representative of all the teaching rooms, the second because it represents the most critical case.

The IPE beams used in the floors can be presented as a linear element of length L, on two supports. In addition to the action of the element's own weight (which can be represented as a uniformly distributed permanent

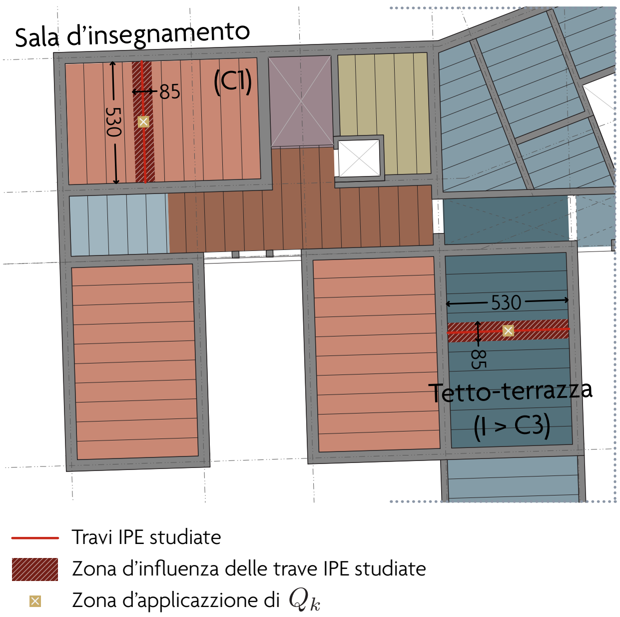


Fig. VII-07.Impalco strutturale del piano terra con le zone d'influenza delle IPE da analizzare.

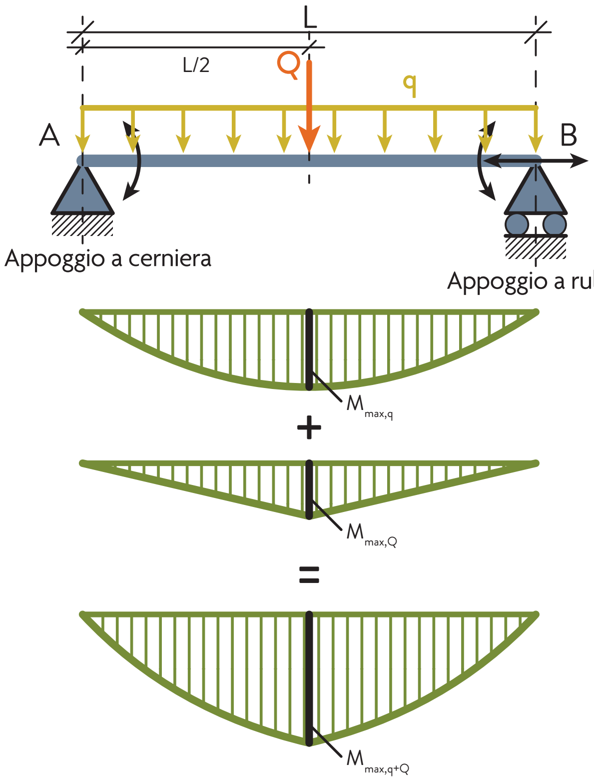


Fig. VII-08.Schema statico dello sistema studiato: trave sue due appoggi.

load), several loads must be applied:

- uniformly distributed non-structural permanent loads;
- service loads;
- the punctual service loads that apply to the most critical point, that is, to the middle of the beam.

One can already obtain the maximum bending moment and the maximum deflection , by applying the following formulas (linear combination of basic cases):

$$M_{max} = M_{max,q} + M_{max,Q} = \frac{qL^2}{8} + \frac{QL}{4}$$

$$\delta_{max} = \delta_{max,q} + \delta_{max,Q} = \frac{5qL^4}{384 \cdot EI} + \frac{QL^3}{48 \cdot EI}$$

Dove:

- $M_{max,q}$ è il contributo al momento flettente massimo dovuta ai carichi uniformemente distribuiti q;
- $M_{max,Q}$ è il contributo al momento flettente massimo dovuto ai carichi puntuali Q;
- L è la lunghezza della trave considerata.

ForIPE240, with a steel S235, we havell modulo di elasticità $E = 210\ GPa$;

- Il secondo momento di inerzia $I = 3.892 \cdot 10^7\ mm^4$
- La resistenza di design elastico al momento flettente $M_{el,Rd,yy} = 76.21\ kNm$.

As an additional analysis, a model of the IPE beam was made in Rhinoceros3D & Grasshopper, with the structural analysis plug-in Karamba3D.

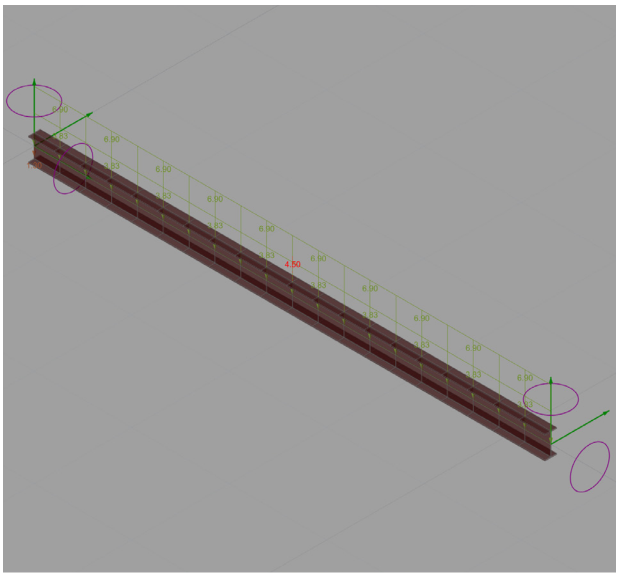


Fig. VII-09. Carichi e supporti della trave IPE240 nel modello Karamba3D

3.2. Verifications in the classroom

Interasse IPE	Car. Permanente		Car. Di Servizio	
i	$G1$	$G2$	$q_{k,C1}$	$Q_{k,C1}$
[m]	[kN/m]	[kN/m]	[kN/m]	[kN]
0.85	0.307	4.598	2.55	3.00

Tab. VII-17. Carichi applicati alle travi IPE dei solai delle aule didattiche.

3.2.a. *Actions*

In our case, considering that the IPE beams of the floor have a spacing of i=85cm (which defines the width of the influence zone for each IPE), the following loads are obtained:

3.2.b. *SLU verifications*

For the combinations of loads at SLU, we consider the unfavourable case for the coefficients . Therefore we obtain:

$\psi_{0,j}$ riduzione applicato a ...	Caso di carico c [-]	Risultanti q [kN/m]	Q [kN]	Contribuzione al momento $M_{max,q}$ [kNm]	$M_{max,Q}$ [kNm]	Momento massimo M_{max} [kNm]
non applicabile	1	7.30	0.00	25.62	0.00	25.62 kNm
nessuno	2	11.12	4.50	39.05	5.96	45.01 kNm

Tab. VII-18. Calcolo dei momenti flettenti massimi

1. $1.3 \cdot G_1 + 1.5 \cdot G_2$ – azione permanente
2. $1.3 \cdot G_1 + 1.5 \cdot G_2 + 1.5 \cdot (q_{k,C1} + Q_{k,C1})$ – azione a breve termine

Using the formulas and load values, the maximum bending moment values are obtained directly:

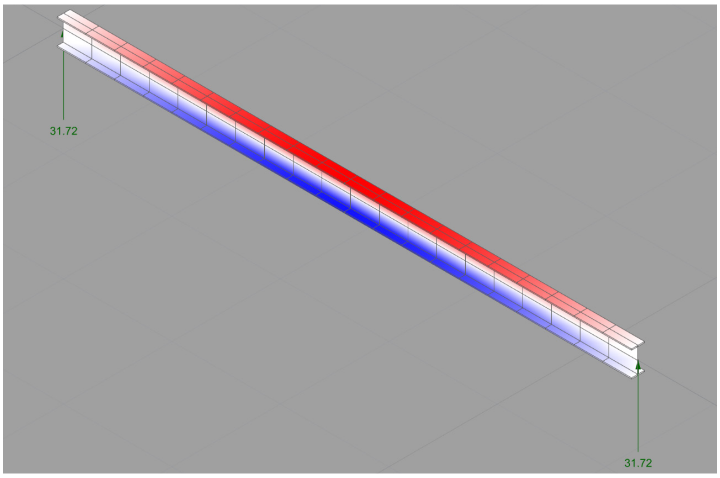
IPE			200	220	240	270	300
Mom. flettente ammisibile	M_d	[kNm]	46	59	76	101	131
Utilizzazione	azione permanente	[%]	56%	43%	34%	25%	20%
	azione a breve termine	[%]	99%	76%	59%	45%	34%

Tab. VII-19. Confronto tra risultati e resistenze di design delle IPE

These values can be compared to the elastic design resistances to bending moment of various sizes of IPE:

It is found that an IPE 220 is the minimum required under loads due to short-term actions, with a fairly small margin. An IPE 240 was therefore chosen for safety.

The Karamba3D model for an IPE 240 beam produces the same results. Furthermore, it immediately gives us the value of the reactions: 31.94kN . The results for short-term actions (load combination n°2) are given below.



stress[kN/cm2]	utilization
-1.39e+01	-59.1%
-1.21e+01	-51.7%
-1.04e+01	-44.3%
-8.67e+00	-36.9%
-6.94e+00	-29.5%
-5.20e+00	-22.1%
-3.47e+00	-14.8%
-1.73e+00	-7.4%
0.00e+00	0.0%
1.73e+00	7.4%
3.47e+00	14.8%
5.20e+00	22.1%
6.94e+00	29.5%
8.67e+00	36.9%
1.04e+01	44.3%
1.21e+01	51.7%
1.39e+01	59.1%

Fig. VII-10. Tensioni interni nella trave IPE e utilizzazione corrispondente del materiale costitutivo,

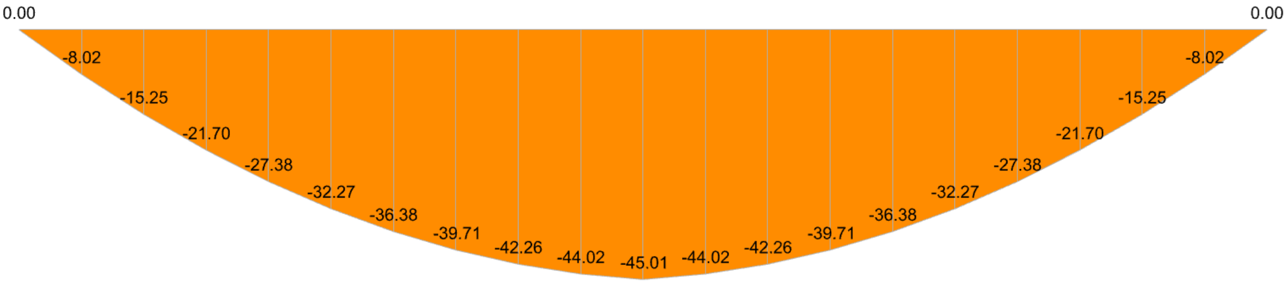


Fig. VII-11. Momento flettente nella trave, combinazione di carichi n°2(SLU, caso più critico).

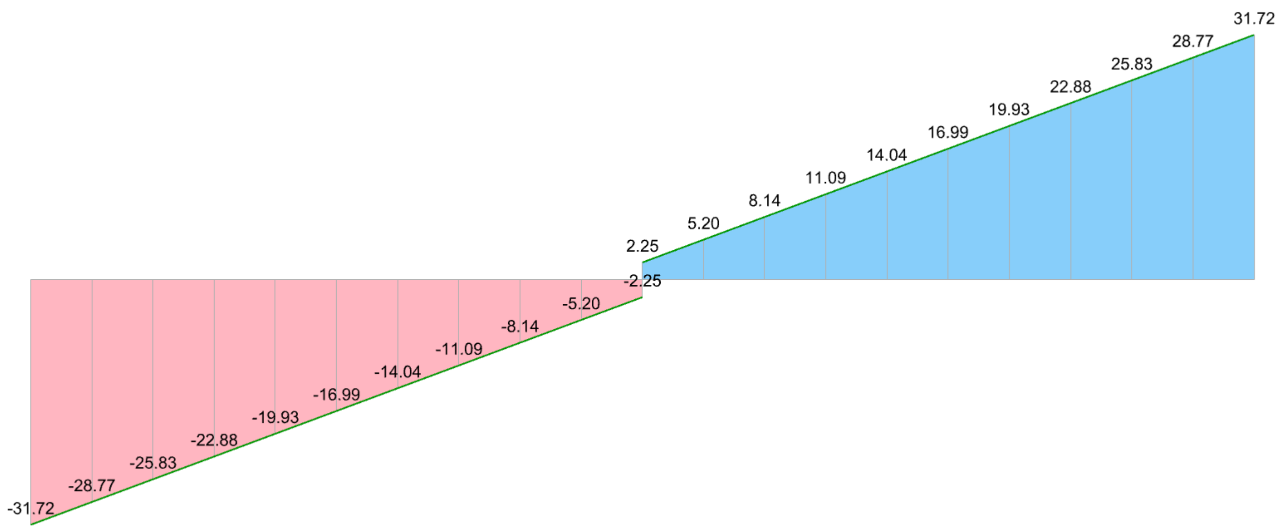


Fig. VII-12. Taglio nella trave, combinazione di carichi n°2(SLU, caso più critico).

3.2.c. *Verification SLE*

The load combination at the SLE are:

3. $G_1 + G_2$ – azione permanente
4. $G_1 + G_2 + (q_{k,C1} + Q_{k,C1})$ – azione a breve termine

We also have the following deflection limits for a beam of span L=5.30m. In our case, the limit is considered to be in the middle of the beam.

Deflessione ammissibile	$\delta_{lim} = L/a$ [cm]	2.12	2.65	5.30	Luce trave
Fatore di limite di deflessione	a [-]	250	200	100	L [m]
	Elemento considerato	Metà trave	Metà trave tetto	Cima di colonna	5.30

Tab. VII-20.Limiti di deflessione di diversi elementi strutturali, secondo la NTC-18.

With the formulas and the load values, the irreversible SLE verification is obtained directly. The model in Karamba3D produces the same results also in deformation. In the following you can see the deflection (i.e. vertical deformation) obtained, with a display scale of 50. Verifiche sul tetto-terrazza

Caso di carico	Risultanti		Contribuzione alla deflessione		Deflessione massima	Limiti di deflessione
c	q	Q	$\delta_{max,q}$	$\delta_{max,Q}$	δ_{max}	Trave di solaio
[-]	[kN/m]	[kN]	[cm]	[cm]	[cm]	[%]
3	4.90	0.00	0.62	0.00	0.62 cm	29.1%
4	7.45	3.00	0.94	0.11	1.05 cm	49.6%

Tab. VII-21.Confronto tra risultati e la deflessione limite delle IPE.

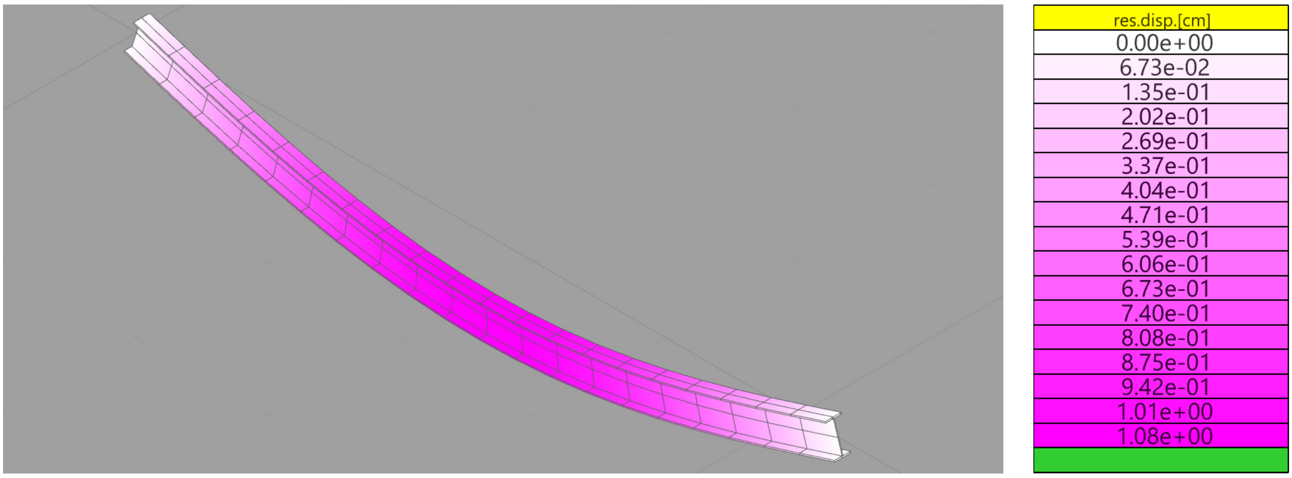


Fig. VII-13.Deflessione della trave IPE 240, combinazione di carichi n°3 (SLE, caso più critico).

3.2.d. *Loads*

Considering that the IPE beams of the roof-terrace have a spacing of i=85cm (which defines the width of the zone of influence for each IPE), the following loads are obtained:

Interasse IPE	Car. Permanente		Car. Di Servizio	
i	$G1$	$G2$	$q_{k,I}$	$Q_{k,I}$
[m]	[kN/m]	[kN/m]	[kN/m]	[kN]
0.85	0.360	5.451	4.25	5.00

Tab. VII-22.Carichi applicati alle travi IPE dei solai dei tetti-terrazza.

3.2.e. *Verification SLU*

As for the IPE of the floor, we consider the unfavourable case for the gamma coefficients for the load combinations at SLU. This results in:

1. $1.3 \cdot G_1 + 1.5 \cdot G_2$ – azione permanente
2. $1.3 \cdot G_1 + 1.5 \cdot G_2 + 1.5 \cdot (q_{k,I} + Q_{k,I})$ – azione a breve termine

Using the formulas and load values, the maximum bending moment values are obtained directly:

These values can be compared to the elastic design resistances to bending moment of various sizes of

$\psi_{0,j}$ riduzione applicato a ...	Caso di carico c [-]	Risultanti q [kN/m]	Risultanti Q [kN]	Contribuzione al momento $M_{max,q}$ [kNm]	Contribuzione al momento $M_{max,Q}$ [kNm]	Momento massimo M_{max} [kNm]
non applicabile	1	8.65	0.00	30.35	0.00	30.35 kNm
nessuno	2	15.02	7.50	52.74	9.94	62.68 kNm

Tab. VII-23. Calcolo dei momenti flettenti massimi nelle travi IPE dei tetti-terrazza.

IPE:

It is found that an IPE 240 is the minimum

IPE			200	220	240	270	300
Mom. flettente ammissibile	M_d	[kNm]	45.7	59.2	76.2	101	131
Utilizzazione	azione permanente	[%]	66%	51%	40%	30%	23%
	azione a breve termine	[%]	137%	106%	82%	62%	48%

Tab. VII-24. Confronto tra risultati e resistenze di design delle IPE dei tetti-terrazza.

required under loads due to short-term actions. The margin of safety on the IPE beam size chosen in the previous section was therefore well needed.

3.2.f. Verification SLE

As with the IPE of the floor, the load combinations at the irreversible SLEs in our case are:

3. $G_1 + G_2$ – azione permanente
4. $G_1 + G_2 + (q_{k,I} + Q_{k,I})$ – azione a breve termine

The deflection limits for a beam with span L=5.30m are the same as for the floor. With the formulas and load values, the irreversible SLE verification is then directly obtained.

Caso di carico c [-]	Risultanti q [kN/m]	Risultanti Q [kN]	Contribuzione alla deflessione $\delta_{max,q}$ [cm]	Contribuzione alla deflessione $\delta_{max,Q}$ [cm]	Deflessione massima δ_{max} [cm]	Limiti di deflessione Trave di solaio [%]
3	5.81	0.00	0.73	0.00	0.73 cm	34.5%
4	10.06	5.00	1.26	0.19	1.45 cm	68.6%

Tab. VII-25. Confronto tra risultati e la deflessione limite delle IPE dei tetti-terrazza

4. PRE-SIZING OF WALLS

In the case of walls, pre-sizing is done in two stages:

first the compressive strength of the walls must be checked;

then, structural stability must be verified.

The particular considerations related to the use of compressed raw earth bricks, the sizing and the construction of walls in this material are derived from Sustainable Building with Earth (2016), by Horst Schroeder.

4.1. Pre-sizing of compression walls

The compression pre-sizing of the walls is concentrated on the base of the walls, where the reaction forces to the loads accumulated throughout the building are maximum. In the case of continuous structural elements (e.g. concrete wall) or punctual (wooden beam and pillars, steel, etc.) with usual mechanical capabilities, it is enough to compare the resulting loads at the base with the compressive strength of the material used. The use of raw earth bricks, that is, an assembly of small-sized elements made from a material with relatively poor cohesion and tied together, requires additional considerations.

In our case, the structural layer of the walls is made from blocks of compacted raw earth, such as Cycle Terre's BTC30, which have a compressive strength of 3Mpa . In addition, compressed raw earth bricks have a limited tensile and bending strength: only 10-20% of their compressive strength - Cycle Terre indicates a tensile strength of 0.3Mpa and does not give values for flexural strength. Finally, with a modulation of elasticity of 2GPa, we can assume a shear strength equal to f=0.4E=0.8GPa.

The possible sizes for bricks are 30×15×9, or 22×11×6. The following wall thicknesses are therefore possible: 45cm, 34cm, 30cm or 22cm. Each case is studied.

To understand what are the additional considerations to keep for a wall of compacted raw earth bricks, you need to know how the tensions are transmitted. Earth blocks are laid as baked bricks to form a masonry of earthen blocks, following the standard rules of gluing masonry. Gluing increases the bearing capacity under compression and cutting stresses. This also allows the transfer of horizontal loads through adhesion and/or friction between the earth block and the joint mortar, provided that the earthen blocks have been laid in a bed filled with mortar. In this context, the transmission of the load from block to block is carried out mainly from the mortar of the masonry in the bedding joint. Partially filled bedding joints cause peak stresses in the block.

It must then be understood that transverse tensile tensions develop in the earth blocks if the masonry is exposed to compression tensions perpendicular to the lodging joints. Mechanical failure of the block occurs when the transverse tensile strength of the block is exceeded. Due to its generally higher level of lateral deformation, the mortar in the bedding joint increases the transverse tensile stresses in the block, since the blockage forces the expansion of the mortar.

It is therefore clear that a classic test - as is done for wood, for example - is not enough for a masonry made of compacted raw earth bricks. In Sustainable Building with Earth, Horst Schroeder presents a simplified method of compressive strength verification that takes these considerations into account. This method is applicable to buildings that comply with certain criteria that ensure the stability of the walls: they must not exceed two floors, and have limits on the distances between the transverse walls and the heights of the walls. The method is called "Lehmbau Regeln" (German for "clay construction rule"). The stability criteria are presented and verified in §4.2.

In this method, we assume that the loads are centered. In reality and also in legislation, there are always stresses that cause eccentricity of loads in the walls - the geometry of the structure itself and the connection of the rest of the structure to the walls, wind loads, horizontal service loads, etc. The criterion to be met is (where and is the eccentricity distance and b is the structural thickness of the wall). In practice, the eccentricity distance is quite complicated to estimate: we will rather hypothesize that this requirement is met as long as the structural part of the walls is not less than 24 cm (a minimum value found in the stability criteria of the Lehmbau Regeln).

The Lehmbau Regeln offers different methods for sizing. As part of the checks at limit states using partial safety coefficients, the method indicates to use a coefficient 6 for actions due to the structural material - that is, to take 6 rather than 1.3 - and to proceed as usual.

4.1.a. System

At the level of the classroom considered, there are two walls that represent critical areas. They are highlighted on the structural deck of the ground floor, in appreso.

The first area – on the façade – is interesting because it must take over the load of the attic but also that of the ventilated façade, and must take into account the windows.

The second – internal – is also interesting because the wall must resume the loads of a part of the classroom, but also those (larger) of a part of the corridor floor.

Fig. VII-14. Posizioni del solaio e tetto, e altezze pertinente in facciata per l'analizzi dei muri in facciata

In the first zone, the presence of windows on the façade requires additional analysis. It is important to understand if the part of the wall between two windows

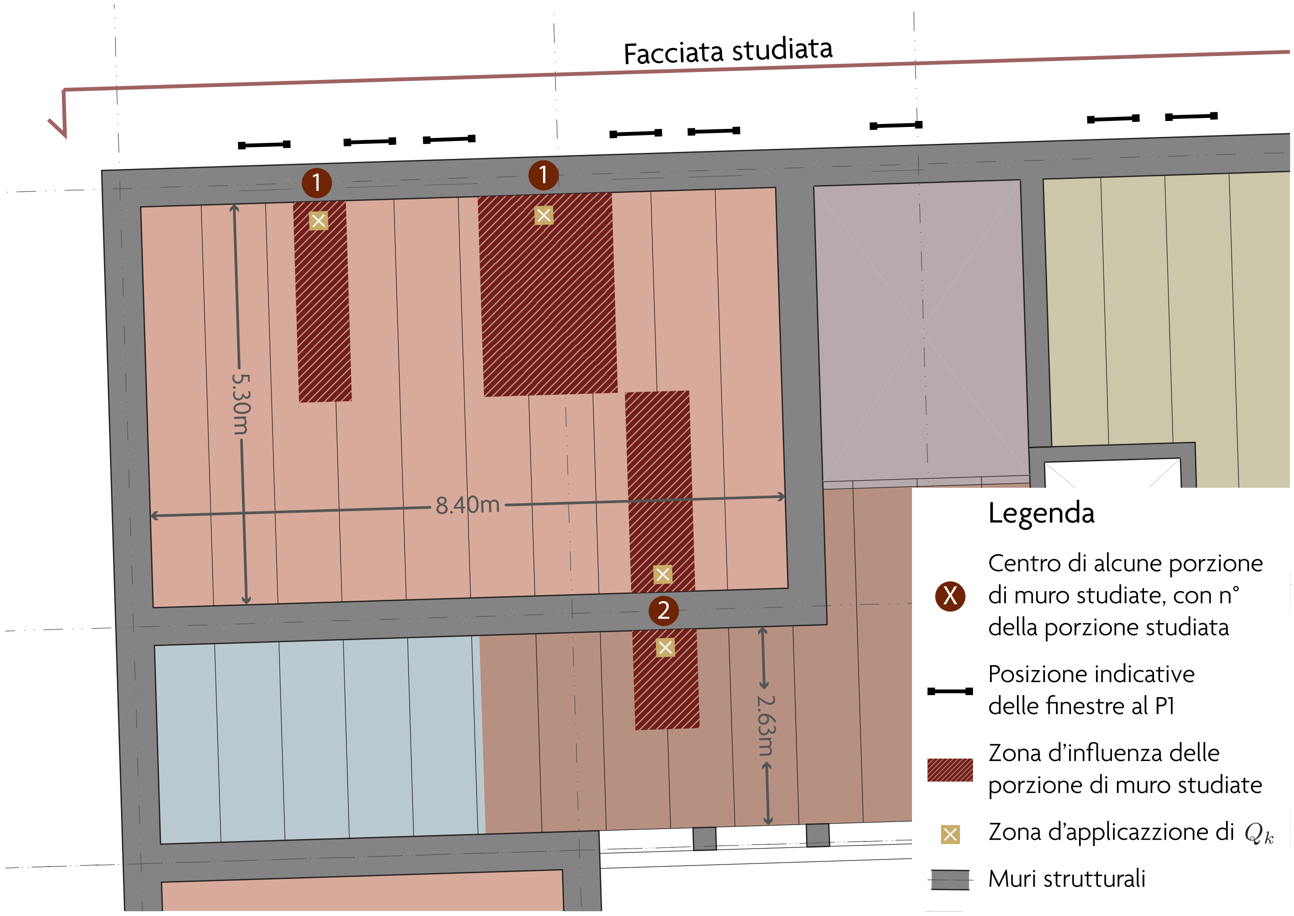


Fig. VII-15. Impalco strutturale dello piano terra con le zone d'influenza di porzioni del muro da analizzare (per la soluzione strutturale n°1 nel caso della prima zona - in facciata).

must be structural (if it is large enough to resume efforts) or if a "group" of windows close to each other can be considered as a single hole with a curb that takes up all the loads to make them pass into the widest parts of the walls. The two solutions are represented in a schematic and simplified way (i.e., not taking into account the redistributions of non-vertical loads where the windows are inserted symmetrically), together with the load paths that result on the North façade of the East part of the building. For convenience, the analyzed portions of the wall are already highlighted with numbers. As follows, we will refer to it as a structural solution:

n°1 – any separation between windows considered structural;

n°2 – windows grouped into structural 'holes'.

It is also considered that the loads due to the floor and transmitted from the IEPs to the walls are distributed over the entire length of the wall through the use of load-sharing elements. A special case can be seen on the technological detail of the ventilation above the doors (node No. 2), where the wooden curb beam plays this role. This serves in order not to have zones of accumulation of efforts that can damage the bricks of compressed earth.

Finally, this allows you to consider a continuous load path. The loads can therefore simply be added together, considering the zones of influence of the different structural parts indicated on the previous scheme.

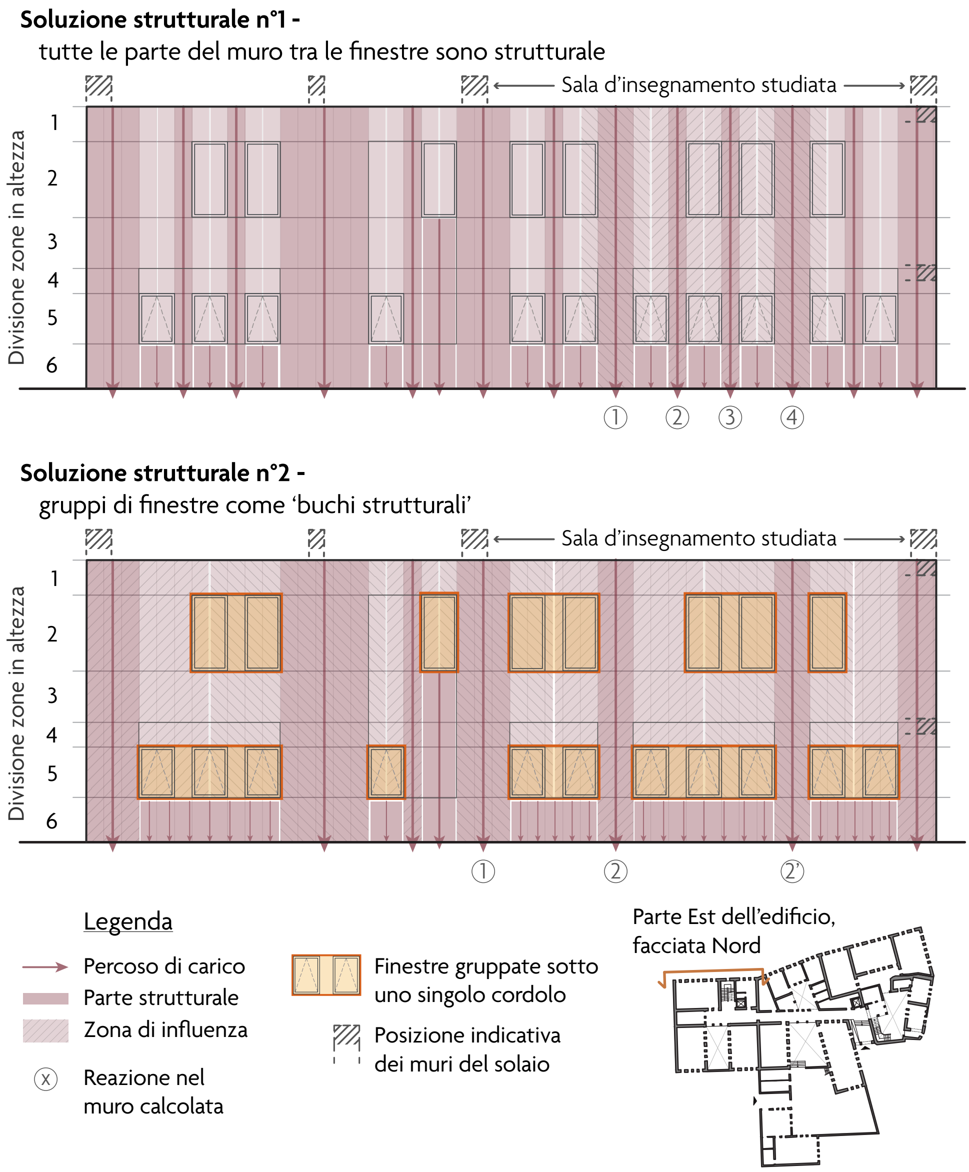


Fig. VII-16. Percorsi di carichi analizzati in facciata, per le due soluzioni strutturali.

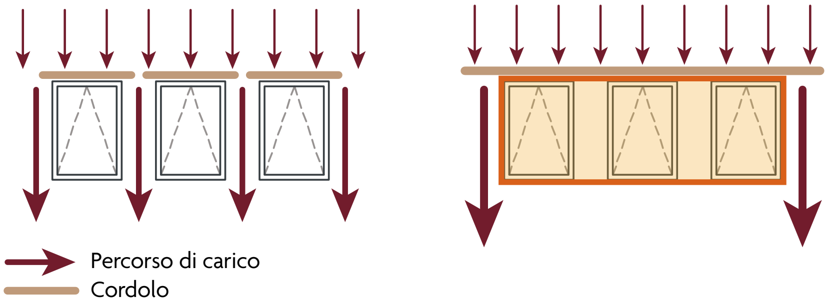


Fig. VII-17.Schema di principio della differenza tra le due soluzioni strutturali.

4.1.b. Loads and combination

General Loads

For the pre-sizing of walls, we use a criterion on the strength of the structural material, i.e. compressed raw earth. Therefore, combinations of loads are used at SLUs, and wind loads are not taken into account. For the various coefficients, we consider the case to be disadvantageable for the relevant coefficients and values of (given in the tables of §2.1).

Loads a little different from those used in the sizing of the floor must be considered:

uniformly distributed structural permanent loads, i.e. the proper weight of the structural material of the wall;

uniformly distributed non-structural permanent loads, i.e. the proper weight of non-structural wall materials;

uniformly distributed non-structural permanent loads due to the floors and the roof, which are taken from the wall - are considered non-structural because the analysis focuses on the wall;

the service loads applied to the floors and roof, which are taken from the wall;

the punctual service loads applied to the floors and the roof and which apply to the most critical point of the portion of the wall considered.

Si adotta le convenzioni seguente per i carichi $g_{pacchetto,ambiente}$

- $pacchetto = s$ nel caso del solaio;
- $pacchetto = t$ nel caso del tetto;
- $ambiente = ins$ nel caso dell'aula didattica;
- $ambiente = cor$ nel caso del corridoio.

In this way, it refers to the permanent loads of the floor in the classroom, relative to the zone of influence of the studied portion of the wall.

The zones of influence and points of application of the loads are shown in Fig. VII-16.

As far as the point service load is concerned, its point of application is chosen so as to have the totality of the load taken up by the portion of wall studied. To obtain a linear load (in kN/m), we divide the load (expressed in kN) by the width of the portion of the wall studied (when studying the first zone), or by a width equal to the distance between centres of the IPE beams i=85cm to reproduce the uniform distribution of the loads mentioned above (when studying the second zone, which does not concentrate on a particular portion of the wall).

First zone - in the façade

In the façade, the presence of windows and mashrabiyya must be considered. We use double-glazed windows (4-16-4 type) and therefore an area density of 20kg/m2 can be assumed (the contribution of the frame is neglected). The mashrabiyya is made of wood (with a density of 500kg/m3), 1.0cm thick. Its

Elemento di facciata [-]	Densità di area [kg/m^2]	Carico di area [kN/m^2]
Finestre	20	0.196
Mashrabiyya	125	1.226
Totale $G_{2,fin.}$	145	1.422

Tab. VII-26.Carico di area della mashrabiyya

Tipo di carico	Carico permanente				Carico permanente		Carico di servizio (solai, ripresi dal muro)			
Porzione d'edificio	Muro (CV01)		CV01b	Finestre	Aula didattica		Aula didattica			
Ambiente	-	-	-	-	-	-	C1		H	
Simbolo	G_1	G_2	G'_2	$G_{2,fin.}$	$g_{s,ing}$	$g_{t,ins}$	$q_{k,C1}$	$Q_{k,C1}$	$q_{k,H,ins}$	$Q_{k,H,ins}$
unità	[kN/m²]	[kN/m²]	[kN/m²]	[kN/m²]	[kN/m]	[kN/m]	[kN/m]	[kN]	[kN/m]	[kN]
Valore*	8.826	1.248	0.265	1.422	15.291	18.118	7.95	3.00	1.33	1.20

Tab. VII-27. Carichi da integrare sulle porzioni di muro della prima zona.

geometry allows us to assimilate it to a perforated panel, with an opening percentage of 75%. This allows us to assume a density of area 375kg/m2 . We therefore have the permanent load of the part with the window and mashrabiyya.

In the first zone, we then obtain the loads presented in Table VII-27.

NB: The values of Qkc1 and QkH will be divided by the width of the portion of the wall considered - e.g. in the case of portion 1 of structural solution No. 1 (refer to the previous diagrams), the width is 70cm.

NB2: The values of G1 and G2 will be divided by the height of the wall portions when integrating the loads.

As there are no snow and seismic loads, we obtain the following load combinations (where the partial coefficient has been replaced with as explained in §4.1:

1. $6 \cdot G_1 + 1.5 \cdot G_2$ — azione permanente
2. $6 \cdot G_1 + 1.5 \cdot G_2 + 1.5 \cdot [q_{k,C1} + Q_{k,C1} + \psi_{02,H} \cdot (q_{k,H} + Q_{k,H})]$ — azione a breve termine con enfasi sui carichi C1 (aula didattica)
3. $6 \cdot G_1 + 1.5 \cdot G_2 + 1.5 \cdot [q_{k,H} + Q_{k,H} + \psi_{02,C} \cdot (q_{k,C1} + Q_{k,C1})]$ — azione a breve termine con enfasi sui carichi H (tetto non accessibile)

Con $\psi_{02,C} = 0.7$ e $\psi_{02,H} = 0.0$.

Second zone - internal wall

For the internal wall, we do not take into account additional elements (doors for example). We therefore have the loads in Table VII-28, with the same comments.

Similarly, we have the following load combinations for the internal wall:

1. $6 \cdot G_1 + 1.5 \cdot G_2$ — azione permanente
2. $6 \cdot G_1 + 1.5 \cdot G_2 + 1.5 \cdot [q_{k,C1} + Q_{k,C1} + \psi_{02,C} \cdot (q_{k,C3} + Q_{k,C3}) + \psi_{02,H} \cdot (q_{k,H} + Q_{k,H})]$ — azione a breve termine con enfasi sui carichi C1 (aula didattica)
3. $6 \cdot G_1 + 1.5 \cdot G_2 + 1.5 \cdot [q_{k,C3} + Q_{k,C3} + \psi_{02,C} \cdot (q_{k,C1} + Q_{k,C1}) + \psi_{02,H} \cdot (q_{k,H} + Q_{k,H})]$ — azione a breve termine con enfasi sui carichi C3 (corridoio)
4. $6 \cdot G_1 + 1.5 \cdot G_2 + 1.5 \cdot [q_{k,H} + Q_{k,H} + \psi_{02,C} \cdot (q_{k,C1} + Q_{k,C1}) + \psi_{02,C} \cdot (q_{k,C3} + Q_{k,C3})]$ — azione a breve termine con enfasi sui carichi H (tetto non accessibile)

Con $\psi_{02,C} = 0.7$ e $\psi_{02,H} = 0.0$.

4.1.c. *Verification in the second zone - internal wall*

The second zone - on the internal wall - is simpler to analyse and is therefore presented first, so that we can concentrate on the specifics of the first zone afterwards without needing to go into the details of the calculations (which will be presented here). We proceed step by step: we divide the wall into various zones, calculate the relevant loads for each, and finally find the load combinations that interest us.

Tipo di carico	Carico permanente		Carico permanente (solai, ripresi dal muro)				Carico di servizio (solai, ripresi dal muro)							
Porzione d'edificio	Muro		Aula didattica		Corridoio		Aula didattica				Corridoio			
Ambiente	-	-	-	-	-	-	C1		H		C3		H	
Simbolo	G_1	G_2	$g_{s,ins}$	$g_{t,ins}$	$g_{s,cor}$	$g_{t,cor}$	$q_{k,C1}$	$Q_{k,C1}$	$q_{k,H,ins}$	$Q_{k,H,ins}$	$q_{k,C3}$	$Q_{k,C3}$	$q_{k,H,cor}$	$Q_{k,H,cor}$
unità	[kN/m²]	[kN/m²]	[kN/m]	[kN/m]	[kN/m]	[kN/m]	[kN/m]	[kN]	[kN/m]	[kN]	[kN/m]	[kN]	[kN/m]	[kN]
Valore*	8.826	0.178	15.291	18.118	7.588	8.991	7.95	3.00	1.33	1.20	6.58	5.00	0.66	1.20

Tab. VII-28. Carichi da integrare sulle porzioni di muro della seconda zona.

On this part of the wall, the resulting loads are calculated as linear loads applied on the wall. By dividing these linear loads by the structural thickness of the wall to obtain a pressure, a comparison can then be made to the tensile strength of 3MPa compacted unfired earth bricks.

It is found that in the worst case (load combination n°4), we always have a utilisation of the structural material (ratio of compression to material strength) that does not exceed 40%. Any wall thickness that meets the stability criteria can therefore be used.

Zona in altezza		**Carichi pertinenti**								
ID [-]	Altezza [m]	$G1$ [kN/m]	$G2$ [kN/m]	g [kN/m]	$q_{k,C1}$ [kN/m]	$Q_{k,C1}$ [kN/m]	$q_{k,C3}$ [kN/m]	$Q_{k,C3}$ [kN/m]	$q_{k,H}$ [kN/m]	$Q_{k,H}$ [kN/m]
Tetto	-	0	0	27.11	0	0	0	0	1.98	2.82
Muro P1	3.2	28.24	0.57	0	0	0	0	0	0	0
Solaio P1	-	0	0	22.88	7.95	3.53	6.58	5.88	0	0
Muro PT	2.4	21.18	0.43	0	0	0	0	0	0	0
Totale		49.43	0.99	49.99	7.95	3.53	6.58	5.88	1.98	2.82

		Carico totale [kN/m]	Pressione [kN/m²]	Pressione [MPa]	**Utiliza-zzione [%]**
Combinazioni di carichi	n°1	373	829	0.829	**27.6%**
	n°2	403	896	0.896	**29.9%**
	n°3	404	897	0.897	**29.9%**
	n°4	405	901	0.901	**30.0%**

Soluzione con mattoni 30x15x9	
Spessore muro str.	0.45 *m*
Carico G_1	8.82599 *kN/m²*

Tab. VII-29. Carichi del muro strutturale interno, spessore 45cm.

Zona in altezza		**Carichi pertinenti**								
ID [-]	Altezza [m]	$G1$ [kN/m]	$G2$ [kN/m]	g [kN/m]	$q_{k,C1}$ [kN/m]	$Q_{k,C1}$ [kN/m]	$q_{k,C3}$ [kN/m]	$Q_{k,C3}$ [kN/m]	$q_{k,H}$ [kN/m]	$Q_{k,H}$ [kN/m]
Tetto	-	0	0	27.11	0	0	0	0	1.98	2.82
Muro P1	3.2	21.34	0.57	0	0	0	0	0	0	0
Solaio P1	-	0	0	22.88	7.95	3.53	6.58	5.88	0	0
Muro PT	2.4	16.00	0.43	0	0	0	0	0	0	0
Totale		37.34	0.99	49.99	7.95	3.53	6.58	5.88	1.98	2.82

		Carico totale [kN/m]	Pressione [kN/m²]	Pressione [MPa]	**Utiliza-zzione [%]**
Combinazioni di carichi	n°1	301	884	0.884	**29.5%**
	n°2	331	973	0.973	**32.4%**
	n°3	331	974	0.974	**32.5%**
	n°4	333	979	0.979	**32.6%**

Soluzione con mattoni 22x11x6	
Spessore muro str.	0.34 *m*
Carico G_1	6.66852 *kN/m²*

Tab. VII-30. Carichi del muro strutturale interno, spessore 34cm.

Zona in altezza		**Carichi pertinenti**								
ID [-]	Altezza [m]	$G1$ [kN/m]	$G2$ [kN/m]	g [kN/m]	$q_{k,C1}$ [kN/m]	$Q_{k,C1}$ [kN/m]	$q_{k,C3}$ [kN/m]	$Q_{k,C3}$ [kN/m]	$q_{k,H}$ [kN/m]	$Q_{k,H}$ [kN/m]
Tetto	-	0	0	27.11	0	0	0	0	1.98	2.82
Muro P1	3.2	18.83	0.57	0	0	0	0	0	0	0
Solaio P1	-	0	0	22.88	7.95	3.53	6.58	5.88	0	0
Muro PT	2.4	14.12	0.43	0	0	0	0	0	0	0
Totale		32.95	0.99	49.99	7.95	3.53	6.58	5.88	1.98	2.82

		Carico totale [kN/m]	Pressione [kN/m²]	Pressione [MPa]	**Utiliza-zzione [%]**
Combinazioni di carichi	n°1	274	914	0.914	**30.5%**
	n°2	304	1015	1.015	**33.8%**
	n°3	305	1016	1.016	**33.9%**
	n°4	307	1022	1.022	**34.1%**

Soluzione con mattoni 30x15x9	
Spessore muro str.	0.3 *m*
Carico G_1	5.88399 *kN/m²*

Tab. VII-31. Carichi del muro strutturale interno, spessore 30cm.

Zona in altezza		Carichi pertinenti								
ID	Altezza	$G1$	$G2$	g	$q_{k,C1}$	$Q_{k,C1}$	$q_{k,C3}$	$Q_{k,C3}$	$q_{k,H}$	$Q_{k,H}$
[-]	[m]	[kN/m]	[kN/m]	[kN/m]	[kN/m]	[kN/m]	[kN/m]	[kN/m]	[kN/m]	[kN/m]
Tetto	-	0	0	27.11	0	0	0	0	1.98	2.82
Muro P1	3.2	13.81	0.57	0	0	0	0	0	0	0
Solaio P1	-	0	0	22.88	7.95	3.53	6.58	5.88	0	0
Muro PT	2.4	10.36	0.43	0	0	0	0	0	0	0
Totale		24.16	0.99	49.99	7.95	3.53	6.58	5.88	1.98	2.82

		Carico totale [kN/m]	Pressione [kN/m²]	Pressione [MPa]	**Utilizzazione [%]**
Combinazioni di carichi	n°1	221	1007	1.007	**33.6%**
	n°2	252	1144	1.144	**38.1%**
	n°3	252	1146	1.146	**38.2%**
	n°4	254	1154	1.154	**38.5%**

Soluzione con mattoni 22x11x6	
Spessore muro str.	0.22 m
Carico G_1	4.31493 kN/m²

Tab. VII-32.Carichi del muro strutturale interno, spessore 22cm.

Spessore muro str.	**Utilizzazione massima**	
	Comb. Associata	Valore
0.45 m	n°4	30.0%
0.34 m	n°4	32.6%
0.3 m	n°4	34.1%
0.22 m	n°4	38.5%

Tab. VII-33.Utilizzazioni massime in compressione nei muri della seconda zona - interna

4.1.d. Verification on first zone- in elevation

The first zone on the façade requires a more detailed vertical subdivision than the second zone, due to the windows and mashrabiyya - six in total, shown on the following diagram, repeated for convenience. In addition, the width of the structural zone (fixed on the studied portion) and that of the influence zones (which change according to the vertical subdivision considered) must be considered. These widths are given in the number of 35cm modules governing the façade (horizontal subdivision).

The last difference with the procedure applied to the second zone is the way of adding up the loads. Here, for each type of load (, , etc.), the resulting point (and non-linear) load is calculated. These loads are then summed over all zones of the vertical subdivision and the load combinations are obtained. Finally, to obtain a compressive value, it is divided by the structural area: i.e. the width of the structural zone multiplied by the structural thickness of the wall. A comparison can then be made with the tensile strength of 3MPa compacted unfired earth bricks.

Structural solution n°1

For the façade zone, let us first consider the solution without 'groups' of windows, called structural solution n°1 on the previous diagram. The portions of the wall to be studied, i.e. the 4 most critical situations found on other facades of the project, are indicated with numbers. For each, the loads are analysed.

For each wall thickness considered, i.e. s=22 or 30 or 34 or 45 , the loads in the different portions are analysed to find the most critical case. The results of the first portion, for a wall thickness of 45cm are detailed below, while the results for other wall thicknesses are summarised.

In all cases, the maximum compression is reached with load combination n°2. The maximum utilisation results according to structural wall thickness are as follows:

Spessore muro str.	**Utilizzazione**				**Massimale**	
	n° 1	n° 2	n° 3	n° 4	Porz. Associata	Valore
0.45 m	35.9%	44.5%	43.1%	35.2%	n° 2	44.5%
0.34 m	39.5%	50.0%	48.5%	38.8%	n° 2	50.0%
0.3 m	41.5%	52.9%	51.5%	40.8%	n° 2	52.9%
0.22 m	47.5%	62.1%	60.7%	46.8%	n° 2	62.1%

Tab. VII-34.Confronto tra risultati più critici e resistenza di design, per ogni porzione e ogni spessore considerata , soluzione strutturale n°1.

Soluzione con mattoni 30x15x9	
Spessore muro str.	0.45 m
Carico G_1	8.826 kN/m^2

Tab. VII-35.Carico permanente strutturale per uno spessore di 45cm

Porzione n° 1 Larghezza (in n° moduli) 2

Zona in altezza									
ID [-]	Altezza [m]	$G1$ [kN]	$G2$ [kN]	g [kN]	$q_{k,C1}$ [kN]	$Q_{k,C1}$ [kN]	$q_{k,H}$ [kN]	$Q_{k,H}$ [kN]
Tetto	-	0	0	25.37	0	0	1.86	1.20
1	0.7	4.32	5.55	0	0	0	0	0
2	1.5	9.27	7.35	0	0	0	0	0
3	1	6.18	7.93	0	0	0	0	0
Solaio P1	-	0	0	21.41	11.13	3	0	0
4	0.5	3.09	3.62	0	0	0	0	0
5	1	6.18	1.87	0	0	0	0	0
6	0.9	5.56	0.79	0	0	0	0	0
Totale								

		Carico totale [kN]	Pressione [kN/m²]	Pressione [MPa]	Utilizzazione [%]
Combinazioni di carichi	n°1	318.4	1011	1.011	**33.7%**
	n°2	339.6	1078	1.078	**35.9%**
	n°3	337.8	1072	1.072	**35.7%**

Tab. VII-36.Calcolo delle combinazioni di carichi e confronto tra risultati e resistenze di design del muro, sulla porzione studiata n°1, per uno spessore di muro di 45cm (sol. strutturale n°1).

Porzione n° 2 Larghezza (in n° moduli) 1

Zona in altezza								
ID [-]	Altezza [m]	$G1$ [kN]	$G2$ [kN]	g [kN]	$q_{k,C1}$ [kN]	$Q_{k,C1}$ [kN]	$q_{k,H}$ [kN]	$Q_{k,H}$ [kN]
Tetto	-	0	0	19.02	0	0	1.39	1.20
1	0.7	2.16	5.24	0	0	0	0	0
2	1.5	4.63	6.69	0	0	0	0	0
3	1	3.09	7.49	0	0	0	0	0
Solaio P1	-	0	0	16.06	8.35	3	0	0
4	0.5	1.54	3.40	0	0	0	0	0
5	1	3.09	1.43	0	0	0	0	0
6	0.9	2.78	0.39	0	0	0	0	0
Totale		17.30	24.65	35.08	8.35	3.00	1.39	1.20

		Carico totale [kN]	Pressione [kN/m²]	Pressione [MPa]	Utilizzazione [%]
Combinazioni di carichi	n°1	193.4	1228	1.228	**40.9%**
	n°2	210.4	1336	1.336	**44.5%**
	n°3	209.2	1328	1.328	**44.3%**

Tab. VII-37.Calcolo delle combinazioni di carichi e confronto tra risultati e resistenze di design del muro, sulla porzione studiata n°2, per uno spessore di muro di 45cm (sol. strutturale n°1).

Porzione n° 3 Larghezza (in n° moduli) 1

Zona in altezza								
ID [-]	Altezza [m]	$G1$ [kN]	$G2$ [kN]	g [kN]	$q_{k,C1}$ [kN]	$Q_{k,C1}$ [kN]	$q_{k,H}$ [kN]	$Q_{k,H}$ [kN]
Tetto	-	0	0	19.02	0	0	1.39	1.20
1	0.7	2.16	5.24	0	0	0	0	0
2	1.5	4.63	2.15	0	0	0	0	0
3	1	3.09	7.49	0	0	0	0	0
Solaio P1	-	0	0	16.06	8.35	3	0	0
4	0.5	1.54	3.40	0	0	0	0	0
5	1	3.09	1.43	0	0	0	0	0
6	0.9	2.78	0.39	0	0	0	0	0
Totale		17.30	20.10	35.08	8.35	3.00	1.39	1.20

		Carico totale [kN]	Pressione [kN/m²]	Pressione [MPa]	**Utilizzazione [%]**
Combinazioni di carichi	n°1	186.6	1185	1.185	**39.5%**
	n°2	203.6	1293	1.293	**43.1%**
	n°3	202.4	1285	1.285	**42.8%**

Tab. VII-38.Calcolo delle combinazioni di carichi e confronto tra risultati e resistenze di design del muro, sulla porzione studiata n°4, per uno spessore di muro di 45cm (sol. strutturale n°1).

Porzione n° 4 Larghezza (in n° moduli) 2

Zona in altezza								
ID [-]	Altezza [m]	$G1$ [kN]	$G2$ [kN]	g [kN]	$q_{k,C1}$ [kN]	$Q_{k,C1}$ [kN]	$q_{k,H}$ [kN]	$Q_{k,H}$ [kN]
Tetto	-	0	0	25.37	0	0	1.86	1.20
1	0.7	4.32	5.55	0	0	0	0	0
2	1.5	9.27	2.80	0	0	0	0	0
3	1	6.18	7.93	0	0	0	0	0
Solaio P1	-	0	0	21.41	11.13	3	0	0
4	0.5	3.09	3.62	0	0	0	0	0
5	1	6.18	1.87	0	0	0	0	0
6	0.9	5.56	0.79	0	0	0	0	0
Totale		34.60	22.55	46.77	11.13	3.00	1.86	1.20

		Carico totale [kN]	Pressione [kN/m²]	Pressione [MPa]	**Utilizzazione [%]**
Combinazioni di carichi	n°1	311.6	989	0.989	**33.0%**
	n°2	332.8	1056	1.056	**35.2%**
	n°3	331.0	1051	1.051	**35.0%**

Tab. VII-39.Calcolo delle combinazioni di carichi e confronto tra risultati e resistenze di design del muro, sulla porzione studiata n°3, per uno spessore di muro di 45cm (sol. strutturale n°1).

Structural solution n°2

For structural solution No. 2, the same is done. The compression is also the maximum for the combination of loads n°2, and the maxima are obtained according to the thickness of the structural wall:

Spessore	Utilizzazione			Massimale	
muro str.	n° 1	n° 2	n° 3	Porz.	Valore
0.45 m	35.2%	55.0%	53.4%	n° 2	55.0%
0.34 m	38.7%	62.3%	60.8%	n° 2	62.3%
0.3 m	40.6%	66.3%	64.8%	n° 2	66.3%
0.22 m	46.5%	78.7%	77.1%	n° 2	78.7%

Tab. VII-40.Confronto tra risultati più critici e resistenza di design, per ogni porzione e ogni spessore considerata, soluzione strutturale n°2.

Conclusion

Even with a partial safety coefficient much higher (6) than usual (1.3), the compressive forces at the base of the walls remain within the acceptable limits according to the Lehmbau Regeln method. There will be no loss of cohesion, crack or other problems due to excessive compression and the use of compacted raw earth bricks. This means that the structural thickness of the wall can be chosen freely, with respect to the criterion of strength of the wall. However, this structural thickness must comply with the stability criteria analysed in the following section.

4.2. Pre-sizing of walls – structural stability

The two regulations presented in §1.1 give us the minimum values for the structural thickness of raw earth brick walls. According to Middleton's method, the height of the Al-Nuri school requires walls of at least 30cm. Other considerations on the shape and arrangement of the school windows recommend 40cm of wall.

The Lehmbau Regeln method is a bit more detailed and more recent, though, and true therefore used. According to this method, we have the following minimum thicknesses:

36.5cm for perimeter walls (which can be reduced to 24cm for buildings of 1 single floor and a height of less than 2.5m);

24 cm for interior walls, or the same value as the perimeter walls if the following are not respected:

Floor height less than or equal to 2.9m (OK, in the Al-Nuri school, the floors are 2.8m high)

Service loads must be less than 0.275 MPa (OK, the sum of the service loads on the inner wall analyzed in §4.1.c is equal to 0.064 MPa at the base of the wall)

In addition, a building with earthen walls needs stiffening elements placed quite regularly. The Lehmbau Regeln method gives the values given in Table VII-41.

Spessore della parete	Altezza del piano	Spessore min. della parete trasversale	Distanza tra centri
24.0 - 36.5 cm	≤3.25 m	11.5 cm	4.5 m
>36.5 - 49.0 cm	≤3.25 m	17.5 cm	6.0 m
>49.0 - 61.5 cm	≤3.50 m	24.0 cm	7.0 m

Tab. VII-41.Raccomendazione del metodo Lehmbau-Regeln per la stabilità dei muri in terra cruda.

The latter criterion becomes essential in the case of the Al Nuri school. In fact, the classrooms have a length of 8.40m that exceeds the maximum pitch between transverse elements of stiffening (which are the perpendicular walls in our case). We must add at least one element in the center of the classroom to obtain a new step between stiffening elements that allows a structural wall thickness of 36.5cm. In order to be able to go down to 24cm thick, two stiffening elements must be added. We do not use earthen brick walls as stiffening elements, but rather metal reinforcement

He must therefore add reinforcements in two places not far away by more than 4.5m in the brick walls of compacted raw earth. This allows us in theory to descend to perimeter walls 24cm thick at a minimum.

4.2.a. Conclusions

Finally, although the Lehmbau Regeln method recommends a structural thickness for perimeter walls of 36.5cm at a minimum, it was not made for compacted raw earth bricks but for adobe bricks. Given this and the discourse on the stiffening of the walls, it can be considered that perimeter walls with a structural thickness of 30cm will have a sufficiently high stability. The compressive strength has already been verified in the previous section.

For internal walls, from a structural point of view,

STRUCTURAL LAYOUT

1. FOUNDATION

1.1. Plant

The choice is a surface foundation system with plinth and foundation beam. The area is considered as non-seismic and the building is not tall; therefore, no special deep foundation systems are required.

The layout follows the layout of the load-bearing walls of the ground floor. Under the court it was decided not to make special devices to allow a better exchange of heat with the ground and leave the possibility of greening the courts.

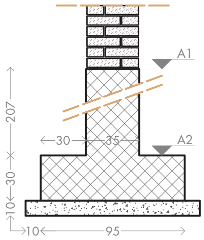
Regarding the existing house, the structure of the foundations is unknown. Considering the construction habits there is a good chance that it is formed by narrow plinths with a concrete floor thrown directly to the ground.

Fig. VII-18.Pianta strutturale delle fondazione. Scala 1/300

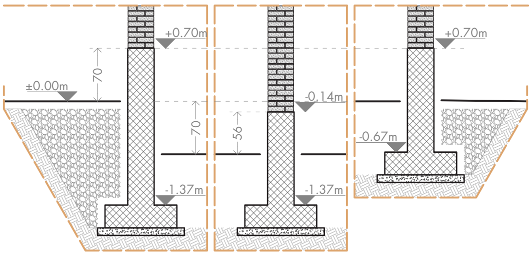
1.2. Abbachi

NUOVE COSTRUZIONI

FC1 & 2



Fondazione continua con muro di basamento (per muratura da 34cm) in calcestruzzo armato, gettato in opera su massetto in magrone.



FC1

Muro perimetrale (contro terra) della parte scolastica (piano di calpestio a -0.7m)

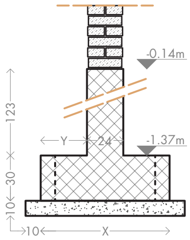
FC2

Muro non contro terra della parte scolastica (piano di calpestio a -0.7m)

FC1'

Muro perimetrale della parte publicca (piano di calpestio a ±0.0m)

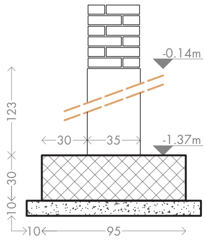
FC3 & 4



Fondazione continua con muro di basamento (per muratura da 23cm) in calcestruzzo armato, gettato in opera su massetto in magrone.

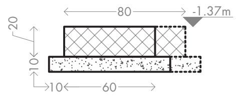
FC3 - In parte a due piani:
X=95cm & Y=30cm
FC4 - In parte ad uno piano:
X=65cm & Y=21cm

TR1

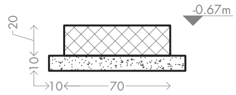


Trave rovescia in calcestruzzo armato con basamento di pilastri (34x34cm), gettato in opera su massetto in magrone.

TR2

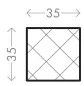


TR2'



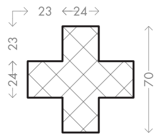
Trave rovescia in calcestruzzo armato, gettato in opera su massetto in magrone. (Spessore indicata in pianta, profondità diversa tra 2 e 2').

PI1



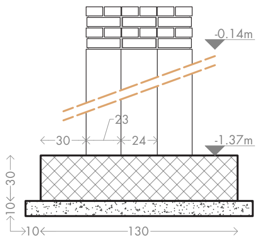
Pilastro in calcestruzzo armato.

PI2



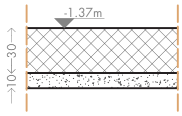
Pilastro a forma di croce in calcestruzzo armato.

PL1



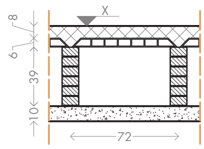
Plinto di fondazione in calcestruzzo armato con basamento di pilastro a forma di croce centrale.

PL2



Platea di fondazione in calcestruzzo armato, gettato in opera su massetto in magrone.

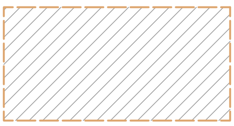
S1 & 1'



Solaio contro terra a muricci.
S1 - X=-0.84m
S1'- X=-0.14m

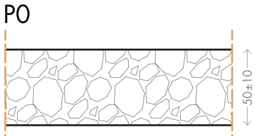
EDIFICIO ESISTENTE

PLO



Platea di fondazione (ipotizzata).

PO



Muratura portante in pietra di gesso e calcare (spessore variabile).

Fig. VII-19.Abaco strutturale delle fondazioni, scala 1/50.

2. DECKS

2.1. Plants

As described above the various scaffolding and roof are made with jack arches with steel beam resting on the walls of raw earth. The burial of the beams varies depending on the size of the spaces between 70cm and 80cm.

The beams are resting on a wooden curb that protects the wall below and distributes the loads. A curb fixing system with a square limits lateral displacement. In addition, the beams appear as inserted up to half the thickness of the wall.

2.2. Abachi

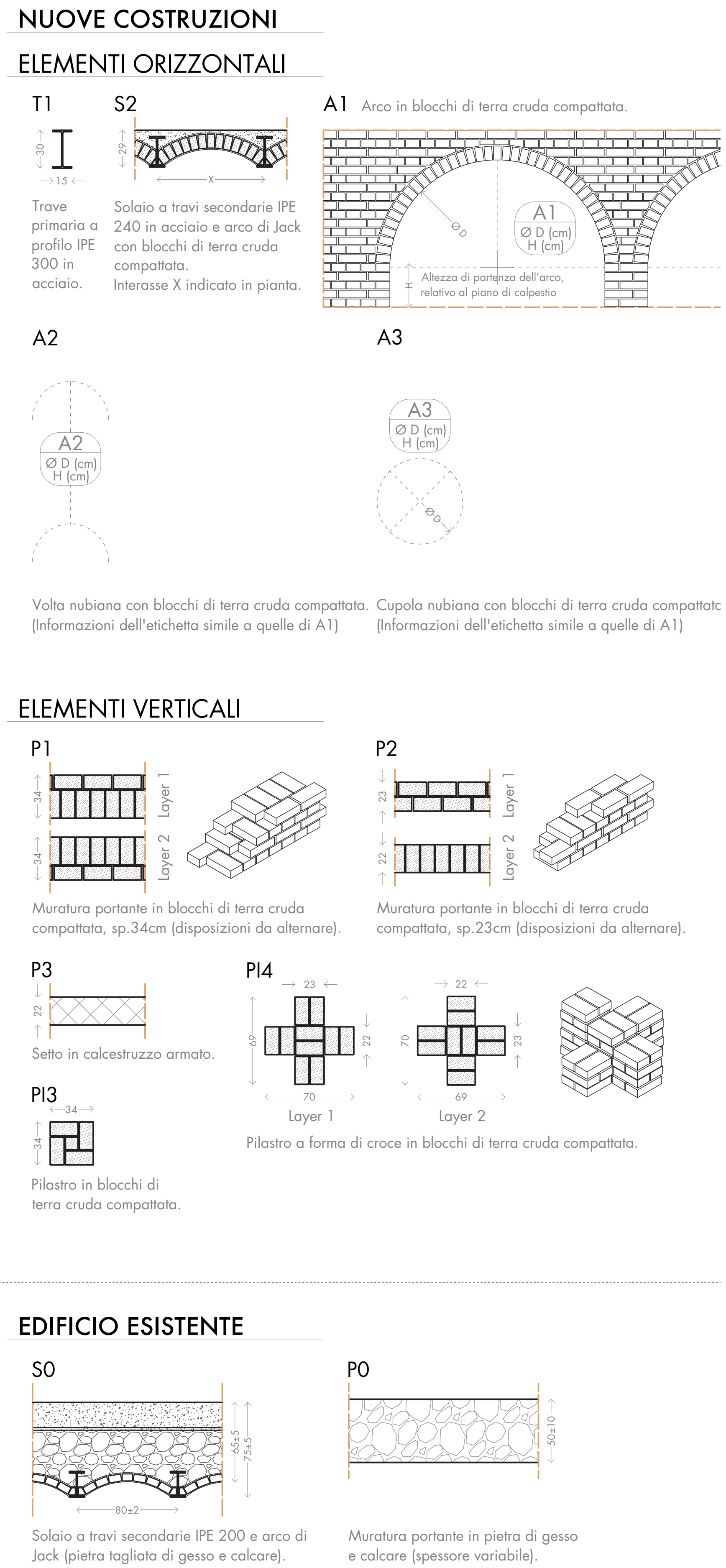


Fig. VII-20.Abaco strutturale degli impalchi strutturali. Scala 1/50.

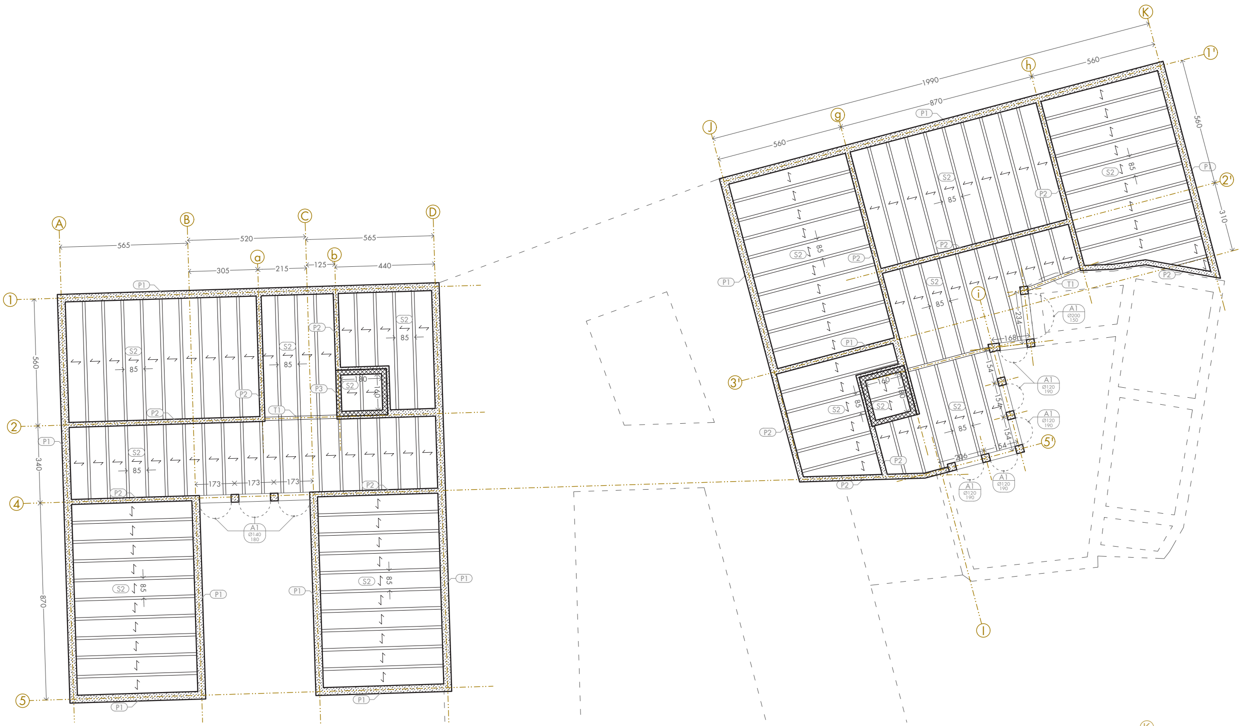


Fig. VII-22.Pianta strutturale delle secondo impalco. Scala 1/300

Fig. VII-21.Pianta strutturale delle primo impalco. Scala 1/300

3. ASSEMBLY STEPS

The assembly begins with the realization of the foundation plinths. Then they climb the foundation walls up to one and a half meters. Some armor is left protruding to reinforce the connection with the wall above.

Mounting the walls with raw earth bricks and done evenly over the entire surface of the building. It does not consist in mounting one wall after another but considers the whole layout as if it were unique. This peculiarity guarantees continuity between the nearby walls and avoids having particularly critical points. At the same time, reinforcing frames for openings are inserted: windows and doors.

Once the walls of the ground floor are completed, a wooden curb is resting on all the walls that will carry the beams. Now, you can fasten the beams and mount Jack's bows. A dry sprint are filled to adjust the level.

The first floor is built in the same way as the ground floor.

The building ends with the roof and its protruding parapets of the structure.

CONSTRUCTIVE ELEMENTS

1. VERTICAL ELEMENTS

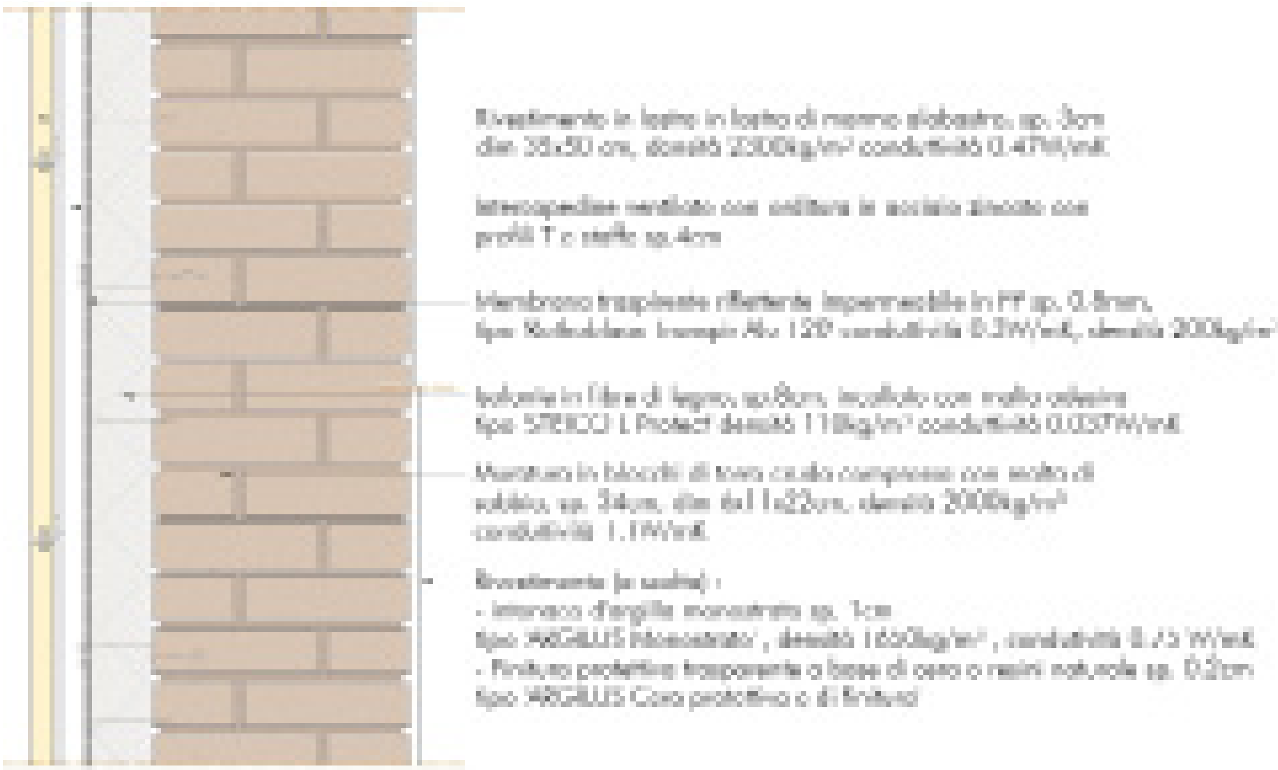
1.1. Building cover

1.1.a. C.V 01 | principale

A mixed vernacular and innovative system was adopted. The expensive ventilated façade increased comfort by being a screen against external thermal radiation. The traditional system is composed of hydroscopic and breathable materials.

CV 01	
Spessore	51 cm
Conduttività	0.364 W/m²K
Sfasamento	15.2 ore

Tab. VII-42.Prestazioni del pacchetto CV01



Strato	Componenti	Spessore s [cm]	Parametrici geometrici [cm]	Condutività U [W/mK]	Densità ρ [kg/m³]	Calore specifico Cp [J/kgK]	Trasmissione del vapore Sd [m]	Resistenza al vapore μ []
Finitura	Lastre di marmo alabastro	3	lunghezza 50 larghezza 35	0.47	2300	750	300	750
Ventilazione	Orditura metallica	4	larghezza 4	-	-	-	-	-
Tenuta all'acqua	Membrana traspirente riflettente	0.08		0.3	200	1800		166
Isolante	Pannello in fibre di legno	8	lunghezza 120 larghezza 40	0.037	110	2100	0.24	3
Struttura	Blocchi di terra cruda compressa	34	lunghezza 22 larghezza 6 profondità 11	1.1	2000	900	-	15
	Malta di sabbia	1		-	-	-	-	-
Finitura op.1	Intonaco di terra e calce monostrato	2		0.75	1650	850	0.1	-
Finitura op.2	Cera di carnauba	0.2		-	1.1	-	-	-

Tab. VII-43.Descrizione del pacchetto CV01

1.1.b. C.V 02 | Thin

It follows the same high inertia mixed system as the main lock. The lock is more subtle because it is developed on one floor in the community centre.

CV 02	
Spessore	41 cm
Conduttività	0.315 W/m²K
Sfasamento	12.7 ore

Tab. VII-44.Prestazioni del pacchetto CV02

Strato	Componenti	Spessore s *[cm]*	Parametrici geometrici	*[cm]*	Condutività U *[W/mK]*	Densità ρ *[kg/m³]*	Calore specifico Cp *[J/kgK]*	Trasmissione del vapore Sd *[m]*	Resistenza al vapore μ *[/]*
Finitura	Lastre di marmo alabastro	3	lunghezza larghezza	50 35	0.47	2300	750	300	750
Ventilazione	Orditura metallica	4	larghezza	4	-	-	-	-	-
Tenuta all'acqua	Membrana traspirente riflettente	0.08			0.3	200	1800		166
Isolante	Pannello in fibre di legno	8	lunghezza larghezza	120 40	0.037	110	2100	0.24	3
Struttura	Blocchi di terra cruda compressa	22	lunghezza larghezza profondità	22 6 11	1.1	2000	900	-	15
	Malta di sabbia	1			-	-	-	-	-
Finitura op.1	Intonaco di terra e calce monostrato	2			0.75	1650	850	0.1	-
Finitura op.2	Cera di carnauba	0.2			-	1.1	-	-	-

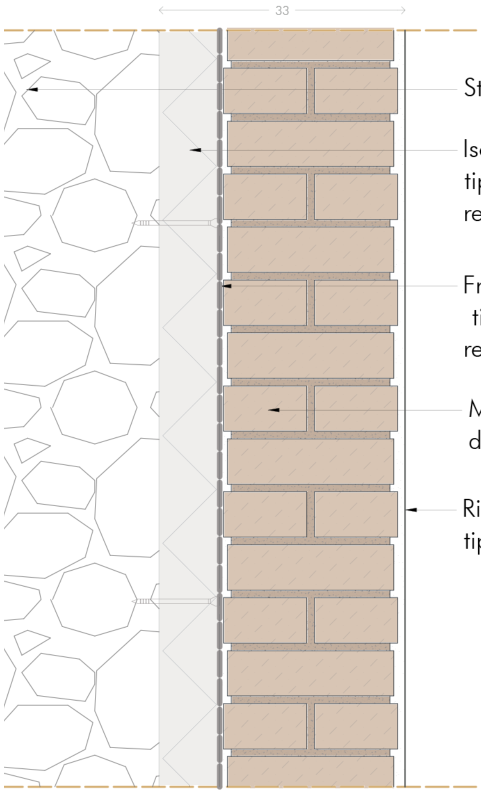
Tab. VII-45.Descrizione del pacchetto CV02

1.1.c. C.V 03 | Against existent

As the existing building is unable to support a new construction, it is reinforced by an adjacent structure. The significant presence of rising water in the existing building leads to a protection of the new closure.

CV 03	
Spessore	32 cm
Conduttività	0.371 W/m²K
Sfasamento	9 ore

Tab. VII-46.Prestazioni del pacchetto CVo3



Strato	Componenti	Spessore s [cm]	Parametrici geometrici	[cm]	Condutività U [W/mK]	Densità ρ [kg/m³]	Calore specifico Cp [J/kgK]	Trasmissione del vapore Sd [m]	Resistenza al vapore μ [1]
Isolante	Pannello in XPS riciclati	8	lunghezza larghezza		0.035	32			150
Tenuta all'acqua	Freno al vapore in polipropilene	0.08			0.3	290	1800	30	75000
Struttura	Blocchi di terra cruda compressa	22	lunghezza larghezza profondità	22 6 11	1.1	2000	900	-	15
	Malta di sabbia	1			-	-	-	-	-
Finitura	Intonaco di terra e calce monostrato	2			0.75	1650	850	0.1	-

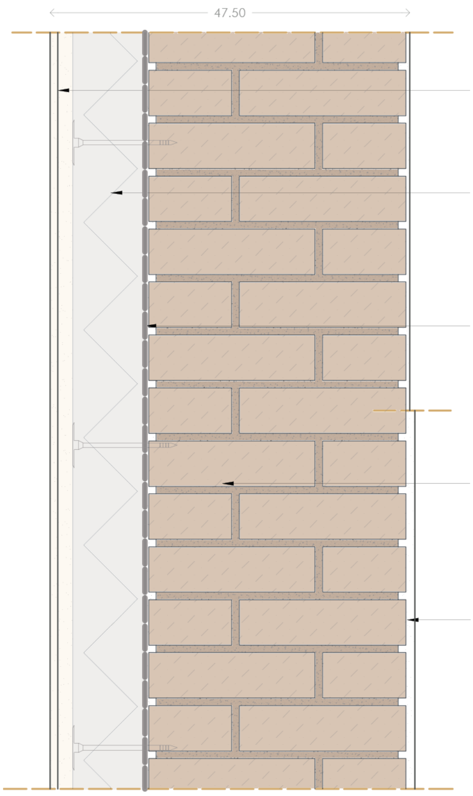
Tab. VII-47.Descrizione del pacchetto CVo3

1.1.d. C.V 04 | Social centre

It corresponds to the closures to a courtyard and the community centre. The courtyard protects against direct radiation, so the cost of a ventilated façade is not justified. In addition, promoting exchange with the courtyard helps with heating..

CV 04	
Spessore	48 cm
Conduttività	0.341 W/m²K
Sfasamento	14.8 ore

Tab. VII-48.Prestazioni del pacchetto CV04



Strato	Componenti	Spessore s [cm]	Parametrici geometrici	 [cm]	Condutività U [W/mK]	Densità ρ [kg/m³]	Calore specifico Cp [J/kgK]	Trasmissione del vapore Sd [m]	Resistenza al vapore μ [/]
Finitura	Intonaco di terra stabiliazato con calce	3			0.75	1650	850	0.1	-
Isolante	Pannello in fibre di legno	8	lunghezza larghezza	120 40	0.037	110	2100	0.24	3
Tenuta all'acqua	Membrana traspirente riflettente	0.08			0.3	200	1800		166
Struttura	Blocchi di terra cruda compressa	22	lunghezza larghezza profondità	22 6 11	1.1	2000	900	-	15
	Malta di sabbia	1			-	-	-	-	-
Finitura op.1	Intonaco di terra e calce monostrato	2			0.75	1650	850	0.1	-
Finitura op.2	Cera di carnauba	0.2			-	1.1	-	-	-

Tab. VII-49.Descrizione del pacchetto CV04

1.2. Partitions

1.2.a. P.V 01 | Bearing wallt

Its function is exclusively structural, which justifies its low thermal performance. A bridge is created between two comfort spaces.

PV 01	
Spessore	38 cm
Conduttività	1.78 W/m²K
Sfasamento	11.2 ore

Tab. VII-50.Prestazioni del pacchetto PV 01

Strato	Componenti	Spessore s [cm]	Parametrici geometrici	[cm]	Condutività U [W/mK]	Densità ρ [kg/m³]	Calore specifico Cp [J/kgK]	Trasmissione del vapore Sd [m]	Resistenza al vapore μ [1]
Finitura	Intonaco di terra e calce monostrato	2			0.75	1650	850	0.1	-
Struttura	Blocchi di terra cruda compressa	34	lunghezza larghezza profondità	22 6 11	1.1	2000	900	-	15
	Malta di sabbia	1			-	-	-	-	-
Finitura op.1	Intonaco di terra e calce monostrato	2			0.75	1650	850	0.1	-
Finitura op.2	Cera di carnauba	0.2			-	1.1	-	-	-

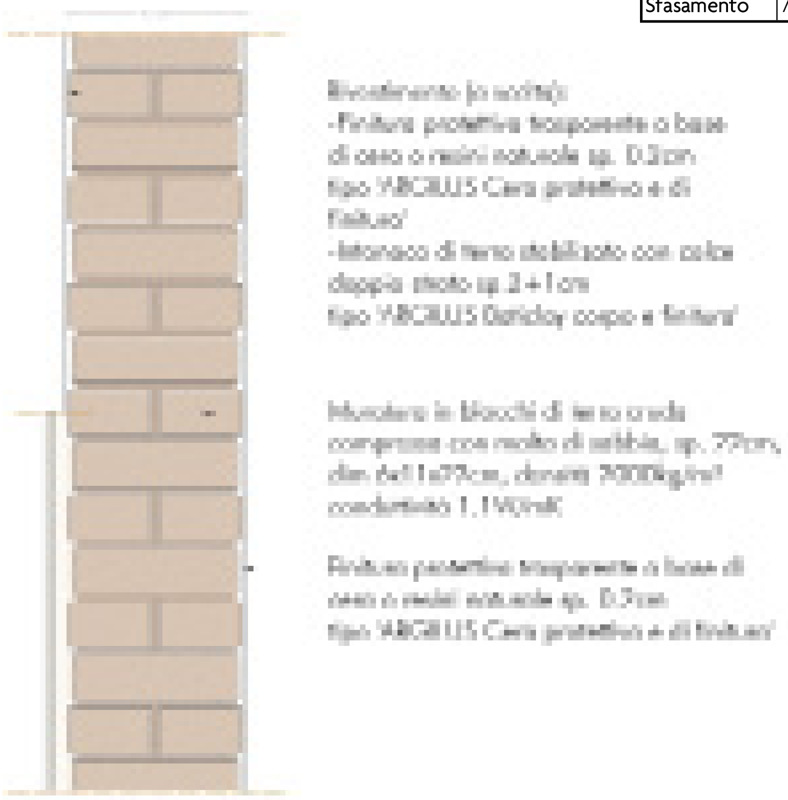
Tab. VII-51.Descrizione del pacchetto PVo1

1.2.b. P.V 02 | Bearing wallAdmin

Its function is exclusively structural, which justifies its low thermal performance. A bridge is created between two comfort spaces.

PV 02	
Spessore	25 cm
Conduttività	2.174W/m²K
Sfasamento	7.2 ore

Tab. VII-52.Prestazioni del pacchetto PV 02



Strato	Componenti	Spessore s [cm]	Parametrici geometrici [cm]	Condutività U [W/mK]	Densità ρ [kg/m³]	Calore specifico Cp [J/kgK]	Trasmissione del vapore Sd [m]	Resistenza al vapore μ [/]
Finitura	Intonaco di terra e calce monostrato	2		0.75	1650	850	0.1	-
Struttura	Blocchi di terra cruda compressa	22	lunghezza 22 larghezza 6 profondità 11	1.1	2000	900	-	15
	Malta di sabbia	1		-	-	-	-	-
Finitura op.1	Intonaco di terra e calce monostrato	2		0.75	1650	850	0.1	-
Finitura op.2	Cera di carnauba	0.2		-	1.1	-	-	-

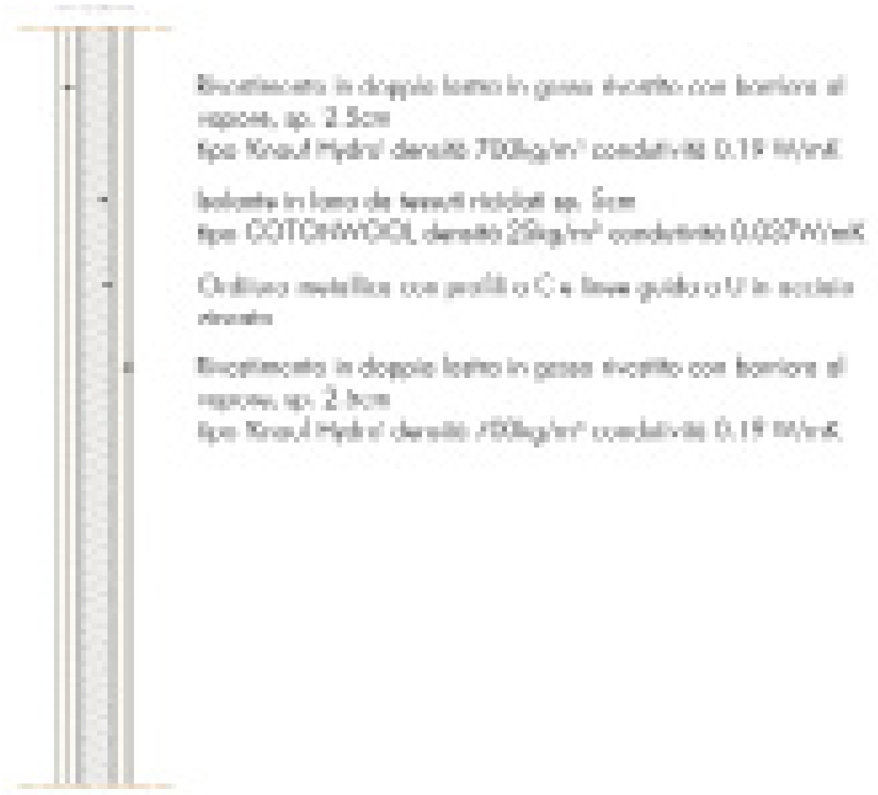
Tab. VII-53.Descrizione del pacchetto PV 02

1.2.c. *P.V 03 | Thin partition*

Here is a simple metal frame wall system. The special feature is the use of recycled fabrics as insulation in the spirit of recovering war waste..

PV 03	
Spessore	10 cm
Conduttività	0.568 W/m²K
Sfasamento	1.9 ore

Tab. VII-54.Prestazioni del pacchetto PV 03



Strato	Componenti	Spessore s [cm]	Parametrici geometrici	[cm]	Condutività U [W/mK]	Densità ρ [kg/m³]	Calore specifico Cp [J/kgK]	Trasmissione del vapore Sd [m]	Resistenza al vapore μ [/]
Finitura	Intonaco di gesso	1			0.34	1000	1000		10
	Lastra di cartongesso	2.5	lunghezza larghezza	280 120	0.21	800	1100	-	10
Struttura	Orditura metallica con profili a C e linee guida a U	5	interasse	50	-	-	-	-	-
Isolante	Pannello in lana da tessuti riciclati	5	lunghezza larghezza	160 60	0.037	25	1600	-	2
Finitura	Lastra di cartongesso	2.5	lunghezza larghezza	200 125	0.21	800	1100	-	10

Tab. VII-55.Descrizione del pacchetto PV 03

2. HORIZZONTAL ELEMENTS

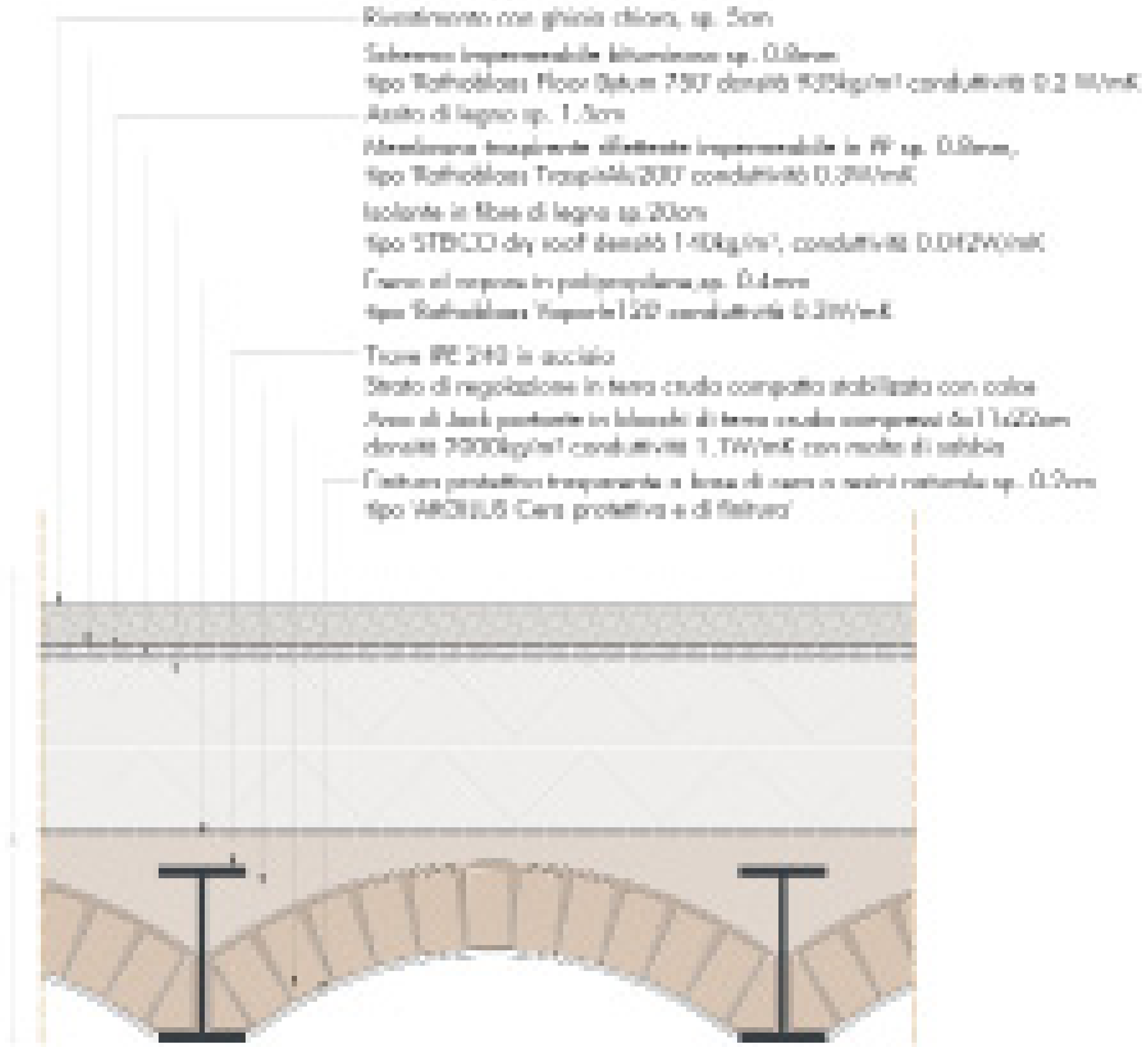
2.1. Building cover

CO 01	
Spessore	60 cm
Conduttività	0.189 W/m²K
Sfasamento	19.3 ore

Tab. VII-56.Prestazioni del pacchetto CO 01

2.1.a. C.o 01 | Flat roof

Like vertical closures, it is a mixed heat-reflective system with high inertia and insulation.



Strato	Componenti	Spessore s [cm]	Parametrici geometrici	[cm]	Condutività U [W/mK]	Densità ρ [kg/m³]	Calore specifico Cp [J/kgK]	Trasmissione del vapore Sd [m]	Resistenza al vapore μ [/]
Finitura	Ghiaia	5	lunghezza	50	1.2	1700	-	-	-
Tenuta all'acqua	Membrana bituminosa	0.08			0.2	935	120	38	-
Regolazione	Pannello di legno OSB	1.5			0.14	600	2000	-	0.013
Tenuta all'acqua	Membrana traspirente riflettente	0.08			0.3	200	1800		166
Isolante	Pannello in fibre di legno	20	lunghezza larghezza	120 40	0.042	140	2100	0.24	3
Tenuta all'acqua	Freno al vapore in polipropilene	0.08			0.3	290	1800	30	75000
Regolazione	Terra stabilizata compatta	5			1.1	2000	900	-	15
Struttura	Blocchi di terra cruda compressa	11	lunghezza larghezza profondità	22 6 11	1.1	2000	900	-	15
	Malta di sabbia	1			-	-	-	-	-
	Trave IPE 240	24	larghezza	12	45	7850	-	-	-
Finitura	Cera di carnauba	0.2			-	1.1	-	-	-

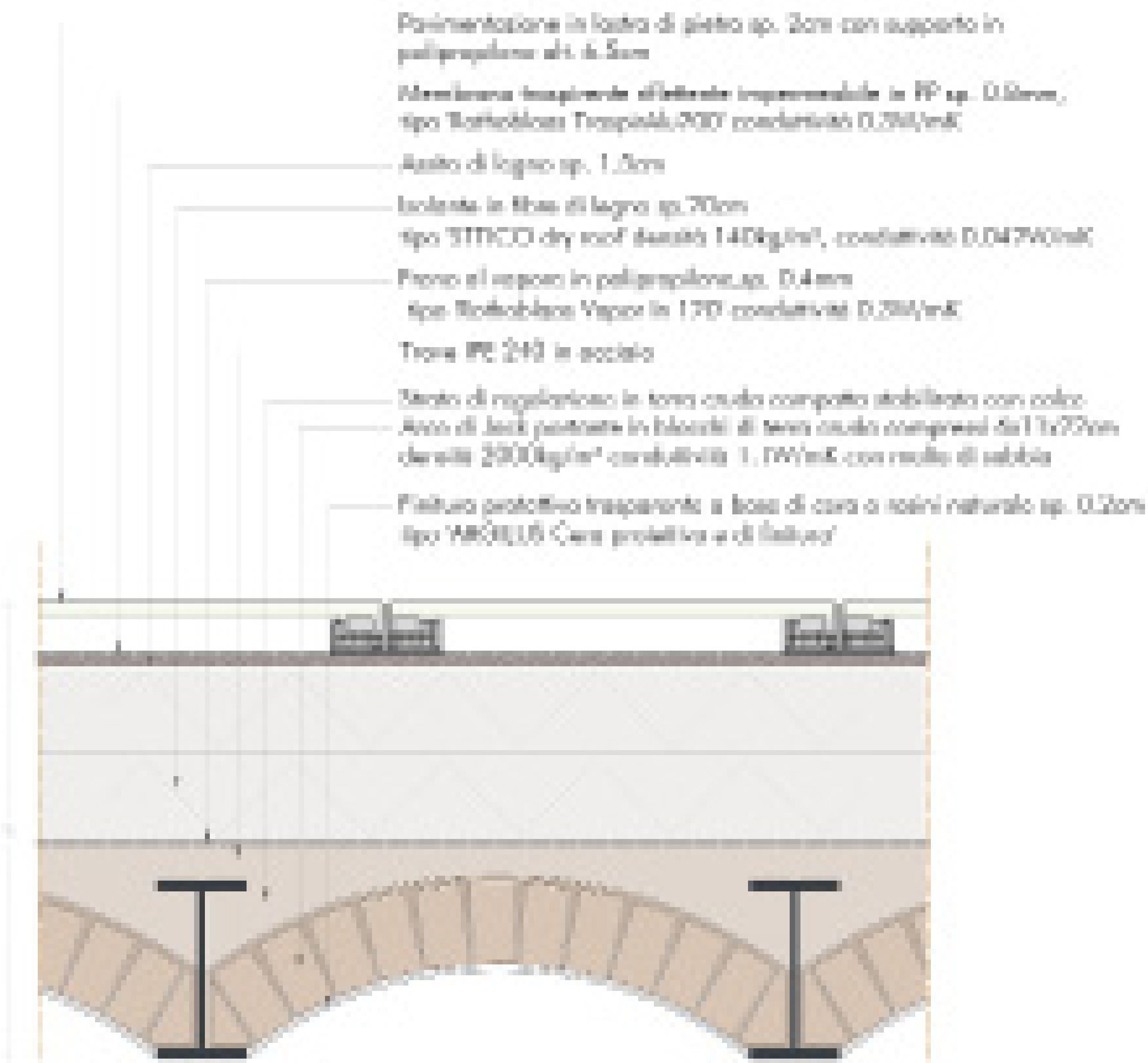
Tab. VII-57.Descrizione del pacchetto CO 01

2.1.b. C.0 02 | Roof terrace

The walkable cladding allowed for an effect similar to a ventilated and reflective roof structure.

CO 02	
Spessore	62 cm
Conduttività	0.190W/m²K
Sfasamento	19 ore

Tab. VII-58.Prestazioni del pacchetto CO 02



Strato	Componenti	Spessore s [cm]	Parametri geometrici	[cm]	Condutività U [W/mK]	Densità ρ [kg/m³]	Calore specifico Cp [J/kgK]	Trasmissione del vapore Sd [m]	Resistenza al vapore μ [J]
Finitura	Lastre di marmo alabastro	3	lunghezza larghezza	35 35	0.47	2300	750	300	750
Ventilazione	Intercapedine	5			-	-	-		-
Tenuta all'acqua	Membrana traspirente riflettente	0.08			0.3	200	1800		166
Isolante	Pannello in fibre di legno	20	lunghezza larghezza	120 40	0.042	140	2100	0.24	3
Tenuta all'acqua	Freno al vapore in polipropilene	0.08			0.3	290	1800	30	75000
Regolazione	Terra stabilizata compatta	5			1.1	2000	900	-	15
Struttura	Blocchi di terra cruda compressa	11	lunghezza larghezza profondità	22 6 11	1.1	2000	900	-	15
	Malta di sabbia	1			-	-	-	-	-
	Trave IPE 240	24	larghezza	12	45	7850	-	-	-
Finitura	Cera di carnauba	0.2			-	1.1	-	-	-

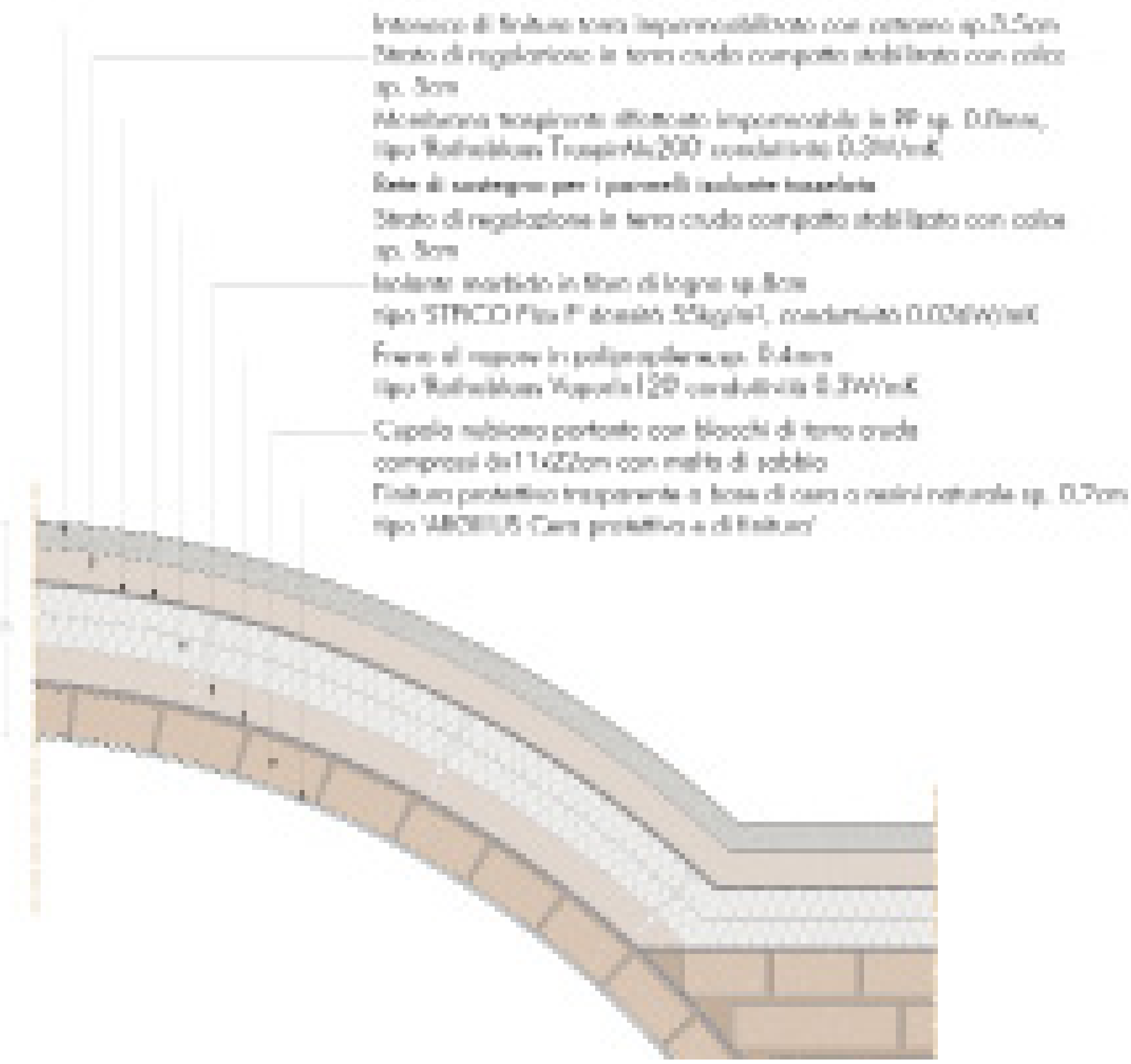
Tab. VII-59.Descrizione del pacchetto CO 02

2.1.c. C.O 03 | Nubian roof

The vaults and domes are built according to the traditional Nubian principle with a structure made entirely of earth. A layer of insulation is added to increase the inertia of the roof.

CO 03	
Spessore	30 cm
Conduttività	0.165 W/m²K
Sfasamento	15.2 ore

Tab. VII-60. Prestazioni del pacchetto CO03



Strato	Componenti	Spessore s [cm]	Parametrici geometrici [cm]	Condutività U [W/mK]	Densità ρ [kg/m³]	Calore specifico Cp [J/kgK]	Trasmissione del vapore Sd [m]	Resistenza al vapore μ []
Finitura	Intonaco stabilizato con bitumo	3.5		0.26	1300	-	1750	50000
Regolazione	Terra compatta	5		0.3	290	1800	30	75000
Isolante	Rete di sostegno	0.2		-	-	-	-	-
	Pannello in fibre di legno	8	lunghezza 120 larghezza 40	0.036	55	2100	0.24	2
Tenuta all'acqua	Freno al vapore in polipropilene	0.08		0.3	290	1800	30	75000
Struttura	Blocchi di terra cruda compressa	6	lunghezza 22 larghezza 6 profondità 11	1.1	2000	900	-	15
	Malta di sabbia	1		-	-	-	-	-
Finitura	Cera di carnauba	0.2		-	1.1	-	-	-

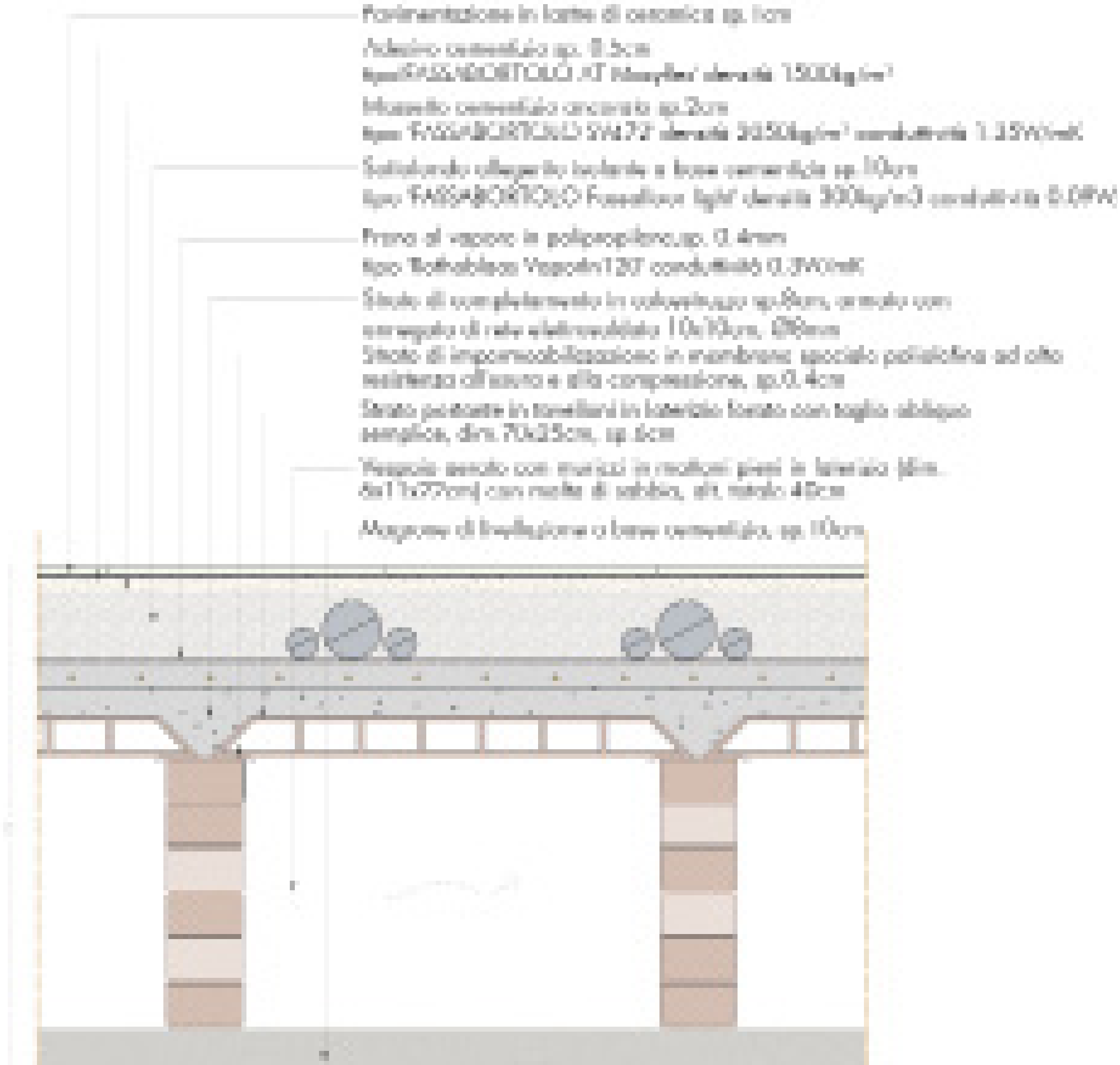
Tab. VII-61. Descrizione del pacchetto CO03

2.1.d. C.0 04 | Solaio a terra

The structure is made of concrete to protect itself from the dampness of the ground. The temperature of the ground, being around 20°C, does not insulate the building passively.

CO 04	
Spessore	77 cm
Conduttività	0.657 W/m²K
Sfasamento	9.8 ore

Tab. VII-62.Prestazioni del pacchetto CO 04



Strato	Componenti	Spessore s [cm]	Parametrici geometrici	 [cm]	Condutività U [W/mK]	Densità ρ [kg/m³]	Calore specifico Cp [J/kgK]	Trasmissione del vapore Sd [m]	Resistenza al vapore μ [/]
Finitura	Piastrelle di ceramica	1	lunghezza larghezza	25 25	1	2300	-	100000	-
Adesivo	Adesivo cementizio	0.5			1.2	1500	100	-	100
	Massetto cementizio	2			1.35	2050	100	-	100
Regolazione	Sottofondo allegerito a base	10			0.09	300	1000	-	0.33
Tenuta all'acqua	Freno al vapore in polipropilene	0.08			0.3	290	1800	30	75000
	Solaio in calcestruzzo armato	5			1.48	2200	-	18	225
Struttura	Tavelloni di terra cotta	6	lunghezza larghezza	40 25	0.34	870	-	0.03	0.5
	Vespaio aerato	40			-	-	-	-	-
Ventilazione	Mattoni di terra cotta	40	lunghezza larghezza profondità	22 6 11	0.35	900	-	0.03	0.5
Regolazione	Magrone di cemento	5			1.4	2000	-	-	-

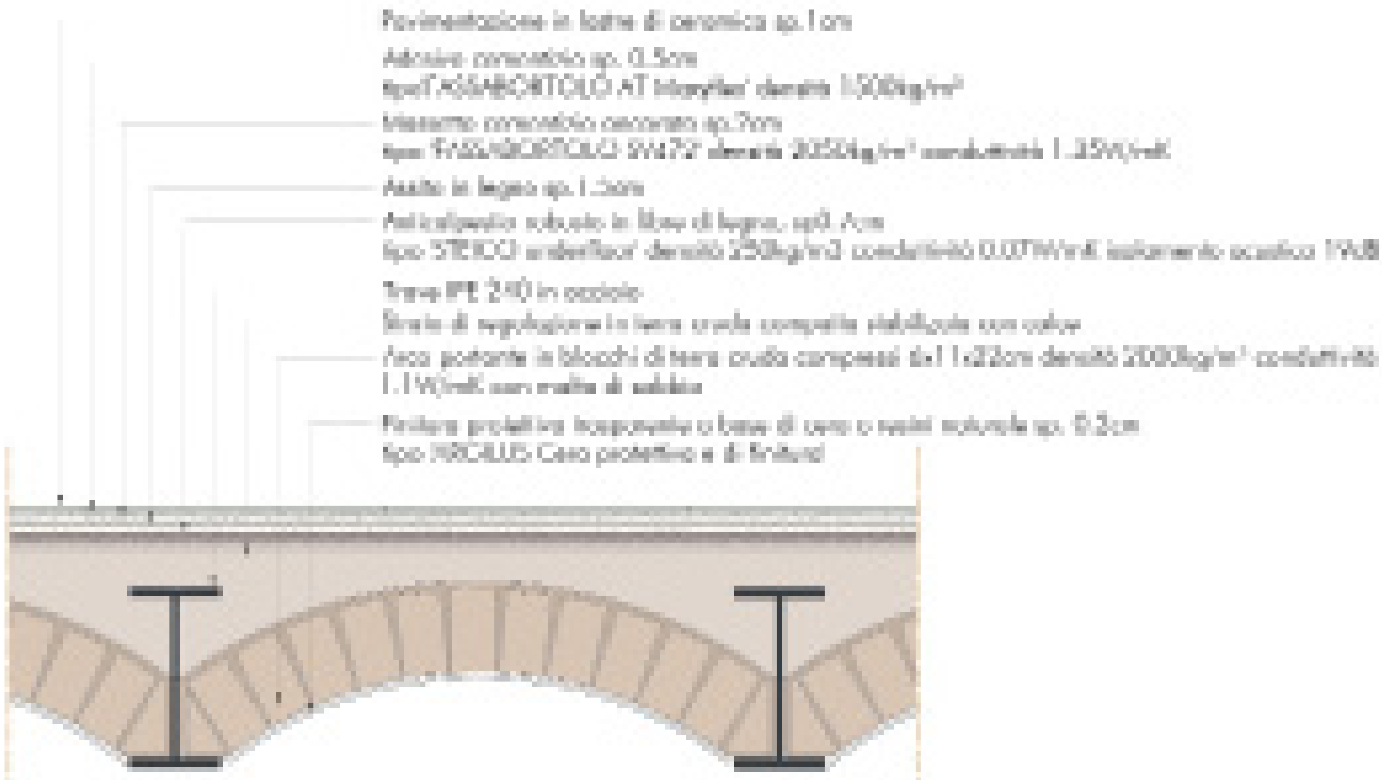
Tab. VII-63.Descrizione del pacchetto CO 04

2.2. Partition

2.2.a. P.O 01 | Intermediate ceiling

PO 01	
Spessore	35 cm
Conduttività	2.199 W/m²K
Sfasamento	2.5 ore

Tab. VII-64.Prestazioni del pacchetto PO 01



Strato	Componenti	Spessore s [cm]	Parametrici geometrici	[cm]	Condutività U [W/mK]	Densità ρ [kg/m³]	Calore specifico Cp [J/kgK]	Trasmissione del vapore Sd [m]	Resistenza al vapore μ [1]
Finitura	Piastrelle di ceramica	1	lunghezza larghezza	25 25	1	2300	-	100000	-
Adesivo	Adesivo cementizio	0.5			1.2	1500	100	-	100
	Massetto cementizio	2			1.35	2050	100	-	100
Tenuta all'acqua	Membrana bituminosa	0.08			0.2	935	120	38	
Regolazione	Pannello di legno OSB	1.5			0.14	600	2000	-	0.013
Isolante	Anticalpestio in fibre di legno	0.7	lunghezza larghezza	79 59	0.07	250	-	-	5
Regolazione	Terra stabilizata compatta	5			1.1	2000	900	-	15
Struttura	Blocchi di terra cruda compressa	11	lunghezza larghezza profondità	22 6 11	1.1	2000	900	-	15
	Malta di sabbia	1			-	-	-	-	-
	Trave IPE 240	24	larghezza	12	45	7850	-	-	-
Finitura	Cera di carnauba	0.2			-	1.1	-	-	-

Tab. VII-65.Descrizione del pacchetto PO 01

VIII. PASSIVE DESIGN

INDICE DEL CAPITOLO

STRATEGY

1. GENERALITY

1.1. Objective

The overall strategy is to be at most self-sufficient. Taking into account the instability in the city, developing an independence relative to the services allowed to ensure a continuity in the functioning of the school. No matter what happens outside, the building remains functional. It creates a reliable environment for the population.

The following set of energy strategies serve to create a comfortable environment for users inside the building based on quantifiable and scientific criteria.

Although the desire of the school is to produce a passive building, the primary goal is to ensure the comfort of users. Therefore, some active systems are still implemented and will complement the design choices.

1.2. Retrieval of climatic data

In order to carry out energy studies, it is first necessary to recover the climate data of Mosul. In fact, energy efficiency is strongly linked to the external climate due to the thermal exchanges between the system and its environment. Due to its history, Iraq is a country far from European considerations. If you add the fact that the country has few weather facilities, it is difficult to get free climate data for Mosul.

The situation has been circumvented thanks to the History+ software of Meteoblue (https://www.meteoblue.com/fr/historyplus). The company provides local weather forecasts for the whole world. Their software uses as much climate and geographic data as possible to estimate the missing data. In this way it was possible to obtain the climatic trend accurately simulated for at least the last 20 years.

The general climate profile is set out in the introductory part of the report.

Then, to ensure date compatibility with Climate Consultant, Rhinoceros 3D and TRNSYS software, the data was converted to the appropriate formats using Python, Matlab and Microsoft Excel programs.

2. PSYCHOMETRIC STUDY

To ensure strategies to develop, there is a scientific tool that is the psychometric diagram. It is based on the fact that the efficiency of the different strategies arises from their compatibility with the external climate.

For psychometric analysis, a study was done with the Climate consultant software. The strategic advice is summarised in the following graph (FigVIII-2, right).

Compared to the ambient temperature and humidity in Mosul, the greatest way to ensure the comfort of users is the use of a cooling system. A system like this is expensive and should be avoided. Eventually, the use of a ceiling fan will be examined, it creates a feeling of freshness, and the perceived temperature drops by 3 degrees.

Except for active rescaling systems, the REASONING related to the ASHRAE regulation evaluates the darkening strategies with 20% success and ventilation with about 12%.

With different models, ventilation always remains the passive solution to exploit to optimize internal comfort.

There are limitations to these studies. First of all, they are models created according to foreign regulations. Consequently, compatibility with the Iraqi context must be put into perspective. In addition, it does not take into account the constructive and material

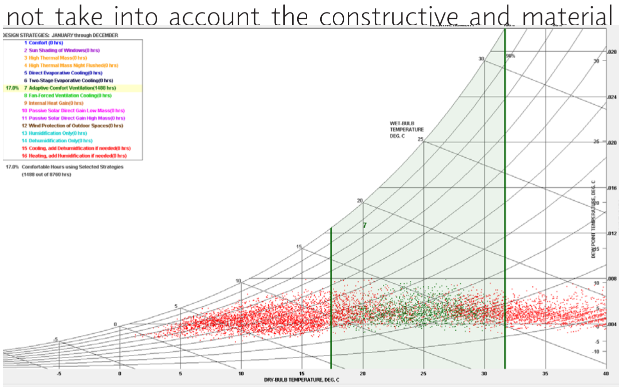


Fig. VIII-01.Contribuzione della ventilazione al confort @ClimateConsultant

peculiarities of the building and its context. And an average situation. Finally, it assumes continuous use of the building, but the school remains closed during the

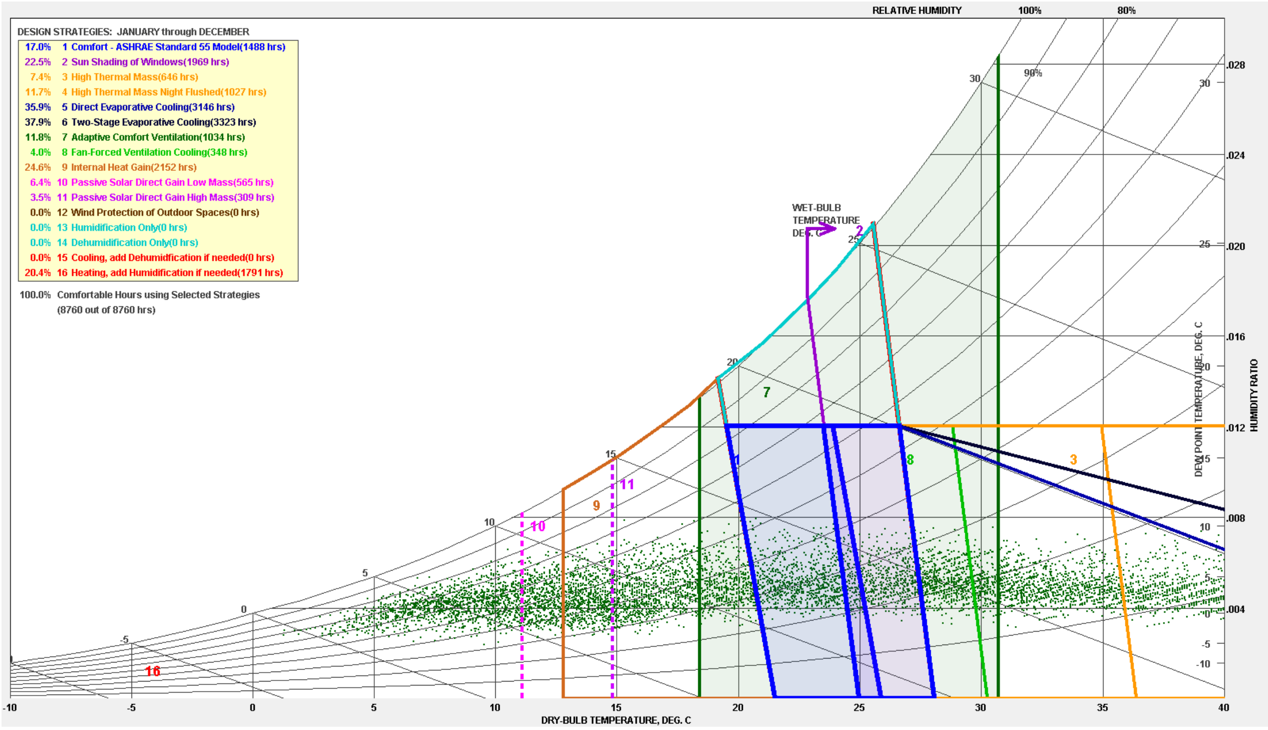


Fig. VIII-02.Strategie effetive in accordo con la normativa ASHRAE sul confort @ClimateConsultant

two months of summer when temperatures are critical. The percentage comfort performance is weighted.

3. VERNACULAR ANALYSIS

The current design traditions are born from the empirical development on architecture. For this reason, vernacular design remains a relevant indicator of strategies to adopt in similar regions.

During the study of Arabic vernacular architecture, some design strategies related to energy behavior were shown.

In sum, the Arab building develops ventilation thanks to special systems that are the courtyards and wind towers. In addition, it makes maximum use of shading to protect against the solar radiation that heats the casing. Finally, the choice of materials is turned towards high inertia systems.

4. DESIGN CHOICES

Strong compositional and constructive choices have been made in an aesthetic logic but also in accordance with the above strategic assessment to provide the best comfort to the occupants and high energy independence.

4.1. Enclosure management

1.4.a. Protection against radiation in summer

The choice to have a clear ventilated casing was born from the idea of providing protection against the sun. The ventilated façade protects against direct thermal radiation. Less energy is absorbed by the building. In addition, the light color of the coating reflects the light waves. The flat roof on-per block is thought out in the same way.

1.4.b. Thermal storage

The entire casing is insulated and composed of high inertia materials. The aim is to limit thermal variations. In summer, the building preserves the cold of the night. In winter, on the other hand, inertia slows down the cooling of spaces at night. The super insulated flat roof blocks the release of heat.

4.2. Opening management

1.4.a. Strategic positioning

After the calculation of cumulative irradiation (presented later), it was decided to close the west and south facades to protect the building from direct radiation. A diffused, less warm light is preferable both from the point of view of visual and thermal comfort.

1.4.b. Windows

The window with double low emissive glass is placed towards the inside of the room, to reduce direct radiation. On the façade, a system of mobile and fixed blackouts concludes the protection.

In addition to the windows, there are opening ventilation vents. They help to decrease the inertia of the building. In summer, they accelerate cooling at night or during mild days, thanks to cross ventilation.

4.3. Basement configuration.

The building is basement in architectural coherence with the existing house. This configuration seeks to increase the exchange with the sub-ground. With a weakly insulated ground closure with low inertia, it helps cooling by favoring the exchange of heat with the under the ground always quite cold in summer and quite hot in winter (with an average temperature of about 20 ° C). Instead, this decreases energy exchanges with the particularly hot atmosphere in summer.

The closure made of concrete is ventilated, it is a protection against underground moisture whose damage is visible in the houses of Mosul.

4.4. Construction systems

1.4.a. Raw earth wall.

Raw earth with its high inertia constitutes an adequate thermal protection with high phase shift. Avoid thermal points. In addition, the exposed wall inside favors hygrometric adjustment in space.

1.4.b. Partitions

Weak thermal insulation of horizontal intermediate partitions creates a thermal bubble of classroom bodies by increasing heat exchange. It helps cool the classrooms on the first floor exposed to the sun. Procure, however, a sufficient sound insulation.

4.5. Traditional spaces

1.4.a. Inner courtyard.

The courtyard is the central element of the passive behavior of the building. Pick up the wind to increase ventilation. At the thermal level, in summer it captures the cold of the night to release it during the day. In winter, the courtyard welcomes the light and distributes the heat.

1.4.b. Iwan Spaces.

They are balcony-type transitive spaces. Oriented towards the south they create a protective shading. They are elements that open the façade for cold days. Oriented towards the south they are a strategy to captare the heat.

4.6. Active strategy

1.4.a. Photovoltaic panels.

In the city under post-war reconstruction, photovoltaic panels ensure minimal independence from weakly operational services. It also opens a door to sustainability.

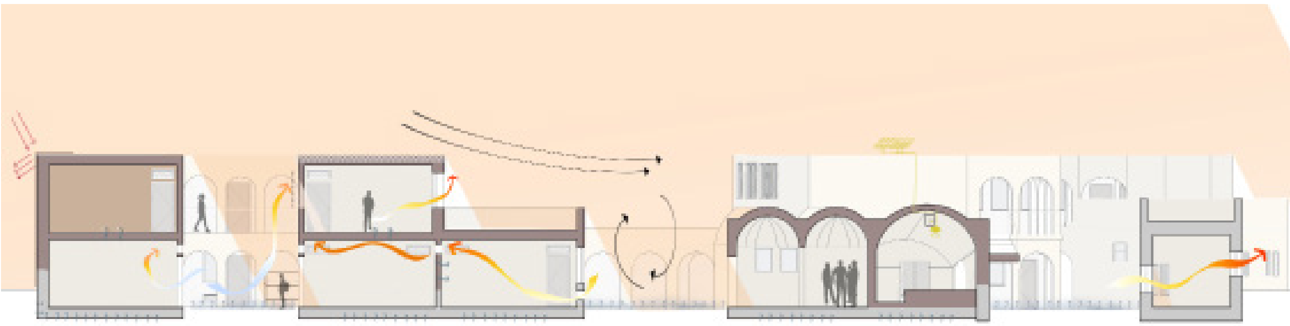


Fig. VIII-03.Schematic design in staggione estiva

VISUAL COMFORT - NATURAL LIGHT

One of the first steps of architectural design is the study of the natural light that enters the building. Natural light is a necessary element for humans, it interacts with physical and psychological health. In the school, the availability of natural light improves visual comfort and helps to reduce the electricity requirement due to lighting. The following studies were done simultaneously with the architectural composition.

1. EXTERNAL RADIATION

1.1. Generality

The study begins with a study of the radiation on the building envelope. The need for this analysis comes from the disavowal of the Iraqi environment. It was a preliminary study to give the basics to the composition of the casing, and verify the efficiency of the geometry.

Solar irradiation is the flux of radiation emitted by the sun across the frequency spectrum that hits one surface per unit area. It composes direct and diffuse radiation. The phenomenon of irradiation results from the irradiation of the surface. And energy exchange in the form of heat. Solar radiation brings light and heat into the building. In Mosul, despite the need to welcome natural light inside buildings, it is absolutely vital to avoid excessive heat input. The study of irradiation helps to find a comfortable balance.

1.2. Study

Solar radiation is designed with Rhinoceros 3D and Grasshopper software. Rhinoceros 3D is a computer-aided design software used in the field of industrial design and architecture. Grasshopper is a calculation module that uses the Rhinoceros environment to model.

The geometry of the building is usually plotted in Rhinoceros 3D, in this case it is plotted in Sketchup and loaded into the Rhinoceros environment. The building is designed and the winning buildings are able to intervene in the trend of solar radiation.

The program used in Grasshopper comes from the public library Food4Rhino. It treats the climate file and extracts data on solar radiation and calculates the solar radiation on the surfaci represents in the Rhinoceros environment.

1.3. Results

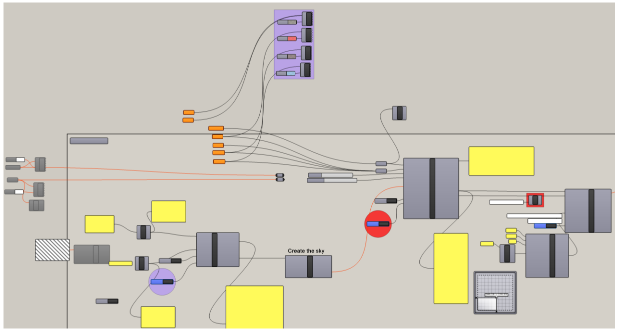


Fig. VIII-04.Interfaccia software globale

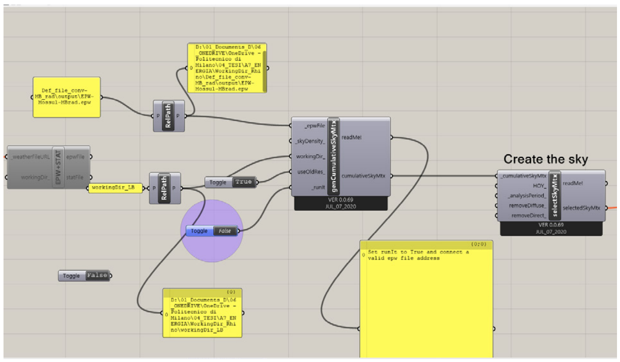


Fig. VIII-05.Interfaccia software del tratamento climatico

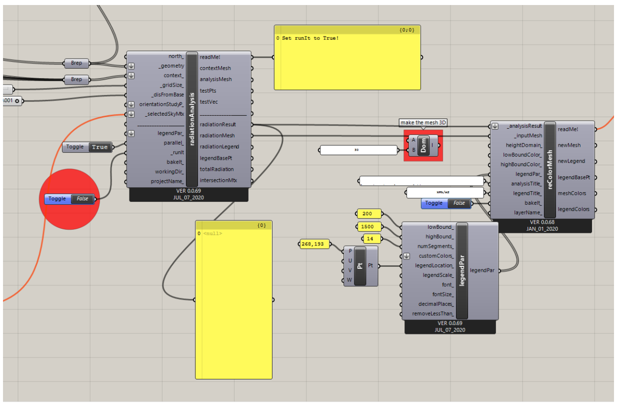


Fig. VIII-06.Interfaccia software del calcolo dell'irraggiamento

Annual solar radiation at each point of the casing is achieved by the process described above.

The critical surfaces are above all the roofs. Geometry with flat roofs is particularly suitable. Reduces the surface in contact with the outside. In this situation, the use of skylights looks dangerous.

In the composition of the facades, the radiation profile shows a comfortable possibility to open on the north and east sides. In addition, on the first floor, it is advisable to avoid the west side and always favor the north. Instead, the south side is always critical.

For this reason, the composition provides to close the south side. Nevertheless, complete closure is not acceptable for interior spaces. For this, the covered open spaces in front of the classrooms shield direct radiation and let in a minimum of light.

To multiply the possibility of opening on the other sides, the configuration with courtyard creates additional facades protected from direct radiation. Except for the central court for which improved protection will be implemented, the study shows that courts are favorable environments in the Iraqi climate.

2. EVALUATION OF THE QUAILITY OF INTERIOR SPACES

In European and Italian regulations, the design quality linked to natural light depends on various criteria.

2.1. Illuminance

Illuminance corresponds to the ratio of the luminous flux affecting a surface. It is measured in lux. Represents the amount of light available at a spatial point.

For a school space, the EN12464 standard provides for an illuminance of more than 300lux. This value contains artificial lighting of the space. The goal with respect to the illuminance criterion in the design of natural light is to participate as much as possible.

2.2. The RAI

The Aeroilluminante Report, commonly RAI, represents the relationship between the surface of the windows that can be opened that participates in the lighting and ventilation of a space and the floor surface of the same. It made it possible to evaluate the accessibility of a space to light and ventilation.

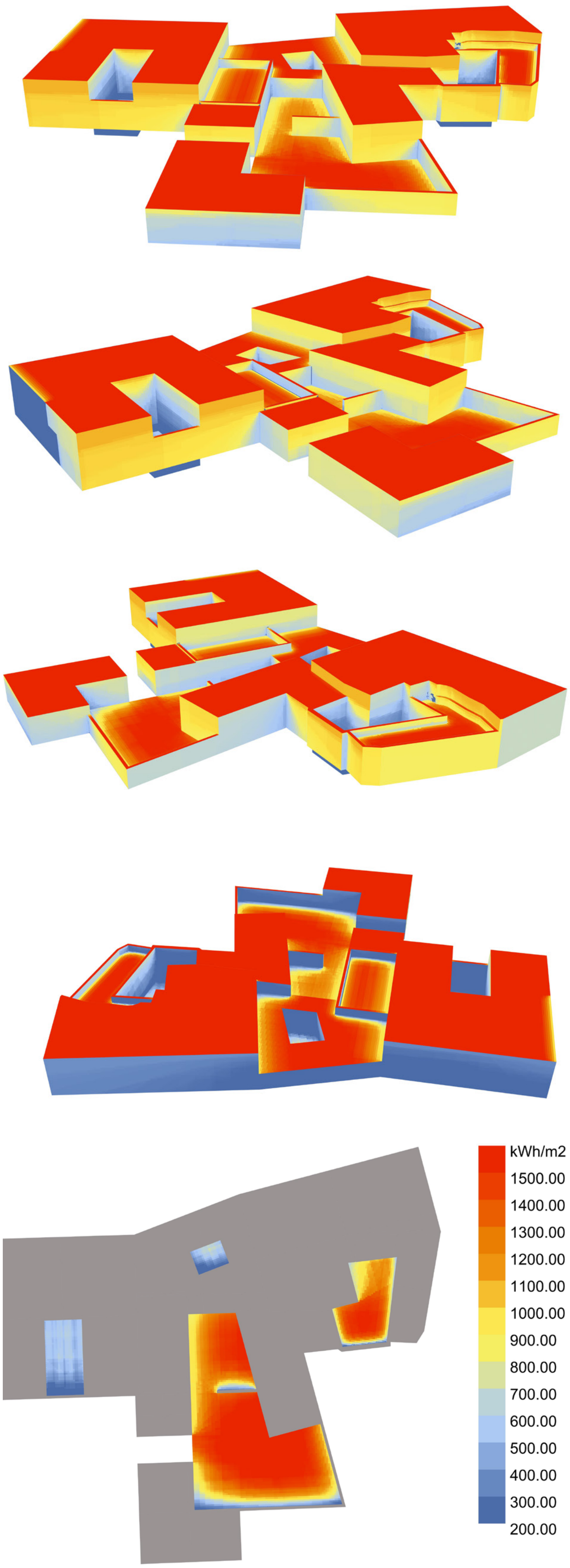


Fig. VIII-07.Irraggiamento solare cumulativo annuale sull'involucre

From the Italian legislation, the RAI must exceed 1/8. For the Al-Nuri school it was designed in order to have the appropriate relationships.

2.3. The FLD

The Average Daylight Factor, commonly FLD, expresses the ratio, as a percentage, between the average illuminance of the environment and the illuminance that occurs at the same time on an external horizontal surface exposed to the sky in a covered climatic situation. It represents the quality of light available in a space in comparison to the outdoor lighting situation.

From the UNI 10840 standard, the FLD in Europe must exceed 2% to guarantee a suitable quality of light.

3. INTERIOR LIGHTING

3.1. Process

To study the trend of natural light inside the building, a study was done with the Dialux software. It is a free tool from the German Institute for Technology Applied to Lighting (DIAL) for professional lighting design.

Modelling begins with the geometric modelling of buildings to study and adjacent and neighbouring buildings capable of changing the outdoor lighting environment. The internal classrooms to be studied in their geometry and with their coatings are modeled. Once the windows and the different dimming systems have been posted, it is possible to simulate the trend of natural light.

Modelling takes into account the spatial location of the building, specific climatic conditions and the date.

3.2. Choice in modelling

For this study, the residential block to the north, the adjacent administrative building and the university to the south were considered. The influence of other buildings is considered minimal. At the geometric level, the software being limited are not modeled the vaulted roofs.

To lighten the internal study, only the spaces of primary functional importance are represented, which are the classrooms, the offices and the library. Service spaces are not studied.

3.3. Results

Two main simulations were made to describe the

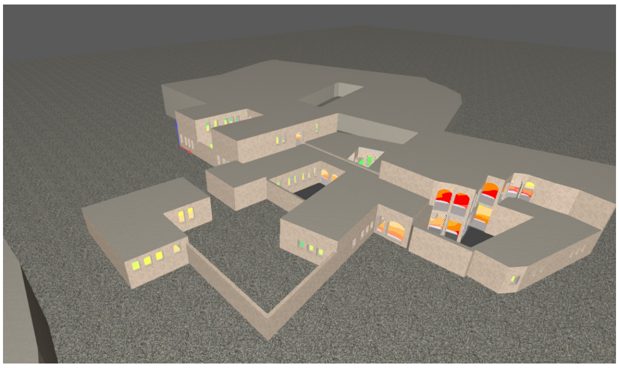


Fig. VIII-08.Modello dell'edificio e il suo contesto

SPAZI				RAI	
Corpi	Piano	Tipo	Area	normativo	effetivo
[]	[]	[]	m2	[1]	[1]
Admin	0	Ufficio secondarie	16.0	0.125	0.132
Admin	0	Ufficio principale	12.6	0.125	0.335
Admin	0	Ufficio secondarie	16.1	0.125	0.130
Scuola	0	Libreria	70.3	0.125	0.244
Scuola	0	Aula didattica	44.7	0.125	0.164
ScuolaEst	0	Sala professori	16.7	0.125	0.172
ScuolaEst	0	Sala studio	20.2	0.125	0.220
ScuolaEst	0	Aula didattica	44.7	0.125	0.14
ScuolaEst	0	Aula didattica	44.7	0.125	0.188
ScuolaEst	0	Aula didattica	43.3	0.125	0.162
ScuolaEst	1	Aula didattica	44.7	0.125	0.211
ScuolaEst	1	Aula didattica	44.7	0.125	0.258
ScuolaEst	1	Aula didattica	43.3	0.125	0.194
ScuolaOvest	0	Sala professori	15.3	0.125	0.138
ScuolaOvest	1	Sala studio	17.3	0.125	0.261
ScuolaOvest	0	Aula didattica	44.7	0.125	0.133
ScuolaOvest	0	Aula didattica	44.7	0.125	0.180
ScuolaOvest	0	Aula didattica	44.7	0.125	0.180
ScuolaOvest	1	Aula didattica	44.7	0.125	0.141
ScuolaOvest	1	Aula didattica	44.7	0.125	0.164
ScuolaOvest	1	Aula didattica	44.7	0.125	0.164
Centro	0	Aula didattica	44.8	0.125	0.133
Centro	0	Sala mista	27.4	0.125	0.192

Tab. VIII-01.Rapporti Aero-illuminanti

situation, one on May 15 at 11 a.m. and one on December 15 at 3 p.m. in the open air. These two simulations give a simple overview of the situation, for the two main Iraqi seasons. The study was not deliberately done at the time of the solstices to represent more standard configurations and is not specific to the solstices. In addition to these two simulations, there is also a simulation with the same conditions as the daylight factor calculation.

On May 15, the amount of light is acceptable but moderate. The effect of iwan spaces is particularly noticeable, as they bring diffused light and prevent glare.

Fig. VIII-09.Illuminamento al 15/05 alle 11:00

Fig. VIII-10.Illluminamento al 15/12 alle 15:00

The greatest aspect of this light profile is the uniformity in the distribution of light. Considering, the importance of this parameter, is appreciated.

Instead in December, =S40+S42+S43with the low sun, uniformity was partially lost. In return the amount of light is better. This trend provides for a comfortable situation in winter. When, the outside temperatures drop the natural light heats the building.

However, there are some glare phenomena in the southern parts of the school. They require the presence of darkening systems. It is preferable that they are mobile so as not to prevent light from entering the building on days when the sky is overcast and light shy.

The results in terms of FLD may seem average. However, not opening more is a choice motivated by several factors. The opening on the ground floor decreases the privacy effect and sound insulation necessary for a workplace and school. The situation of the studied irradiation makes an excessive opening of the facades rather unfavorable. The risk of creating a critical greenhouse effect is high. In addition, the raw earth construction system does not support a large number of openings, especially for a multi-storey building.

SPAZI				FLD		
Corpi	Piano	Tipo	Area	UNI 10804	EN 17037	Misurato
[]	[]	[]	m2	[%]	[%]	[%]
Admin	0	Ufficio secondarie	15.95	2%	2%	1.75%
Admin	0	Ufficio principale	12.55	2%	2%	2.01%
Admin	0	Ufficio secondarie	16.12	2%	2%	1.79%
Scuola	0	Libreria	70.34	3%	2%	2.14%
Scuola	0	Aula didattica	44.71	3%	2%	1.30%
ScuolaEst	0	Sala professori	16.73	2%	2%	2.39%
ScuolaEst	0	Sala studio	20.20	3%	2%	2.30%
ScuolaEst	0	Aula didattica	44.71	2%	1%	1.50%
ScuolaEst	0	Aula didattica	44.71	2%	1%	1.43%
ScuolaEst	0	Aula didattica	44.48	2%	1%	2.22%
ScuolaEst	1	Aula didattica	44.71	2%	1%	3.33%
ScuolaEst	1	Aula didattica	44.71	2%	1%	2.59%
ScuolaEst	1	Aula didattica	44.48	2%	1%	3.07%
ScuolaOvest	0	Sala professori	15.27	2%	2%	2.73%
ScuolaOvest	1	Sala studio	17.27	3%	2%	2.87%
ScuolaOvest	0	Aula didattica	44.71	3%	2%	1.68%
ScuolaOvest	0	Aula didattica	44.71	3%	2%	1.48%
ScuolaOvest	0	Aula didattica	44.71	3%	2%	1.39%
ScuolaOvest	1	Aula didattica	44.71	3%	2%	2.40%
ScuolaOvest	1	Aula didattica	44.71	3%	2%	2.24%
ScuolaOvest	1	Aula didattica	44.71	3%	2%	2.19%
Centro	0	Aula didattica	44.71	3%	2%	2.41%
Centro	0	Sala mista	27.39	2%	2%	3.40%

Tab. VIII-02.Fattore di luce misurato dal software DIALux

THERMOTECHNICS WITH TRNSYS

1. PROJECT FRAMEWORK

The sizing of thermal energy is treated in this project by analyzing the thermal comfort parameters of temperature and humidity before energy consumption. In fact, since the building is initially in passive operation as much as possible. It was born of the objective of not participating in the overload of the city's network. In the following paragraphs we will study the possibility of passive operation taking into account the strategic choices described above.

The thermotechnical study is carried out with the Transient System Simulation Tool (TRNSYS) software. It is a graphics-based software environment used to simulate the behavior of transient systems. In the field of architecture he intervenes in the study of energy needs with the modeling of construction systems and systems. It simulates hour by hour the trend of the physical energy quantities of a building. It is divided into five parts: TRNSYS-3D, TRNBuilt, Simulation studio, TRNEdit and TRNSED.

1.1. | Geometry TRNSYS-3D

The first step is the drawing of geometries. TRNSYS uses the SketchUp environment to draw away the TRNSYS-3D module. The principle of building design is organized as an assembly of several calculation zones. Each zone can be studied later independently. The connection between the zones is made by the boundary conditions. Elements that are not intended to be studied but that act as screen elements are drawn separately. For the purpose of the study, it is interesting to obtain comprehensive information about the entire building. Therefore, to simplify the representation, the school was divided into three areas: the ground floor, the western part of the first floor and the eastern part of the first floor. It was decided to study only the main building. The social center and the changing rooms are not studied, instead they are screen elements.

When drawing, TRNSYS-3D automatically assigns the type of surfaces. The arches of the balconies are considered as windows. Their empty nature will be precise in a second phase.

3.1.a. Limit

The geometry in TRNSYS is interpreted by a file with the extension . DARK. The default version of the file does not allow the existence of certain elements that here were an obstacle to a correct representation. Therefore, some approximations have been made. First, the vaulted systems, arches and domes were replaced by rectangular geometries. To be consistent and have a similar exchange with the external climate the semicircular surfaces are replaced by surfaces of the same area, with a system of equivalent height. For example, the library corresponds in TRNSYS3D to a rectangular volume 4 meters high.

To simplify the understanding of courtyard spaces, when it was possible the closing wall are made of shield elements. It should not induce a great modification on the results, it only decreases the heat exchange at the junctions with the building, but they are restricted surface.

3.1.b. Outcome

Once the geometry has been completed it can be imported into TRNBuilt.

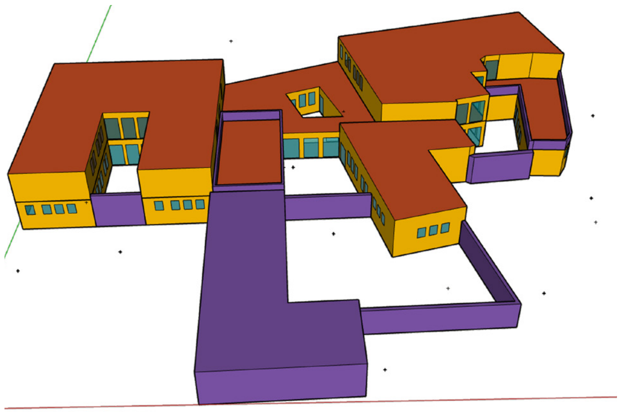


Fig. VIII-11. Modello geometrico in TRNSYS 3D

1.2. | construction systems TRNBuilt

3.1.a. Packets

In the TRNBuilt part, construction systems are implemented. The properties of materials (conductivity, specific heat and density) are recorded according to the design defined in the technological project. Membranes, on the other hand, are too thin for their density to have an impact; therefore, they are called massless layers only for their thermal resistance.

Different materials are used to assemble the construction elements. Again, we proceed with a strategy of equivalent height for vaulted constrictive systems.

For each arc, we consider:
- - H the height of the package
- - Heq the height of the equivalent package in TRNBuilt
- - L the length over which the arc extends
- - R the radius of curvature of the arc
- - the angle of coverage of the arch

$$H_{eq} = H - \frac{S_{sotto\ l'arco}}{L}$$

with $S_{eq} = \frac{R^2}{2}(\theta - \sin\theta)$, e $\theta = 2\sin^{-1}\frac{L}{2R}$

3.1.b. Windows

The creation of the windows was done in two stages. The open arches on the courtyards that were assigned with TRNSYS3D as windows are specified without glazing and therefore as holes. For all other windows, they are classic (because they are not expensive), low-e double-glazed windows via the software database.

1.3. Interior capacity|TRNBuilt

Up to this point, the modelling only included the closing elements. The internal elements of the three zones are recorded by means of a total specific heat value in kJ/K.

The calculation was carried out in the following way. The heat capacity is defined as the specific heat of an element multiplied by its mass.

$$Cp = Cs \times m = Cs \times \rho \times V$$

With:
- Cs the specific heat
- m the mass
- the density of the element
- V the volume occupied by the element

For each calculation zone, the internal capacity can be summarised as the sum of the capacities of the air, the internal partitions and possibly the capacity of all the interior furnishings.

$$Cp_{totale} = Cp_{aria} + Cp_{partizioni\ interne} + Cp_{arredi}$$

In the Al Nuri school is the composition of the air, the internal walls in BTC and the surrender.

The values that have been implemented in TRNSYS

Capacita	Zona		
KJ/K	*PT*	*P1 est*	*P1 ovest*
Predefinito da TRNSYS	3353	906	968
Del volume d'aria	3376	912	975
Delle parete in BTC	272209	63585	58320
Arredamento	690	290	330
TOTALE scelto	**276251**	**64781**	**59618**

Tab. VIII-03.Capacite specifiche

come out. The importance of considering the interior walls is considerable.

1.4. Static gain| TRNBuilt

Then the phenomena due to the functionality of the building that affect the hygrometric and thermal situation are determined. These are phenomena that cannot be changed after the construction of the building. Therefore, they are not really part of the thermal control strategy, but rather part of the characterization of the building.

3.1.a. Air infiltration

During the design and construction of a building, the air tightness is optimized. Air tightness limits heat loss and improves the durability of the building. But a building is not completely hermetic. Regulatory standards require an infiltration rate that is measured with an air exchange of less than 10% per hour.

In accordance with this rate, modelling is done in the worst case with an air exchange of 10% per hour.

3.1.b. Occupation

The presence of people in the building is one of the first phenomena to be taken into account. First of all, it will allow you to plan the moments when it is necessary or not to provide comfortable hydrothermal conditions in an optimization logic. In addition, without automated systems that are expensive, the absence of human presence, the building has a static behavior, and the control of ventilation, heating or air conditioning is disrupted.

Then, on a second level, human presence generates an internal production of thermal energy in the building. To describe energy gains by taking their source inside the building, TRNSYS has a database based on various sources and standards of regulation. As for the human presence, we are interested in the model of the European standard EN1377. This standard defines a nominal power per individual considering his activity rate and room temperature. The more an individual moves, the more heat it will produce.

3.1.c. Calendar

Thus, the first approach is to define the program.

A typical class day is developed at most from 8:00 to 12:00 from 13:00 to 17:00. In TRNBuilt it translates with the following daily calendar. We estimate that the destination of the children take a lunch break outside the school taking into account that the school was designed without a restaurant.

A week is different from the European model. The weekend corresponds to Friday and Saturday. It comes from the fact that in the Muslim religion the holy day is Friday. The weekly calendar in TRNBuilt is composed by assigning daily calendars to each day.

Ora	Valore
00:00 alle 08:00	0
08:00 alle 12:00	1
12:00 alle 13:00	0.5
13:00 alle 17:00	1
17:00 alle 24:00	0

Tab. VIII-04.Calendario giornaliero

The annual academic calendar used as references is that of the International School of Suleimaniah. It is divided into two periods: the classical academic year and a summer school period. Summer school is an optional program. But considering the backlog of children in the city, it seems important to follow this pattern. The functioning of the school evolves as in the previous table.

PERIODO		FUNZIONAMENTO	
inizio	*fine*	*classico*	*estate*
01/01	03/01	0	-
04/01	17/03	1	-
18/03	05/04	0	-
06/04	10/05	1	-
11/05	16/05	0	-
17/05	18/06	1	-
19/06	22/06	-	0
23/06	18/07	-	1
19/07	23/07	-	0
24/07	31/07	-	1
01/08	31/08	-	0
01/09	28/10	1	-
29/10	31/10	0	-
01/11	27/11	1	-
28/11	29/11	0	-
30/11	20/12	1	-
21/12	31/12	0	-

Tab. VIII-05.Calendario annuale

3.1.d. Employment rate

The total population of the school includes at least 12 teachers, 6 people in the administrative staff and at least 300 students. The capacities are distributed in the following way, on the ground floor are about 160 people, on the first east floor 80 people and on the first west floor 80 people.

It was taken into account, first the double functioning of the school. During the summer school a part of the first floor is considered closed. At the beginning, from the architectural point of view it was thought to close the western part but the geometry of this block offers a milder temperature in summer than the east block. So, comfort is promoted, in the summer the first floor of the east block is empty.

Zona	Anno classico		Scuola d'estate	
	tasso	*popolazione*	*tasso*	*popolazione*
Piano Terra	100%	160	50%	80
Piano primo Est	100%	80	0%	-
Piano primo Ovest	100%	80	100%	80

Tab. VIII-06.Occupazione umana

3.1.e. Artificial light systems

Lighting systems intervene in TRNSYS due to their production of heat formed during the operation of a light bulb. Neither the quantity of light produced nor its quality is studied.

Following the same model of earnings from the presence of people, the software proposes different models based on standards. The European model was chosen, despite being based on the regulations of the Société suisse des Ingénieurs et des Architectes SIA, which mentions an intensity of about 10W/m2 for a school building. The profile is weighted according to the students' weekly and annual calendar.

1.5. Context| Simulation Studio

Simulation Studio related the building created in TRNBuilt with the external climate and the ground. In addition, it allowed to program the evolutionary trends of all systems of the building.

Climatic dates are introduced with the TM2 format which is a representation of a typical year. To create the climate file you had to use the EPW file created for analysis with Climate consultant and convert it. The conversion is done with muhammad Tauha Ali's Matlab program (Weather xls to TM2) available in the MathWork library. In a second step, the obtained file is corrected thanks to the official Excel-TM2 VBA conversion programs of the NREL.

For the soil, the software requires an average temperature. Thanks to this temperature and the climatic data, it estimates a trend. The value 23.14 ° C has been entered, which corresponds to the average given by History+ over the last ten years.

2. SHADING STRATEGIES| TRNBUILT & SIMULATION STUDIO

To protect against solar radiation, a double dimming system is designed. The external mashrabiyas continuously filter the light. In addition they are curtains that people can lower manually.

2.1. Implementation of mashrabiya

Fixed mashrabiyas on the façade are implemented thanks to an offset value in the percentage of darkening of a window. Taking into account the geometry, it was assumed that mashrabiya filter 10%.

2.2. Mobile tents

3.2.a. Strategy

The tent management strategy has two levels. First, to limit the accumulation of heat, the curtains are lowered when the school is not in use. Thus, when natural light is not needed, the building is isolated from the sun's rays: from its light but above all from its heat. This means that someone makes sure to close the tents before the weekends and holidays.

This strategy is simply implemented by a variable linked to the school calendar.

3.2.b. Optimisation

For the days when the school is active, an evolutionary strategy must be established to provide maximum protection from heat, while ensuring visual comfort. This strategy is also weighted by the academic calendar so as not to conflict with the previous strategy.

On a visual level, darkening intervenes in situations of glare. To model the action of the curtains TRNSYS has an automatic system dependent on solar irradiation on the surface of the window. By default, if the radiation intensity exceeds 140 W/m2 the curtain is lowered.

In conclusion, the shading system works like this:

$$S\,(t) = P_{tende}\big[1 - Cal(t) \times \big(1 - CTRL_{shading}\big)\big] + P_{mash}$$

With:
-S, the percentage of window shading at time t
-Cal(t) the value of the date in the academic calendar
-CTRL shading, the value that verifies the superiority of the irradiation with respect to a reference set in the software
-P the shading powers of the blinds and mashrabiya.

3.2.c. Comparison in TRNSYS

The study demonstrates the efficiency of having a reasoned shading strategy. The strategy is particularly effective for the ground floor where it represents a gain of 5°C, due to the insularity of the library.

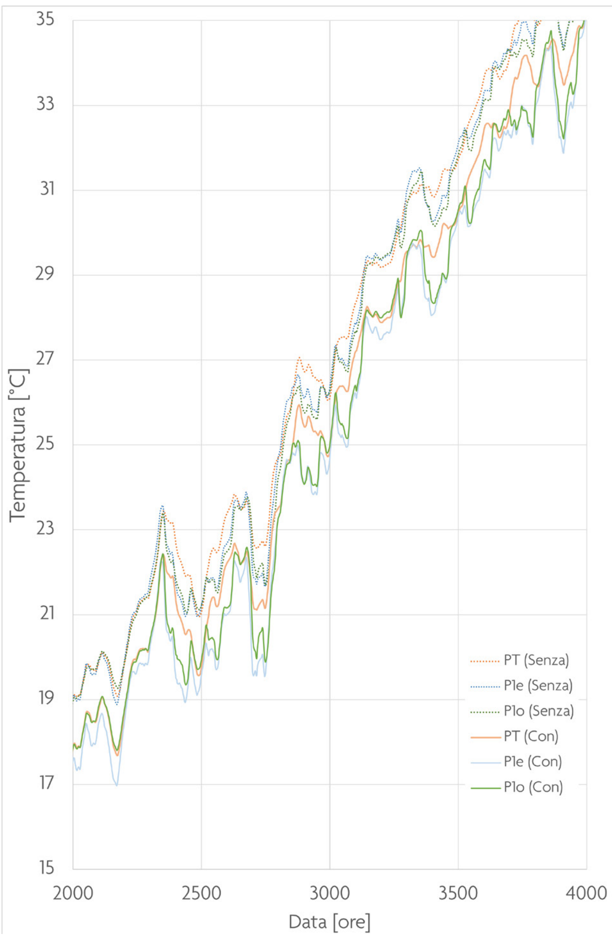


Fig. VIII-12. Confronto d'aprile a giugno

3. VENTILATION |TRNBUILT & SIMULATION STUDIO

In addition to infiltration, there are ventilation phenomena that depend on external conditions and vary greatly. Controlling these phenomena is at the heart of the passive strategy available. According to European legislation, the air exchange due to ventilation must hope for 15m3 per hour per occupant in a classroom of a school building. The purpose of the following study is to evaluate a strategy sized to the building.

3.1. Systems

Thanks to an open configuration, the building uses natural ventilation. The windows are accompanied by a system with vents to increase cross-ventilation.

It aims to improve and control air quality and achieve thermo-hygrometric comfort for the inhabitants.

The mashrabiya are screen elements that slow down the wind and prevent air from entering.

3.2. Theoretical context

Generally speaking, the flow rate of ventilation through an opening is induced by the difference in

SPAZI			Area	Aera aerante	RA
Corpi	Piano	Funziona			
[]	[]	[]	[m2]	[m2]	[1]
Admin	0	Ufficio secondarie	15.95	2.94	0.184
Admin	0	Ufficio principale	12.55	4.76	0.379
Admin	0	Ufficio secondarie	16.12	2.38	0.148
Scuola	0	Libreria	70.34	17.99	0.256
Scuola	0	Aula didattica	44.71	8.47	0.189
ScuolaEst	0	Sala professori	16.73	2.88	0.172
ScuolaEst	0	Sala studio	20.2	4.44	0.220
ScuolaEst	0	Aula didattica	44.71	5.11	0.114
ScuolaEst	0	Aula didattica	44.71	9.52	0.213
ScuolaEst	0	Aula didattica	44.48	8.12	0.183
ScuolaEst	1	Aula didattica	44.71	10.01	0.224
ScuolaEst	1	Aula didattica	44.71	12.39	0.277
ScuolaEst	1	Aula didattica	43.31	9.24	0.213
ScuolaOvest	0	Sala professori	15.27	2.38	0.156
ScuolaOvest	1	Sala studio	17.27	4.78	0.277
ScuolaOvest	0	Aula didattica	44.71	6.51	0.146
ScuolaOvest	0	Aula didattica	44.71	8.89	0.199
ScuolaOvest	0	Aula didattica	44.71	8.61	0.193
ScuolaOvest	1	Aula didattica	44.71	7.42	0.166
ScuolaOvest	1	Aula didattica	44.71	7.35	0.164
ScuolaOvest	1	Aula didattica	44.71	7.35	0.164
Centro	0	Aula didattica	44.71	6.15	0.138
Centro	0	Sala mista	29.76	5.53	0.186

Tab. VIII-07. Rapporti aerante

Fig. VIII-13. Ventilazione nella scuola Al-Nuri

pressure and temperature.

Q=CxDP

- With:
- -C a flow coefficient dependent on various spatial and environmental conditions,
- -DP the pressure difference
- -n the flow coefficient dependent on the physical characteristics of the flow.

The calculation is simplified by separating into different categories of phenomena. In the case of the Al-Nuri school, there are several natural ventilation phenomena occurring under specific conditions.

3.3.a. *Mono-exposed rooms*

For single-exposed rooms, a single window creates weak ventilation. It provides significant air exchange in case the room is narrow enough (with a width less than twice its height) and the window high enough, at least one and a half metres. Rooms on upper floors and ground floor rooms on courtyards will meet the criteria.

Then, the air movement is induced by the temperature difference between inside and outside. A simplified calculation of the incoming flow is defined with a specific coefficient.

$$Q[m3/h] = 260A\sqrt{0,5H \times \Delta T}$$

With A the opening area [m2] and H the height of the window [m].

Two windows on the same façade create quite a lot of ventilation compared to the previous phenomenon. It is also induced by the temperature difference coupled with the height variations between the different windows. This phenomenon occurs in larger rooms with an opening width of at least 1.5m. For this reason a number of vents are placed at the bottom of the ground floor classrooms.

The flow rate is dependent on the height difference between the two windows and the area of the smaller opening.

$$Q[m3/h] = 520\,A\sqrt{H \times \Delta T}$$

With:

- A the area of the smallest opening [m2]

-H the difference in height between the two openings [m]

3.3.b. Ventilation induced by the force of the wind

On days of increased wind, ventilation phenomena are accented. It only works in the case of an open space on two sides.

The calculation is complicated by a coefficient that varies according to the setting. The flow rate of the ventilation flow corresponds to the multiplication of the wind speed entering with the open area. The critical point with this configuration is the variation in wind speed due to the obstacles encountered and the configuration of the room. Inserting this coefficient allows to overcome the lack of knowledge of external and internal surface pressures.

In the climate strategy book Sun, Wind, Light E. Brown publishes a simplified summary of wind speed reduction.

Weighting in relation to the nature of the phenomenon

The ventilation due to the wind, takes advantage of several chimneys. The distribution of air between the various chimneys is not equally balanced. Cross ventilation between two opposite walls is the most favorable phenomenon. Taking into account the geometry and the distribution of openings in the room, the incident wind undergoes a reduction in speed.

3.3.c. Weighting in relation to the short effect

The court allowed to capture the wind in the building.

	larghezza della finestra / larghezza del muro		
	1/3	2/3	3/3
apertura singola	12-14%	13-17%	16-23%
due aperture nella stessa parete	-	22%	23%
due aperture in muri adiacenti	37-45%	37-45%	40-51%
due aperture in pareti opposte	35-42%	37-51%	47-65%

Tab. VIII-08. Forza del vento in ingresso

From consequences, strong ventilation phenomena occur in the court, globally in the same direction as the wind above. However, the geometry of the courtyard decreases the speed of the picked wind.

A reduction coefficient is applied to the incoming air flow into the building. The slowdown depends more on the width of the courtyard in front of the heights of the surrounded buildings. A tall, narrow courtyard did not allow the wind to reach the bottom of the court.

3.3.d. Weighting in relation to wind direction

All phenomena of cross-ventilation are directly related to the direction of the wind. If the wind comes

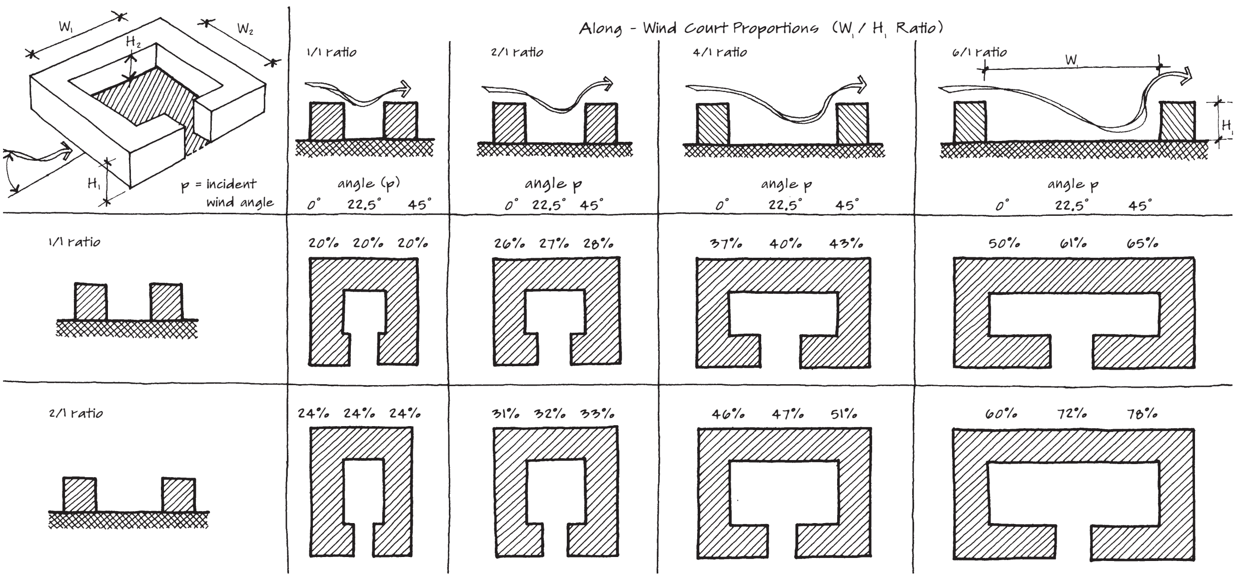


Fig. VIII-14. Effetto corte

on a closed façade, no matter what the openings on the other facades, the flow will not cross. A direct incidence is the most favorable at the entrance. It is important to take into account the angle of incidence of the wind.

3.3.e. Weighting in relation to window openings

The area open to ventilation remains the first ventilation factor. Despite, in the school, in order not to interfere with the activities inside the building, the windows will rarely be fully open but rather open with a vasistas opening. Instead if necessary, the ventilation vents can be left open.

3.3. Approach

3.3.a. Estimation of coefficients

To obtain reduction coefficients for each modelling zone in TRNSYS, an average of the impact of each phenomenon was implemented.

The calculation process is torn to pieces according to the orientation of origin of the wind. To simplify the orientation it was divided according to the fourth cardinal points.

For each orientation, the ventilation phenomena involved are studied and are weighted by the ratio of the surfaces involved to the aerating surface of the room.

At the level of the plane, all the coefficients thus obtained are also averaged on the ratio between the aeration surfaces and the useful aeration surface for the studied orientation.

A coefficient is obtained for each wind direction. The representation of the wind distribution during the year allows to relate the wind profile in Mosul with the coefficients obtained for each zone. Finally, a value is obtained for the ratio of the incoming air flow to the wind speed if all the windows are open.

Risultati		Nord	Sud	Est	Ovest	Totale
Area areante utile	m2	41.72	96.72	86.99	75.99	126.12
Velocita del vento	%	29.47	17.31	17.06	14.91	
Incidenza del vento in inverno	%	13.17	1.42	4.41	2.98	
Coefficiente d'inverno	m2	16.62	1.78	5.56	3.76	27.72
Incidenza del vento in estate	%	9.51	2.07	2.20	6.19	
Coefficiente d'estate	m2	12.00	2.61	2.77	7.81	25.18

Tab. VIII-09. Risultati per il piano terra

Risultati		Nord	Sud	Est	Ovest	Totale
Area areante utile	m2	31.64	48.32	38.31	19.25	57.56
Velocita del vento	%	0.28	0.06	0.06	0.30	
Incidenza del vento in inverno	%	12.46	0.51	1.43	6.01	
Coefficiente d'inverno	m2	7.17	0.29	0.82	3.46	11.75
Incidenza del vento in estate	%	9.00	0.74	0.71	12.50	
Coefficiente d'estate	m2	5.18	0.42	0.41	7.20	13.21

Tab. VIII-10. Risultati per il piano primo est

Risultati		Nord	Sud	Est	Ovest	Totale
Area areante utile	m2	12.20	18.22	19.48	14.70	37.70
Velocita del vento	%	20.22	28.73	12.47	13.18	
Incidenza del vento in inverno	%	9.04	2.34	3.22	2.63	
Coefficiente d'inverno	m2	3.41	0.89	1.22	0.99	6.50
Incidenza del vento in estate	%	6.52	3.43	1.60	5.47	
Coefficiente d'estate	m2	2.46	1.29	0.61	2.06	6.43

Tab. VIII-11. Risultati per il piano primo ovest

Periodo	Nord	Sud	Est	Ovest
Gennaio	44%	10%	29%	15%
Febraio	46%	7%	26%	20%
Marzo	40%	10%	24%	25%
Aprile	44%	10%	18%	27%
Maggio	34%	11%	13%	40%
Giugno	24%	12%	9%	55%
Luglio	21%	15%	10%	52%
Agosto	26%	15%	11%	47%
Settembre	35%	11%	11%	42%
Ottobre	42%	10%	19%	28%
Novembre	47%	7%	22%	22%
Dicembre	46%	6%	28%	18%
Estate	32%	12%	13%	42%
Inverno	45%	8%	26%	20%

Tab. VIII-12. Profilo di distribuzione del vento

$$C_{zona,tot} = \sum_{orient.} D_{vento,orient.} \times C_{zona,orient.}$$

$$= \sum_{ori.} D_v \times \left[\frac{1}{A_{z,ori.}} \sum_{stanze} A_{st} \times \left(\frac{1}{A_{st}} \sum_{ori.} A_{ap} C_{fen} C_{corte} \right) \right]$$

With A the different useful ventilation areas, C the different coefficients and D the percentage of wind distribution according to the specific orientation.

In the software, the coefficients obtained for each ventilation phenomenon are coupled with the occupancy programme and linked to the evolution of temperatures and wind speed. This results in an adjustable ventilation efficiency depending on the size of the window opening.

	Coefficiente di calcolo della ventilazione indotta dalla temperatura [m3/h(°C^0.5)]			dal vento [m2]	
	Ap. singola	Ap.multiple	Totale	estate	inverno
PT	23186.88	32791.20	55978.08	25.18	27.72
P1 est	12960.59	14965.60	27926.19	13.21	11.75
P1 ovest	6931.06	9802.00	16733.06	6.43	6.50

Tab. VIII-13. Fattori finali

3.3.b. Limit

The model is not a fluid mechanics model, which would be the best way to deal with the phenomen... The airflow pattern is not known. Ventilation powers are estimated approximately and making a generality of the particular situations of each window. The objective is only a pre-dimensioning that can be used to quantify heat gains and losses.

3.4. Setting in TRNSYS

In the TRNSYS model, the ventilation behaviour is automatically managed by input variables calculated outside the TRNBuilt building.

There are three types of ventilation: one constant ventilation and two variable ventilations due to the behaviour of the building occupants during the day and night.

3.3.a. Constant ventilation

Constant ventilation is considered to ensure a continuous renewal of air in the school for sanitary conditions. Physically, this ventilation is due to temperature differences and passes through vents left open. During the day it warms the building and at night it cools it. The objective was to find the number of vents to leave open to minimise heating in summer and cooling in winter. It is a balancing act. Then, it is sufficient to optimise to keep 5% of the ventilation surface open.

3.3.b. Ventilazione notturna

This is the most important ventilation in the case

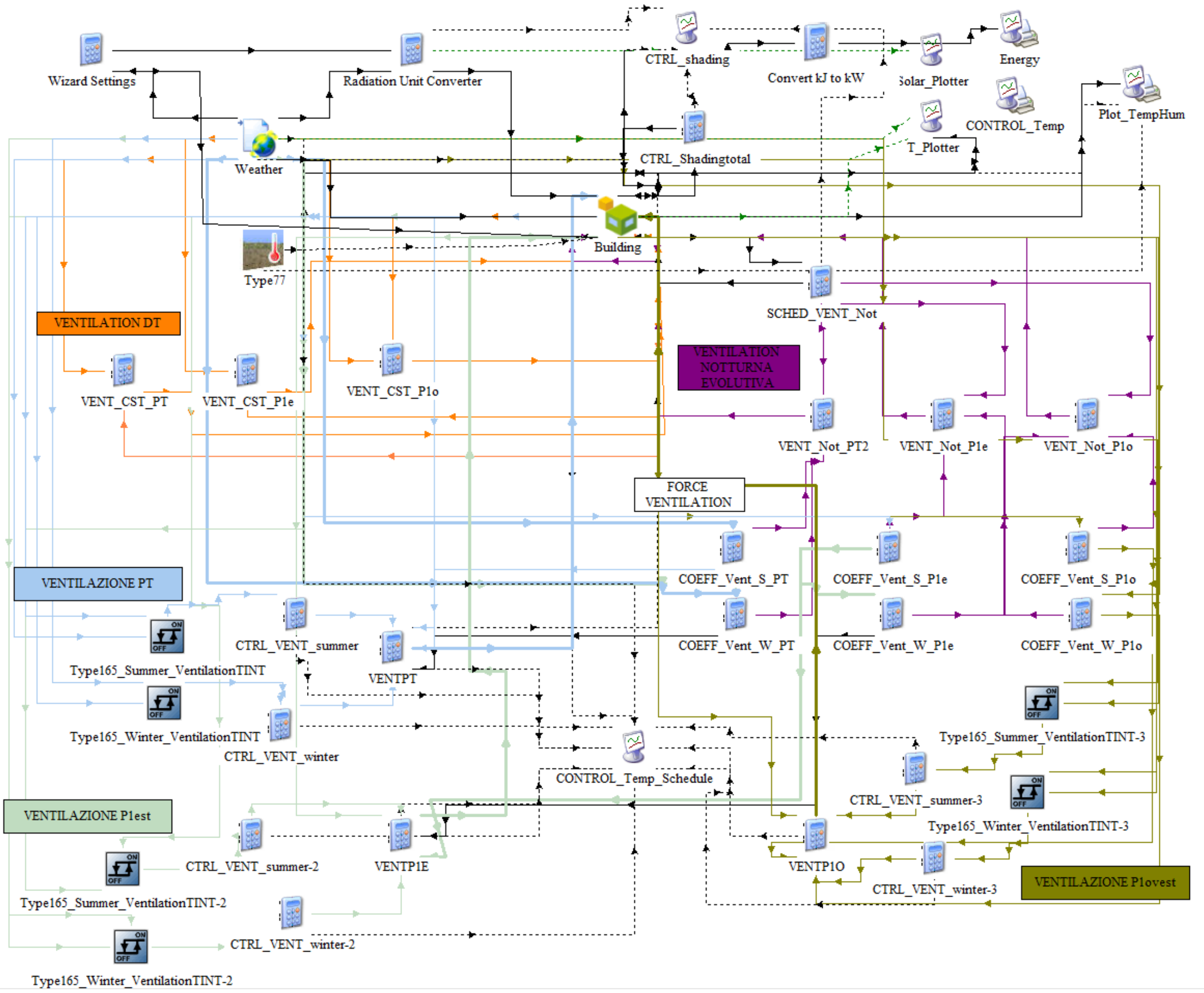


Fig. VIII-15. Modello TRNSYS

of the Al-Nuri school. During the hot season, night ventilation is the only way to cool the building. But in winter, this ventilation does not serve thermal comfort. In the model, this ventilation is active from April to October. In reality, the windows and doors are partially opened when the school closes in the evening and are closed the next morning. As this manipulation is done by a person from the school, this ventilation can only be active from Sunday evening to Thursday morning according to the school calendar.

To quantify this phenomenon, the wind ventilation model is used. And it is found that all openings (windows and doors) are required. But for safety reasons the ground floor remains 50% closed.

3.3.c. Daytime ventilation

Daytime ventilation refers to the opening of windows and other openings by someone who is too hot or too cold in the school when the outside temperature seems more appropriate.

In summer it is activated if the outside temperature is lower than the inside temperature, in winter when the outside temperature is higher than the inside temperature.

As it models the manual opening of windows, this ventilation model is only active if someone is present in the school. On the other hand, it does not correspond to the total opening of the windows, because in order not to disturb the occupants, the door and window sashes are not fully opened. After optimisation, this corresponds to the opening of 30% of the surfaces, e.g. a 35 cm wide vasistas or projecting window opening.

3.5. Results

After modelling and optimising the ventilation behaviour, this average comfort situation emerges. For the comfortable temperature count, the study covers the occupancy period of the school.

According to EN 167218, occupant comfort is represented by an adaptive optimal operating temperature according to external conditions.

$$T_{ottimale} = 0.33 \times T_{esterna} + 18.8$$

Different comfort zones are determined to represent the proportion of the population satisfied with the thermal conditions. The first category 1 with 90% satisfaction is located between two degrees above the optimal temperature and three degrees below the optimal temperature. The second category between +3/-4 satisfies 80% of people and the third category (+4/-5) 70%.

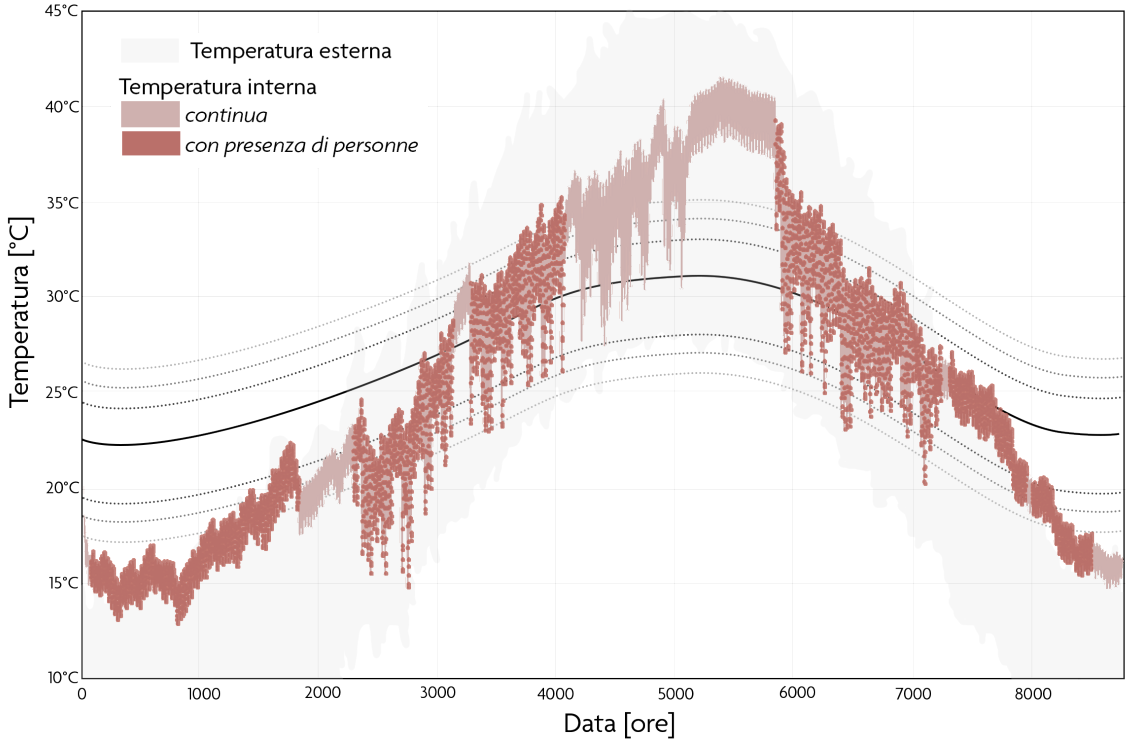


Fig. VIII-16. Evoluzione della temperatura internale

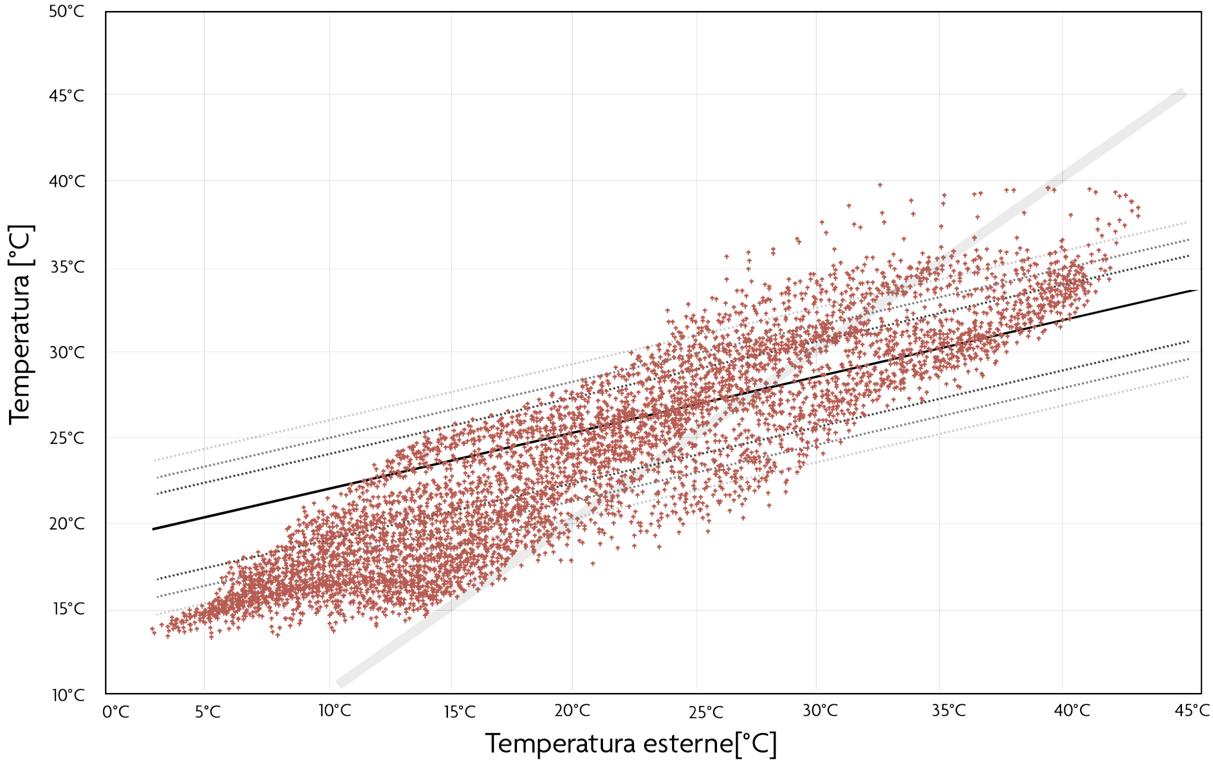
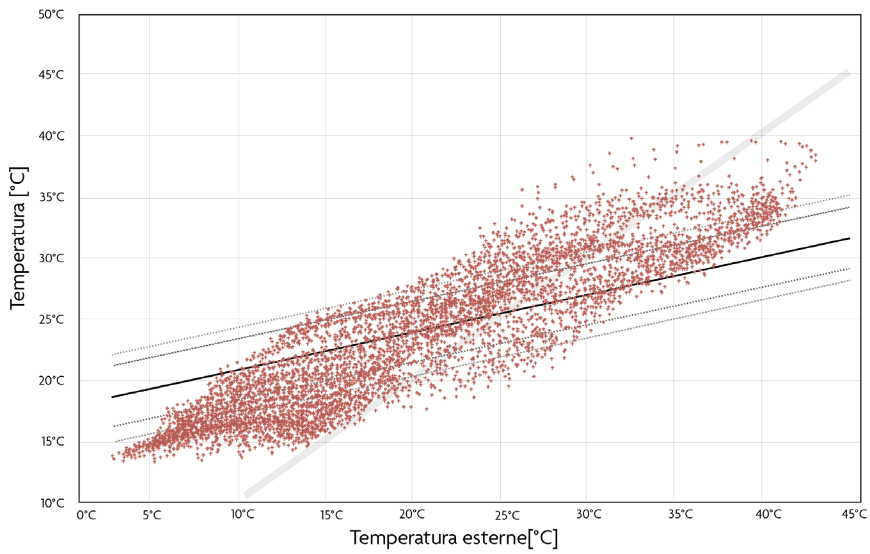


Fig. VIII-17.Diagramma di comfort secondo la norma EN167918



EN 167918		
Categoria 1	*accettabilità 90%*	33%
Categoria 2	*accettabilità 80%*	46%
Categoria 3	*accettabilità 70%*	61%
ASHRAE 55		
Categoria 1	*accettabilità 90%*	42%
Categoria 2	*accettabilità 80%*	58%

Tab. VIII-14. Percentuale di accettabilità nelle categorie di comfort normative

Fig. VIII-18.Diagramma di comfort secondo la norma ASHRAE 55 2018

3.6. Active optimisation

The comfort situation remains problematic between July and September. Several low energy cost solutions are possible. Additional ventilation with a ceiling fan can lower the perceived temperature of the room by 3°C and this is enough to enter the permissible comfort category three. Another solution is to add a humidification system. A passive technique is to put water tanks in front of the air intakes.Inoltre sarà necessario uno sistema di raffrescamento ad aria condizionata.

EN 167918		
Categoria 1	*accettabilità 90%*	43%
Categoria 2	*accettabilità 80%*	55%
Categoria 3	*accettabilità 70%*	67%
ASHRAE 55		
Categoria 1	*accettabilità 90%*	49%
Categoria 2	*accettabilità 80%*	65%

Tab. VIII-15. Percentuale di accettabilità nelle categorie di comfort normative con l'ipotesi di un abbassamento della temperatura di 3°C in estate

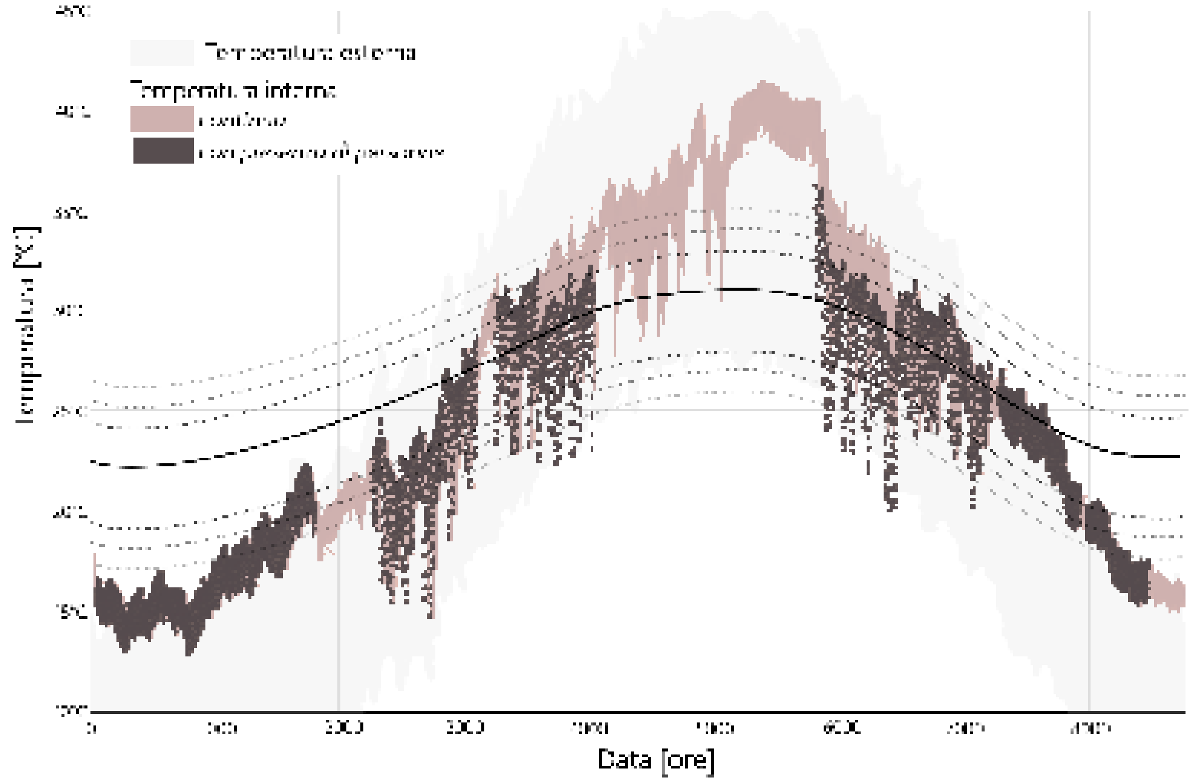


Fig. VIII-19.Evoluzione della temperatura internale con l'ipotesi di un abbassamento della temperatura di 3°C in estate

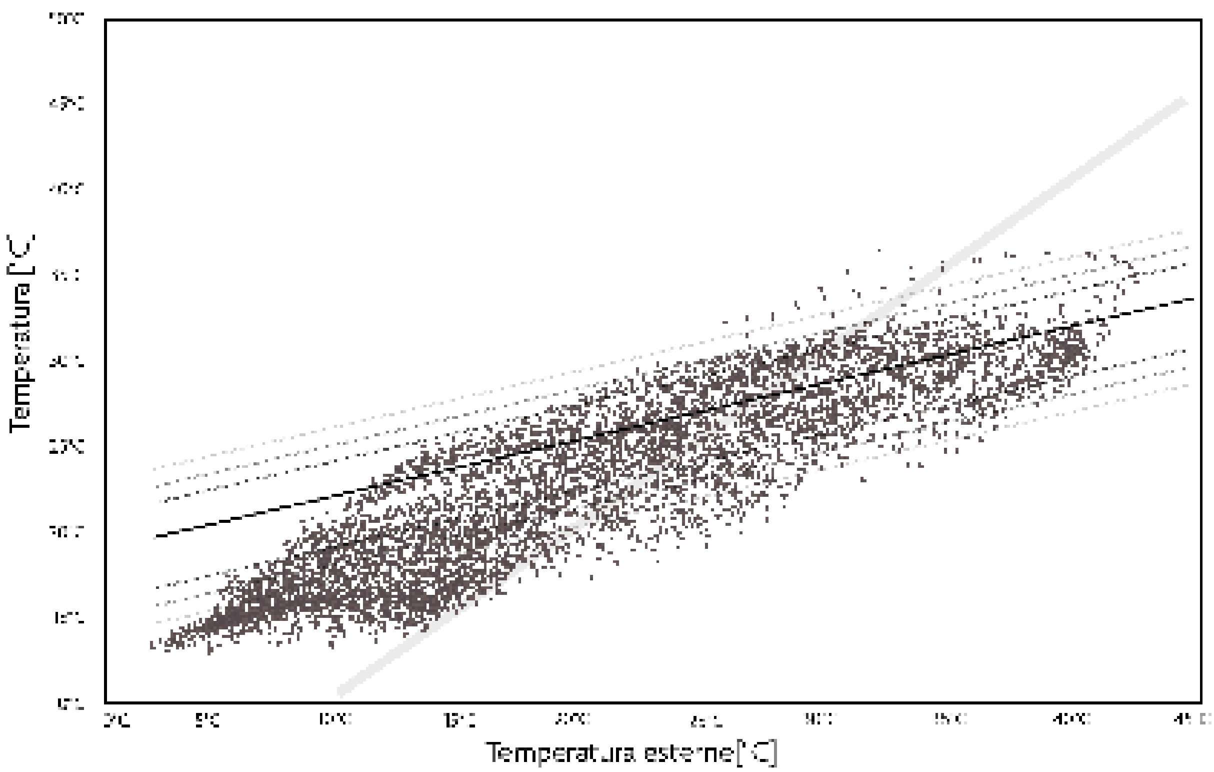


Fig. VIII-20.Diagramma di comfort secondo la norma EN167918 con l'ipotesi di un abbassamento della temperatura di 3°C in estate

ELECTRICITY CONSUMPTION

1. GENERALITIES

The study of electrical consumption is made with a situation of the energy absorbed by electrical equipment. It is a static study of the total in the sense that it does not take into account the consumption trend. Nor does it take into account the trend in equipment loads during its cycle of use; the switch-on, update, use and standby phases are grouped together in a single average use phase. The analysis does not take into account the anomalies linked to the regretted system such as pressure drops etc...

The study starts with the power of the equipment in order to estimate the consumption in the following way.

$$Potenza, ass\ [kWh] = \frac{Potenza, nominale\ [W]}{1000} \times Uso[ore]$$ t:

Per il sistema intero della scuola:

$$Potenza, ass[kWh] = \frac{1}{1000} \times \sum Potenza, i[W] \times Uso[ore]$$

2. ELECTRICAL EQUIPMENT

2.1. Context

In this section, the analysis focuses on electrical equipment other than lighting systems. It is also assumed that the school does not have a water heating system. This assumption derives from the hypothetical low consumption of hot water of a school without a shower system.

Since the Al Nuri school is part of a central complex of cultural and social importance, it is assumed that it has the necessary funds to have adequate equipment.

2.2. Inventory

In accordance with the requirements of the competition, the following equipment is therefore deemed to be present:

- Fridge-freezers - small 200/300 L
- Compact bulbs ("saving")
- Desktop computer and modem
- Printer/Scanner
- Audiovisual site (TV, DVD)
- Microwave
- Coffee machine and electric kettle
- Fan
- Telephone

2.3. Calculations

To assess the order of magnitude of the electricity consumption induced by this equipment, a calculation file was used by "La Casa Attiva - Società di Ingegneria", created to estimate the monthly and annual electrical consumption of electrical and electronic equipment present in a house.

To have a dispute compatible with the fact that the building is not a dwelling but a public building for school use, some adjustments have been made.

First of all, the annual period in its entirety is considered. He allowed to calculate with continuous use, similar to that of a house. To achieve the hardness of occupation of a school, being about 200 days, the calculation is made for periods of three weeks a month,

APPARECCHIATURE		RIPARTIZIONE				PROFILO D'USO DI UNA SINGOLA APPARECCHIATURE				Totale	
Descrizione	Potenza [W]	Uffici	Scuole	Condivise	Totale	min/gg	ore/gg	giorni	sett.	mensile	annuale
Frigocongelatori - piccolo 200/300 L	Classe A	1			1	continuo					
Lampadine compatte (a "risparmio")	15	7	8	10	25		8	5	3	120	1440
Computer fisso	221	7	6	10	23		10	5	3	150	1800
modem	10	1	1	1	3		10	5	3	150	1800
Stampante/Scanner	65	3	4		7		0.5	5	3	7.5	90
Sito audiovisivo (TV, DVD)	162			1	1		7	5	3	105	1260
Forno microonde	819	1			1	35	0.58	5	3	8.75	105
Macchina caffè	1106	1	2		3	10	0.17	5	3	2.5	30
Bollitore elettrico	1800	1	2		3	15	0.25	5	3	3.75	45
Ventilatore	51	3		2	5	90	1.5	5	3	22.5	270
Telefono	7	7	2		9	60	24	5	3	360	4320

Tab. VIII-16.Inventario delle apparecchiature e Durate d'uso di una singola apparecchiatura five days a week.

In addition, the daily uses of the equipment have been lengthened. The calculation file estimated these durations based on the average behavior of a family of four. In a school, numerous equipment is often left on all day. It was decided to oversize consumption based on this hypothesis, many durations of use were sized in correspondence to the ten hours of daily opening of the school

2.4. Results

Annually, the electricity consumption due to the equipment would be a maximum of 11 000kWh. This assessment does not take into account the awareness of users. Hypothetically, it is realistic to consider a decrease of 10%, resulting in a consumption of about 9 900kWh.

APPARECCHIATURE		CONSUMO	
Descrizione	Potenza [W]	mensile [kWh]	annuale [kWh]
Frigocongelatori - piccolo 200/300 L	Classe A	21.10	253.00
Lampadine compatte (a "risparmio")	15	45.00	540.00
Computer fisso	221	761.42	9136.98
modem	10	4.50	54.00
Stampante/Scanner	85	4.47	53.61
Sito audiovisivo (TV, DVD)	182	19.12	229.43
Forno microonde	819	7.16	85.95
Macchina caffè	1176	8.82	105.81
Bollitore elettrico	1500	16.88	202.50
Ventilatore	51	5.77	69.19
Telefono	7	22.68	272.16
		TOTALE	11035.724

Tab. VIII-17. Consumo elettrico

3. LIGHTING

3.1. Static study

To estimate the electrical consumption linked to the artificial light system, a static calculation was made.

From European legislation, the thermal calculation software TRNSYS estimates an electrical profile for school use. Evaluate one system of Power 10W per square meter. This value is the basis used here.

And taken into account a useful area that groups the classrooms, offices, library and study rooms for a use depends on an average agenda of 8 hours a day. A situation of consumption in service spaces is made according to the possible presence of people. Instead, the lights of the transient spaces are accessed in the evening so about 3 per day at most.

In conclusion, the consumption linked to the annual lighting system is about 17 800 kWh.

Spazi	Area	Uso				Consumo [kWh]	
	m2	ore	giorni	sett	totale	mensile	annuale
Uffici	429	8	5	4	160	68.67	824.06
Aule	642	8	5	4	160	1026.88	12322.56
Spazi comuni	152	10	5	4	200	304.96	3659.52
Corridoi	106	3	5	4	60	63.60	763.20
Bagni	64.5	1	5	4	20	12.33	147.96
					TOTALE	1476	17770

Tab. VIII-18. Consumo elettrico per l'illuminazione

3.2. Limit

This study is an approximation that gives an idea of the profile of the building. It cannot be considered of total relevance.

A better knowledge of consumption more be obtained between a complete moralization of the school by sizing the lighting system and its operation together with the contribution of natural light according to the hourly needs.

4. PLANT

Faced with the results of the global irradiation on the building, the prospect of implementing a photovoltaic system to lighten the load of the school on the city network arises.

4.1. Implementation of a photovoltaic system

With the study of radiation and electricity consumption it seems possible to produce a part of the electricity consumption thanks to photovoltaics

4.4.a. Comparative pre-estimation

The photovoltaic potential in Mosul is estimated by Global Solar Atlas 2.0 to be 1680 kWh/kWp. The same body estimates a similar potential in the Italian city of Catania.

Thanks to the Italian software SIME, the production of electricity in Catania is calculable. And so a pre-estimation of production in Mosul comes out.

It is considered a unique photovoltaic module, of 300W, with an area of 1.6 m2. This module is inclined at 30° and oriented to the south.

These are the following results (tables on the right)

Taking into account that the Al Nuri school has 600 m2 of surface available on the roofs, it would be able with a loan to be completely self-sufficient from an energy point of view.

Mese	Produzione per modulo *[kWh]*	Moduli necessari	Area *[m2]*
Gennaio	30	31	50.7
Febbraio	32	29	47.5
Marzo	40	23	37.6
Aprile	43	21	36.0
Maggio	49	19	31.1
Giugno	49	19	31.1
Luglio	50	18	31.1
Agosto	50	18	31.1
Settembre	43	21	36.0
Ottobre	37	25	40.9
Novembre	31	30	49.1
Dicembre	28	33	54.0
	482	33.0	54.0

Tab. VIII-19.Stimazione per il consumo legato alle apparecchiature

Mese	Produzione per modulo *[kWh]*	Moduli necessari	Area *[m2]*
Gennaio	30	47	78.6
Febbraio	32	44	73.7
Marzo	40	35	58.9
Aprile	43	33	54.0
Maggio	49	29	47.5
Giugno	49	29	47.5
Luglio	50	28	47.5
Agosto	50	28	47.5
Settembre	43	33	54.0
Ottobre	37	38	63.8
Novembre	31	46	75.3
Dicembre	28	51	83.5
	482	51.0	83.5

Tab. VIII-20.Stimazione per il consumo legato all'illuminazione

Mese	Produzione per modulo *[kWh]*	Moduli necessari	Area *[m2]*
Gennaio	30	78	127.7
Febbraio	32	73	119.5
Marzo	40	58	94.9
Aprile	43	54	90.0
Maggio	49	48	78.4
Giugno	49	48	78.4
Luglio	50	47	76.9
Agosto	50	47	76.9
Settembre	43	54	90.0
Ottobre	37	64	104.6
Novembre	31	76	124.4
Dicembre	28	84	137.5
	482	84.0	137.5

Tab. VIII-21.Stimazione per il consumo totale

IX. BACK MATTER

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FONTI BIBLIOGRAFICHE

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