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Guidelines for Sustainable Construction Methods to Build Over Difficult Topographies

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Topography, Sloped Sites, Sustainable construction, Site Analysis, Stability

Guidelines for Sustainable Construction Methods to Build Over Difficult Topographies

Abstract

Sustainable construction development is a recent term that is required to create an eco-friendly built environment using renewable and recyclable resources and to reduce energy consumption and waste within protecting the natural environment. This term means such an improvement that pleases the current requirements without limitation of the prospect of sustaining requirements in future. Many problems face builders while executing projects, especially these projects were decided to be built over difficult topographies, such as rivers, falls, inclinations, caves, ridges, cliffs, and mountains. Construction challenges to build a project over a difficult topography are diverse starting by executing piles, retaining walls, conserving stability, and choosing the proper sustainable materials that can withstand the natural environmental factors. This paper sheds the light on the potential of any site's certain criteria; mostly its topography and slope on the provision of sustainable and ecological buildings. It seeks to recognize the sustainable and ecological variables of site topography, consuming a set of characteristics for each building type. The main aim of this research is to propose guidelines of sustainable construction methods that can be used to enable builders to build over difficult topographies, particularly on mountains. The research therefore depended on a scientific methodology through analyzing a sort of literature sources to structure a theoretical base, and then certain parameters were concluded. These parameters were used to analyze a concentrated case study on a site attaching (Beaufort Castle-Chkif), located in Arnoun South of Lebanon. Data of this field-work was conducted by site-visits, capturing photos, interviews, and questionnaire. This site is envisioned to be tested for building projects over sloped contour lines of Chkif Mountain. The paper provides an application for the development of the guidelines for passive and sustainable capability on favorite orientations on the buildings in difficult sloped areas with respect to the climatic local data, Application of the idea of the sustainable and ecological development in the building construction will be an origin of engineering and scientific inspiration for many coming years. One of the conclusion points is the preferable typology of projects to be built over mountains is touristic and entertainment activity to attract people. The sloped contour lines may be employed to be a potential not threat.

Keywords

Topography, Sloped Sites, Sustainable construction, Site Analysis, Stability

1. INTRODUCTION

Topography is an essential feature in site study and analysis. Where the site is flat, the topography will not make an effect directly on the location and design of the building. However, in the slopped site, the topography is an important factor. The sloped site will make an effect on the entry of sun & views (SEANZ, 2019). The Slope will be measured by the distances between a point to another one and the result will be divided over the horizontal distance between the two points (Ghrapedia, 2019). Sustainable and ecological development in building construction is principally important, in order to implement the concept of "the construction way that meets and achieve the requirements of the ecological and sustainable growth" (Czarnecki, 2013). The procedure of surveying, analyzing, or studying the current environment and how it will make an impact on the structure's design and plan on the site is vital. Site Analysis includes: captivating a list of site elements meeting applicable information about the site analysis. These features and potentials should qualify to the needs of the clients and the objective and include them in design. Moreover the physical factors include topography, geographic location, soil, climate, prevailing winds, solar orientation, water, plant material. However, the cultural and man-made features contain codes, zoning ordinances, historical values. Then the Sensory Factors include sounds, views, and smells (Sri, 2015). Construction development challenge, as of late, is reduction of social, conservative and environmental effects of structures along their practical nature and expanding of life quality, and for these points, economic development ends up significant as building development has significant job in reasonable improvement. The referenced attributes are a few things reliable with manageability standards and objectives and they are powerful in satisfying objectives of supportability (Habib, 2012). Moment of the force is characterized as the result of the power and the minute arm, where the minute arm is the most limited separation structure a point to the line of activity of the power. Center of the gravity of a body is where all its weight seems, by all accounts, to be concentrated. It is likewise the point about which all the clockwise and the anticlockwise minutes are equivalent. A body with a low focus of gravity is steadier than a body with a high focal point of gravity. Two equivalent and inverse powers acting at a point are said to be in balance since they balance one another. The Problem is summarized by the challenges that face the constructer on the difficult topography, and make the building stable and strong. In addition, the accessibility for this site and construction equipment and tools, and how solving the climate conditions have effect on the stability of the building, shown in figures 1, 2 & 3.

Fig.1: 3D for the site selection, difficult topography

Fig.2: Construction equipment on difficult topography

Fig.3: Construction problem on difficult topography

Enable builders to build over the difficult topography particularly on mountains. This paper provides an application for the development of the guidelines for passive and sustainable capability on favorite orientations on the buildings in difficult sloped areas with respect to the climatic local data, Application of the idea of the sustainable and ecological development in the building construction will be an origin of engineering and scientific inspiration for many coming years. For this determination, the method used focused on four folds was used based on analytical research, theoretical review, comparative methods, fieldwork and interviews, collection study evidence through following a descriptive and analytical approach to study the factors influencing this growth and predict its future on the subject.

a. Fieldwork through site visit, take photos, interviews through entities and institutions concerned.
b. Studying and analyzing the collected information, as well as case study and similar examples to the subject of the study.

2. LITERATURE REVIEW

Sustainable development faces monetary challenges at various levels. On the macroeconomic level, the objectives of reasonable development are to make the structure steady and solid and face the natural effect, site investigation, and the development materials utilized.

2.1 Construction and Site Topography

The geography in the flat site probably will not affect the area and structure of the structure, however on an inclining site; the geology is probably going to be a critical plan factor. In the meantime, a topographic guide is a diagrammatic and itemized portrayal of a land's surface highlights, which are attracted to scale. In contrast to standard maps, it shows shapes, rises, and any basic highlights of the surface like slopes, valleys, and even lakes and waterways (Philippines, 2009). Obviously, geography influences engineering. The ground gives the essential help to the structure. An excessive number of designers and structural specialists need to review a site level (Chambless, 2015). As per Hans Carl von Carlowitz, who originally referenced "supportability" in 1712 in connection to uncontrolled utilization of backwoods, "the possibility of maintainability rises in the midst of disastrous occasions or deficiencies" (Kundak, 2006). Clients of this definition refer to the "three-legged stool" of maintainability: social, financial and natural (Holdren, 2008). "Affordable progression" presented as essentially synonymous with "sensibility," is tried by makers who battle that "improvement" itself is opposing to supportability (Daly, 1996) considering the way that advancement is intrinsically unsustainable: "human advancement must happen without overpowering the characteristic biological systems that we rely upon" (Wood, 2015).

2.2 Definitions and Principles of Sustainable Construction

Sustainable and environmental plan development worried about the execution of reasonable and natural improvement on the size of the individual structures and destinations. Along these lines while worry of the vitality and the carbon impact significance components supportable and natural development and structure go broad than this (Clark, 2012). Site Analysis includes: captivating a list of site some elements that meet applicable information about the site analysis, these features and potentials qualified to the needs of the clients and the objective and include them in design. There are three factors: physical factors, social and man-made highlights, and sensory factors. About the physical elements, first topography, shape lines are nonexistent lines on display that interface purposes of equivalent tallness above datum or seat mark. Subsurface features, geology that geological history of the area, bedrock type and depth, etc. Hydrology relates to underground water table, aquifers, springs, etc. Finally, soil genesis is erosion susceptibility, moisture, reaction organic content, bearing capacity etc. Second is soil, geographic location, climate, solar orientation, prevailing winds, plant material, and water. About the cultural and fabricated features where utilities they include sanitary, water supply, telephone, electrical etc. While Spatial Pattern are the parts of the site that typically include esteem decisions. Spatial Pattern is the sort of neighborhood; it is the best way to deal with the site, and presence of human movement. Natural Features include significant natural features of the site, water elements, rock formations, views, sounds, and smells. It is very important to preserve the natural elements in order to have a sustainable construction. In addition, reducing the cutting from the mountains is important to achieve sustainability (Sri, 2015).

2.3 The Main Factors of Sustainable Development Construction

There are few meanings of manageable advancement in the writing, particularly that economical improvement is an expansive idea that has been embraced and deciphered in numerous specific circumstances. The most mainstream meaning of practical advancement is that given in the Brundtland report (Brundtland, 1987). Such a chronicled examination will likewise uncover the primary strings of talk and the different issues subsumed under the term 'manageable improvement (Du Pisani, 2007).

Sustainable manageable development is essentially characterized by the business that guarantees the preservation of normal assets for the duration of the existence cycle of the structure (vitality, water, non-sustainable materials), enhancing the utilization of crude materials in reason to diminish the crumbling of the earth and to guarantee social and monetary solace (Stamure, 2015). An ecological and sustainable development undertaking must essentially consider the goals of economical advancement at each phase of choices: plan, development, use, and destruction. Notwithstanding these profit to the degree of financial improvement and the security of nature manageable development practices guarantee other elusive advantages, for example, reinforcing the organization's name in the market, the protection from worldwide challenge, improving the nature of framework and formation of working conditions ensuring inspiration and worker fulfillment (Ogunbiyi, 2013).

2.4 Methods of Mountain Construction

Three provincial narratives concentrating top to bottom on the mechanical difficulties of the entry through Selkirk Mountains, give significant clarifications of changes made to the mainline to neutralize torrential slides and lessen substantial evaluations. John Marsh gives a point by point image of how the development of the Spiral Tunnels and the Connaught Tunnel were done and how they improved the line.(Marsh, 1984) Graeme Pole centers around the Spiral Tunnels from the development along Big Hill to the passage upgrades in the 1950s (Graeme, 1995). These works are important for this theory in disclosing the enhancements to the mainline and in stressing the subtleties of their development. In the mid-90s a comparable model was expounded in incredible detail, proposing quantitative focuses for the Netherlands dependent on evaluations of worldwide and Dutch national "Eco capacity," (the natural conveying limit of the Earth) (Wetterings, 1992). Afterward, Azar et al (1996) exhibited a quantitative way to deal with ascertain "socio-natural pointers" for manageability. Utilizing accessible information, their technique looks at utilization rates to realized asset stores to delineate connections between asset use and supply. The type foundation and the structural system used in the building hugely affect the construction on building on mountains (Wetterings, 1992).

2.5 Practice of Building Design

The methodologies normal for most building rating frameworks occasionally get from unequivocal distinguishing proof of the natural issues that are being tended to or many criteria for making the unavoidable exchange of among accessible answers for ecological issues. Creators wishing to boost structures' general natural presentation must distinguish the commitment of different structure segments and execution on the earth. Such examination starts by posting natural issues, their causes, and assessing elective structure answers for wipe out, limit, or abstain from fueling the ecological issues as pursues (Stamure, 2015):

- Global climate change
- Soil erosion
- Depletion of freshwater resources
- Acid deposition
- Urban air pollution / smog
- Surface water pollution
- Soil and groundwater pollution

2.6 Sustainable Construction Methods To Build Over Difficult Topography

Buildings over difficult topography have many of advantages. The advantages contain prospects of views firstly and secondly the detention of prevalent breezes. Guidance should be required from itemized architects, building designers or builders experienced, engineers in an extensive variety of slope building projects and the structural systems, sideways with the location works and the management of the surface and the sub-surface (Clark, 2012).

2.6.1 Certain consideration while building on sloped terrains (Stamue, 2015):

- Cut and Fill: This depicts the way toward cutting out a level plinth on a slanting site, so as to manufacture a home that is basically intended for use on a level site. Any ruin that is cut from the bank is saved with the goal for it to be taken back to make up the levels on the lower edge. This can be a more financially perceptive arrangement as you do not need to truck ruin away from site.
- Stilts: Developing stilts is one strategy for having a tendency to steeply slanted goals. This avoids the necessity for exorbitant foundations and disproves the essential for falling flat. The other preferred position is that it leaves the ground impeccable. It could be completed on different levels as showed up.
- Views: This about perspectives and augmenting the perspectives at every possible opportunity. One advantage to having a lofty site is that you can take a gander at structuring a ventured structure, which means loads of chance for slimmer rooms with coating and sees. Explore change in levels wand.
- Access: Consider accessibility and how individuals will have the option to travel through and around the precarious site, shown in figures 4 and 5.

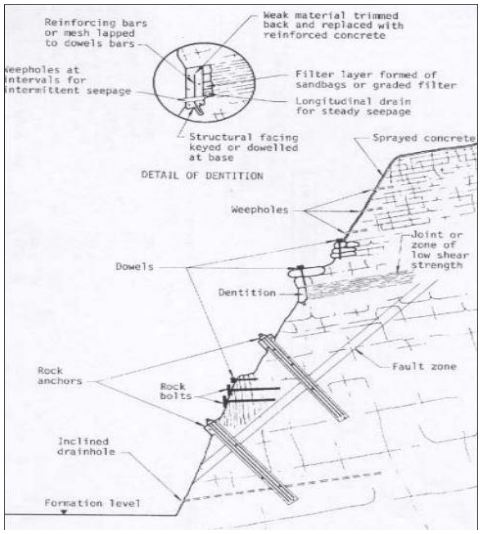

Fig.4: Methods to stabilize a rock slope

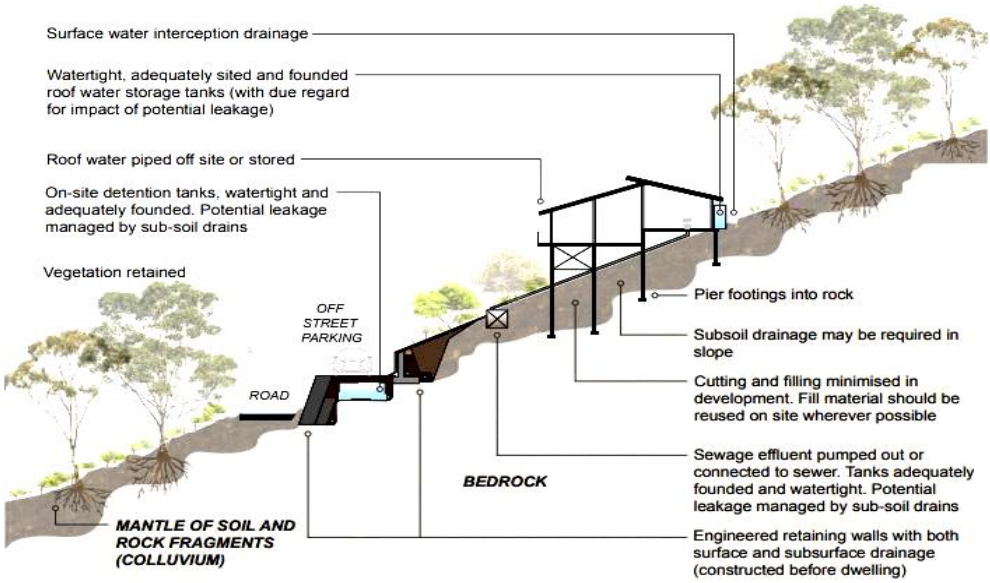

Fig.5: Construction on mountains

2.6.2 Construction methods to build on mountains

Soil-structure connection (SSI) is a region of expanding notoriety that has been applied for quite a while to cases in which the thought of contact between a structure and the dirt wherein it falsehoods could bring about significant changes of the framework's conduct, shown in figures 6 and 7.

- Piling (Soil nail wall)
  Soil nail divider development continues from the start to finish, and head plates are introduced on each nail. Shotcrete or cement is normally applied on the uncovering face to give congruity when a dirt nail divider is developed. For a dirt nail divider the general development methodology includes: Excavate for the primary nail (soil must be adequately self standing) (Clark, 2012).
- Install the first nail.
- Build first stage shotcrete on soil face (discretionary if shotcrete is built) with wire work or other fortification whenever required.
- Introduce soil nail head plate (with or without different connections, shown in figure 6.
- Construct second stage shotcrete (contingent upon organizing determinations).
- Excavate to next soil nail level, and introduce next soil nail, shotcrete and so forth. (Clark, 2012)

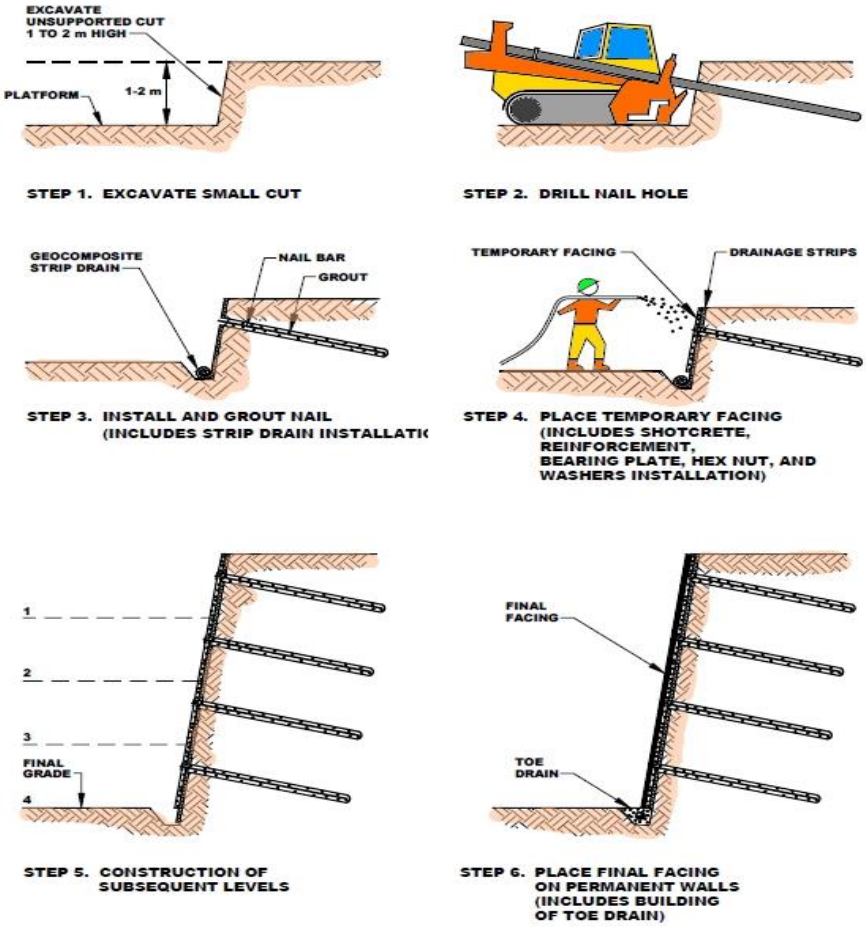

Fig.6: Typical soil nails head plate

So, choosing wisely the structure system and the type of foundation has a vital role in the construction on mountains. It plays a crucial role in making the building feel stable or not. In addition, the material affects a lot the construction on the mountains. It should be strong and stable in order to produce a safe construction and a stable building (Clark, 2012).

2.6.3 Advantages of soil nail

Soil nail dividers display various focal points when contrasted with ground stays and elective top down development procedures. A portion of these focal points are depicted underneath:

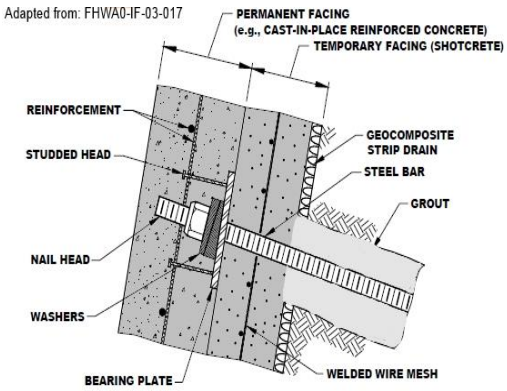

Fig.7: Typical soil nails head plate details

- Less dangerous to traffic and causes less biological impact stood out from other advancement methodologies.
- Provide a less obstructed work place, particularly when stood out from propped uncovering (Franck, 2007).
- There is no convincing motivation to introduce any assistant segment underneath.
- Soil nail foundation is respectably snappy and utilizes customarily less improvement materials than ground stay dividers.
- Soil nailing is valuable at goals with remote access in light of the fact that more diminutive equipment is regularly required.
- Soil nail dividers are commonly versatile and can oblige reasonably huge total and differential settlements.
- Measured hard and fast redirections of soil nail dividers are normally inside center of beyond what many would consider possible. (Clark, 2012)
- Soil nail dividers are generally indistinguishable in cost or more monetarily wise than ground stay dividers when customary soil nailing advancement systems are used.
- Requires tinier right of wat than ground hooks as soil nails are normally shorter.

2.7 Similar Examples for Building on Mountains

The paper presents three examples of building over mountains as follows:

2.7.1 Vertiginous cliff house

A five story particular home sticks to the side of a bluff in this applied structure by Modscape. Propelled by the manner in which barnacles stick to the structure of a ship, an idea was produced for a secluded home to hang off the side of a bluff instead of sitting over it (Inhabit, 2016). The house is imagined as a characteristic augmentation of the precipice face as opposed to an expansion to the scene, making a flat out association with the sea, shown in figures 9, 10, and 11.

Fig.8: Perspective of the building

Fig.9: Plans

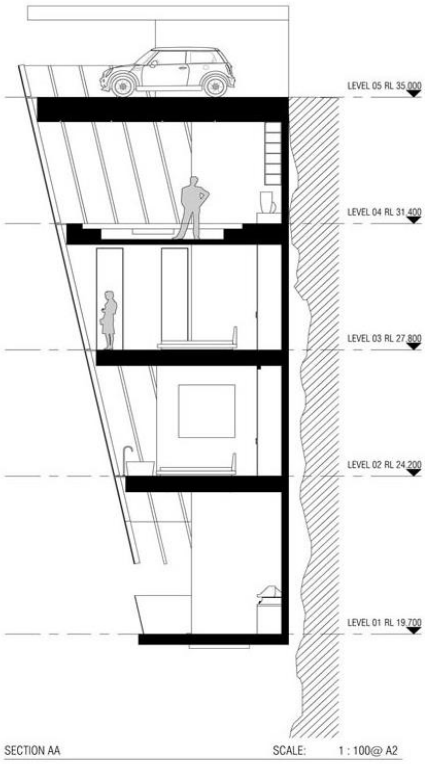

Fig. 10: Section shows the relation of the building with the mountain

2.7.2 Precipice house in Spain

It utilizes the Earth to remain cool framework the undertaking has been to coordinate the house inside the brilliant scene that encompasses it and to coordinate the bearable spaces towards the ocean," said planners Gil and Bartolomé to Dezeen (Inhabit, 2016). "The type of the house and the metallic rooftop delivers a determined stylish equivocalness between the characteristic and the counterfeit, between the skin of a mythical beast set in the ground when seen from beneath, and the floods of the ocean when seen from above, shown in figures 12, 13, and 14.

Fig.11: Perspective of the building

Fig.12: Plan of the house

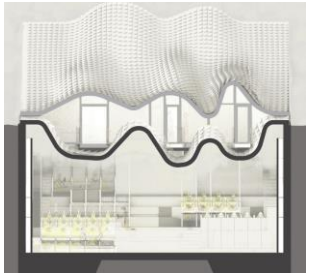

Fig.13: Section

2.7.3 Holy Cross Chapel on the Aegean Sea:

Open Platform for Architecture (OPA) designed the Cliffside building - cross - formed house of prayer implanted into a rough precipice with sensational perspectives on the Aegean Sea (Inhabit, 2016). Named Lux Aeterna, or Holy Cross Chapel, the church was made in a style OPA calls 'Supernatural Brutalism' for its grip of solid, roughness, and breathtaking perspectives, shown in figures 15, 16, 17, & 18.

Fig.14: Day shot of the building

Fig.15: Night shot of the building

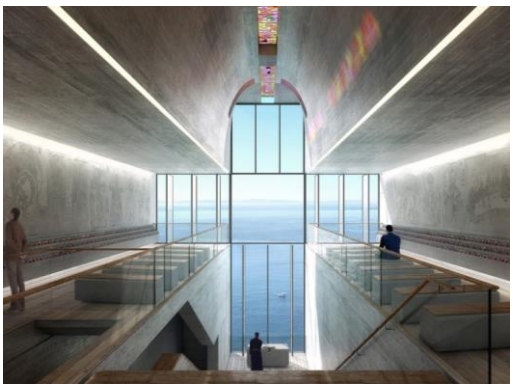

Fig.16: Interior shot

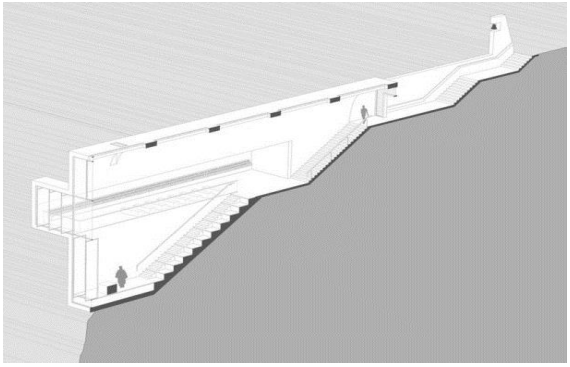

Fig.17: Section of the building

Fig.18: Perspective of the building

2.8 Parameters of Analysis

Based on preceding, there are five Parameters of sustainable construction challenges over the difficult topography: Foundation system, materials strength and stability, Cost, Sustainable construction, Environment: wind, rainwater, shown in table 1.

Table 1: Parameters Table - Reference: Authors

1	2	3	4	5
Foundation and structural system	Materials strength, Stability	Cost	Sustainable construction	Environmental: wind, rain water, sun direction

3. METHODOLOGY

In the context of analyzing the case study, the paper depended on a qualitative type of research based on certain methodologies: introducing a theoretical background about the case study, conducting a fieldwork (site visit, capturing photos, holding interviews, and collection study evidence), activating an analytical method to transform all inputs to numerical outputs, and then deducting certain guidelines of using sustainable construction methods to build structures over mountains.

3.1 Reasons of Selecting the Case Study

The site selection is the procedure and methods of investigative various selections and evaluating their relative advantages and benefits and their disadvantages, then doing the SWOT analysis of each site options to decide what is the suitable one for your project. This site considers one of the forgotten spaces in Lebanon. There is a difficult to access this type of spaces, have irregular shapes. In his book “Finding lost space”, described the poorly used of lands as “lost, less used spaces” or “anti-spaces” (Najjar, 2007). So, the site selection must be a forgotten site by meaning, using, the value of the site neglected.

The site is located on the South of Lebanon, in Al-Nabaiye- Arnoum, Chkif Castle. The case study is selected according to its type, form, and the structure type. The site according to the values that it has social, environmental, and cultural value, plus according to the difficult slop in this site.

3.2 Introducing the Case Study (Cliff of Chkif-Castle in Arnoun)

Arnoun is a Lebanese village 7 kilometers (4.3 mi) southeast of Nabatiyeh, in Nabatiyeh Governorate, southern Lebanon. Chkif Castle, French name is Beaufort Castle. This site has a very important historical value, shown in figures 19 (a), (b), and (c).

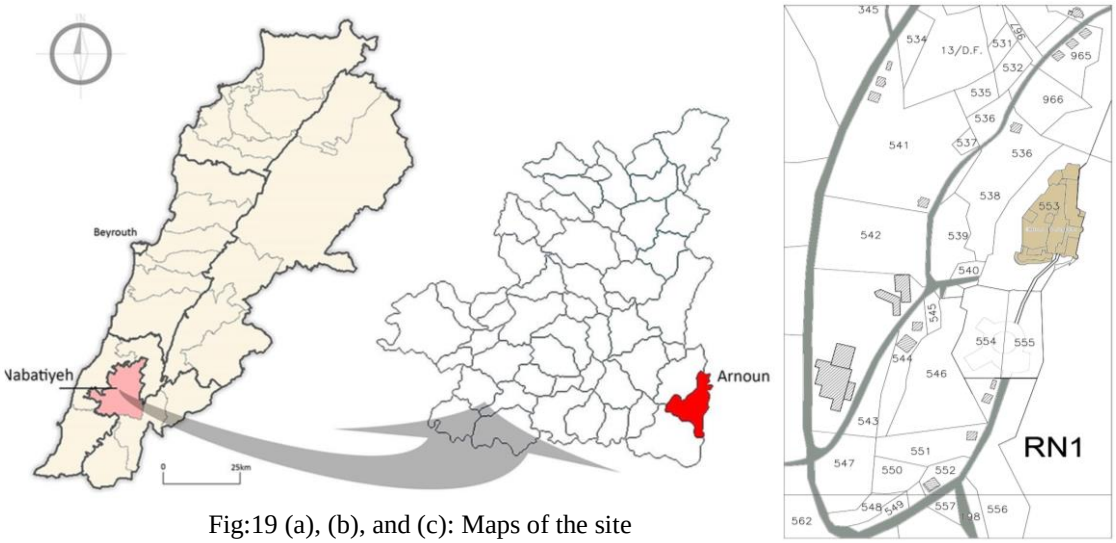

Fig:19 (a), (b), and (c): Maps of the site

3.3 Populations of Al-Nabatieh, and Arnoun

In Al-Nabatieh the population houses more than: 100541, and in Arnoun village the populations of houses is 6000.

3.4 Importance of Chkif-Castle (Beaufort Castle)

The castle through contemporary history, in 1982 when Israeli army entered the south of Lebanon, 'Beaufort Castle' was the first p to be conquest, shown in figure 20.

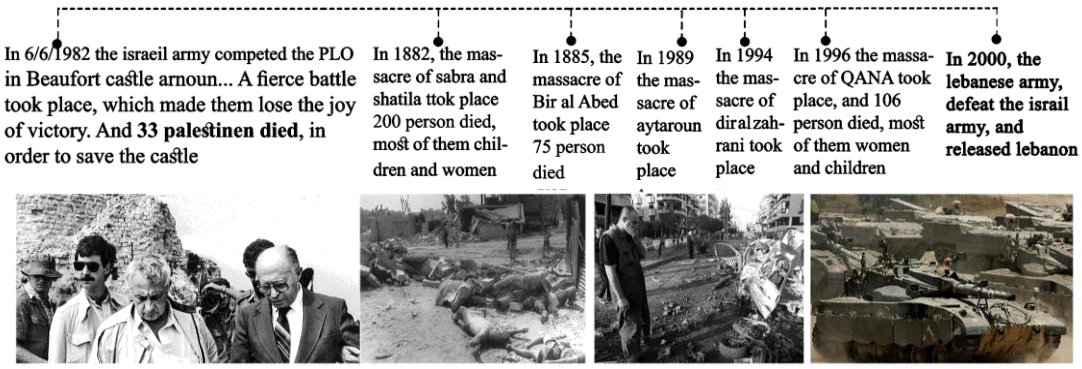

Fig.20: The castle through contemporary history

Chqif Castle has a visual relation with many other castles, and Beaufort castle was the highest one, so by controlling it, you control the entire region covered by these castle. These castles are Chamaa, Tebnin, Sbbeibeh, Dubbey, Hounin, Deir-Kifa.

3.5 Location of Chkif-Castle

Chkif Castle is located in Arnoun, seated on a pick of mountain at a height of 450 m above the valley, and 700 m above the sea100m wide, 160m with Overlooking its high tower in southern Lebanon on the borders of occupied Palestine and Syria, overlooking in Lebanon on Litani River and Marjeyoun and Nabatieh, shown in figures 21, 22, 23, and 24.

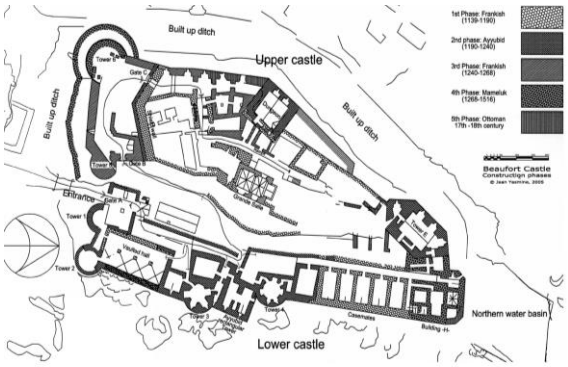

Fig.21: Ground floor plan of the castle

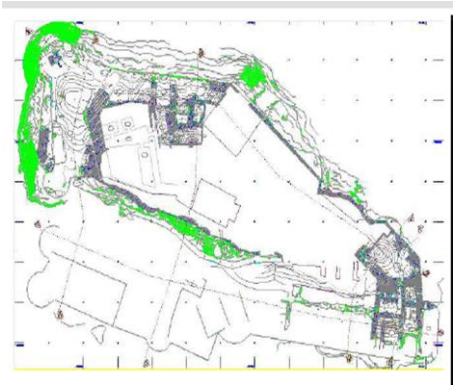

Fig.22: First floor plan of the castle

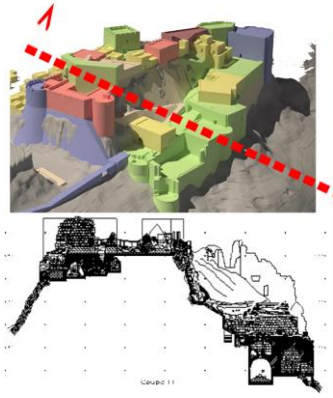

Fig.23: Section in the castle

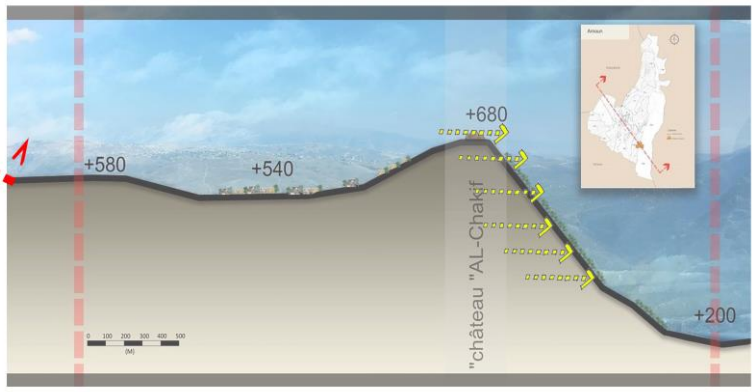

Fig.24: Section in the site shown the slop

3.6 Historical Background of Chkif-Castle (Beaufort Castle)

The historical background of Chkif Castle (Beaufort Castle) from 1000 to 1873 is presented in figure 25.

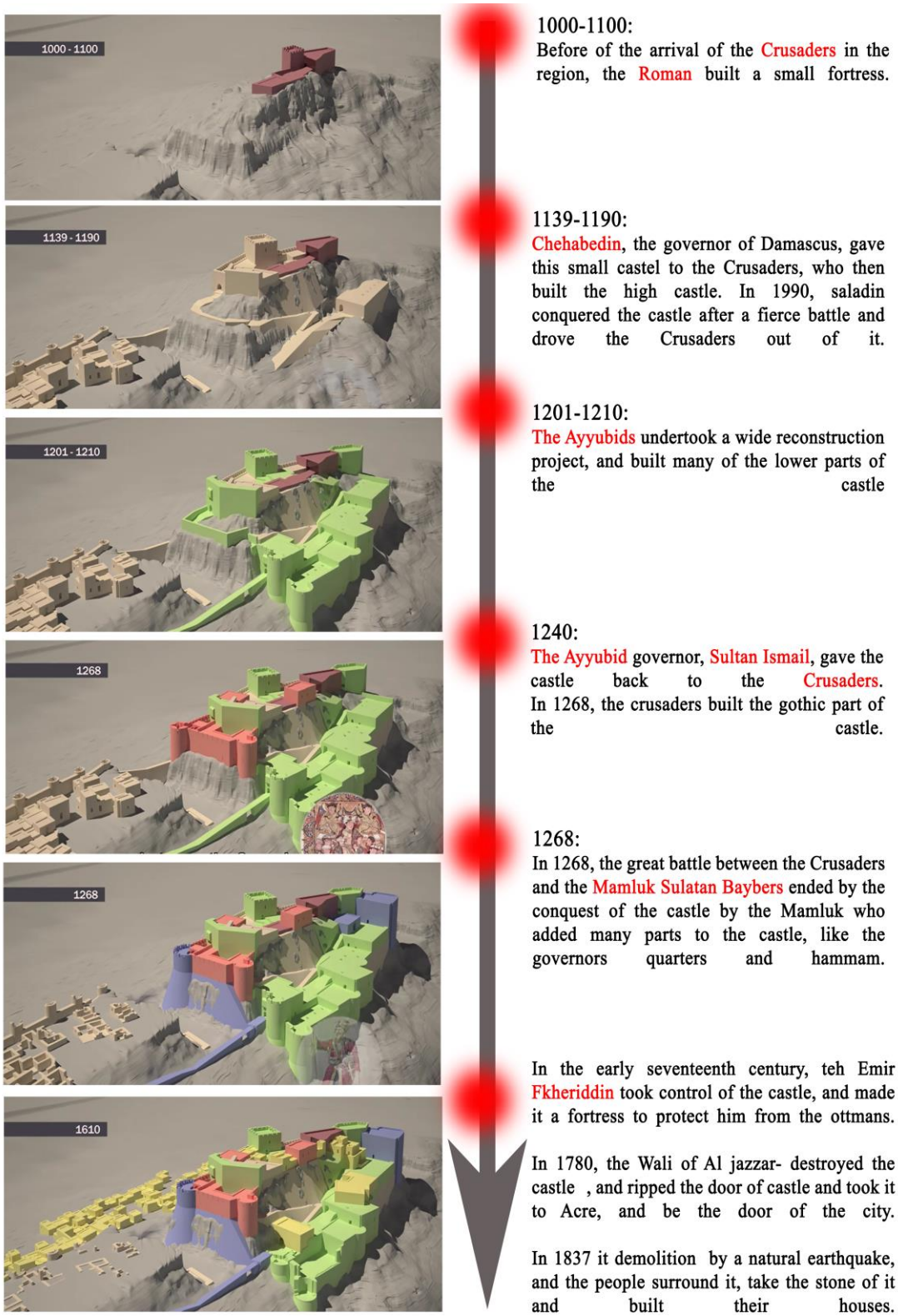

Fig.25: The Historical timeline of the Chkif Castle

3.7 Problems and Challenges of the Chkif-Castle Site

The following points shed the light on the problems of the site as follows:

3.7.1 Environmental effect and natural disasters

Consider the territory's atmosphere before building a slope home. A region acquainted with overwhelming downpours might be progressively disposed to endure landslides. Slope homes are increasingly defenseless against calamitous occasions, for example, tremors, hurricanes, tornadoes and out of control fires. Ensure your house is developed in view of these conceivable outcomes. Appropriate safeguards may limit harms and spare lives (Tsompanakis, 2008).

3.7.2 Construction problems

Considering the above difficulties, legitimate development rehearses, just as satisfactory waste are significant contemplations when expanding on slanted land. Solid breezes, for example, tropical storm power winds can likewise significantly affect homes based on slopes. Development, in which the arrangement is first spearheaded and in this way settled, with satisfactory arrangements made for waste and possibly unsteady slants (Tsompanakis, 2008).

3.7.3 Protection and safety

Assurance and adjustment works that are inappropriately structured or ineffectively developed may intensify incline precariousness. Concerning biotechnical adjustment works, confuse of plant animal types may quicken root wedging in uncovered stone or the fracture of workmanship holding structures. Further, to accomplish the ideal goals for incline security the subsequent vegetation spread must develop to be adequately vigorous. (Tsompanakis, 2008)

3.7.4 Sustainable construction environmental friendly

Green improvement goes well beyond than viability and asks how we can constrain our regular impact in the advancement technique, and in explicit cases, how we can adjust the impact that we do have. (Ogunbiyi, 2013)

3.7.5 Executing projects serving the castle

Project serves the castle and revives the function of it; continue the touristic compound surrounds the castle that contains a memorial museum, theater, and gathering area. The project that will be proposed is a sport hubs and some residential unites serve the sport clubs. (Ogunbiyi, 2013)

3.8 Meeting With Civil Engineers And Architects And Questionnaires To Inhabitants From The Chosen Site

3.8.1 Meeting with Civil Engineers (expert in structure), Architects

To reach tangible results and findings, the authors preferred to meet some civil engineers to identify their opinions, following a questionnaire.

- What is the most economical structure system that provides safety and does not cost much?
  Most of the engineers that I asked answered that the frame structure and the shear wall are the safest in construction in the mountains.
- What is the most economical structure system to use in construction?
  Most of the engineers that I asked answered that the frame structure and the reinforced concrete are the most economical and most sustainable ways.
- What is more dangerous for construction; wind or earthquake?
  Twenty engineers answered that the wind is more dangerous than the earthquake, and ten answered that the earthquake is more dangerous more than the wind.
- What are the challenges may face the building when it is built on mountains?

All the engineers answered that the strength of structure and the selection of materials are the most challenges that face the engineers while building on the mountains.

- What is the most used architectural style used on the difficult topography on the mountains?
  Some of the architects answered that the style refers to the architect itself while designing, but the most used style is the deconstruction style, to make a harmony between the building and the shape of the natural topography or slope.

3.8.2 Questionnaires to some inhabitants from the chosen site

In order to reach tangible results and findings, the authors preferred to do a questionnaire to identify their opinions.

The objective group was haphazard inhabitants, from 7 to 20 years old since they are more affecting the upcoming generations. The survey was bursting by thirty persons to confirm several views and opinions and to mark what services and the activities can consider and enhance the quality of life. Three questions were focused to the sample: What are the big problems in the area? What is your educational level? Moreover, what are the facilities that you favor to be provided to upgrade your community?

4. FINDINGS

From the answers of the sample and the questionnaire, the following results were concluded as follows:

- 65% of the engineers answered that the wind is more dangerous than the earthquake, and 35% answered that the earthquake is more dangerous more than the wind, shown in the chart of figure 26.
- Most of the engineers that the authors asked answered that the frame structure and shear wall are the most economical and most sustainable, shown in the chart of figure 27.

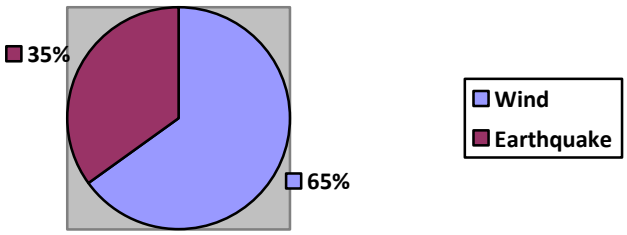

Fig.26: Chart of answering of what is more dangerous for Construction wind or the earthquake
Reference: Authors

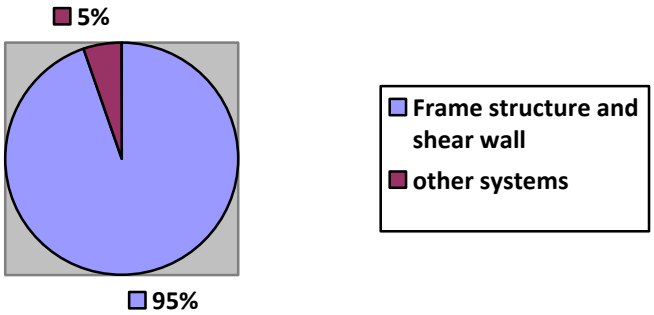

Fig.27: Chart of answering of what is the most economical and sustainable to use in construction?
Reference: Authors

5. DISCUSSION

The paper follows the analytical methodology to investigate and analyze the answers said in the meetings and the answers submitted in the questionnaire forms.

5.1. Findings of the meetings with the engineers and the architects, checklist of the decisions making to build on the mountains, and the type of the selected structure type, used in the building are shown in table 2.

Table 2: Checklist of the decisions making - Reference: Authors

Checklist of the decisions making	✓ Type of structure: steel frames ✓ Material selection: steel and concrete ✓ Style used: deconstruction style or minimalism ✓ Be environmental by less excavation

5.2. Findings of the questionnaire to some inhabitants from the chosen site, checklist of the needs in Arnoun-Chkif castle: Most of people in the region answered that the sport entertainment activities serve the city and the castle and revive the site and grabs the attention. In addition, the need for a gathering area, and the need for an amphitheater for the conferences that make it side the castle are shown in table 3.

Table 3: Needs in Arnoun-Chkif castle - Reference: Authors

Sport entertainment activities	Restaurants	Gathering area	Amphitheater	Residential units serve the project

5.3. The discussion may reach to certain deductions from the analysis of the case study:

a. Revive Chkif Castle with projects surrounding it to help it to its growth and develops it.
b. Provide the needs of the country and the needs of the castle like having a theater to make conferences and new activities in order to attract people.
c. Use the best type of structure and the most efficient and sustainable ones to save the natural topography.
d. Benefit from the natural resources to increase the use of energy and renewable resources.
e. Save the value of the castle, by style and shape of the building.

6. CONCLUSION

The paper ends with a set of conclusion points as specific guidelines of using the sustainable construction methods over mountains as follows:

- Using sustainable construction materials:
  - Use renewable and recyclable materials to be friendly with less effect on the environment.
  - Types of glass must be multiple glazed, lightweight, and well-isolated.
  - Beside steel and concrete, there are new types of thermoplastic polymers that can be used to sustain such projects. These materials are like: Acrylic panels, Tephlon sheets, PVC (Photo-Voltaic-Cells), E.T.F.E (Ethylene-Tetra-Floro-Ethylene), F.T.F.E (Floro-Tetra-Floro-Ethylene). These economic eco-friendly materials have high corrosion resistance and they can withstand the high temperature and the difficult extreme conditions.
- Structure types: there are different types of structures to build on mountains; but based on the theoretical information gathered in this paper, the most recommended are frame steel structures, suspended structures, and shear concrete structures.
- Roofs: the roofs should include an inclination to withstand the natural environmental conditions.
- Retaining walls: it is an important element for resisting forces coming from mountain layers. Execution works of these walls require professional level of building construction.

Essentially, building projects over mountains include the use of retaining walls as a part of construction.

- Loads (Tension / Compression); according to the type of structure, loads are tensile or compressed, or a composite of both. In suspended structures, loads are tension where cables suspend the building over a mountain, while in shear concrete structures, loads are compressive. To sustain the structural safety, elements of structure should conserve the fluidity of loads with no obstacles and with full consideration to the anticipated future natural hazards - such as layer-slides, earthquakes, tornadoes, wind, snow, storms, immigrating fleets of birds, … etc.
- Stability (gravity / anti-gravity); A body with a low focus of gravity is steadier than a body with a high focal point of gravity. An ecstatic structure over a mountain attracts people to visit, especially if it implies an aesthetic structural dimension. To sustain this value, structural engineers can support the building with additional items for conserving stability.
- Design features - (view, entrances, and circulation): Architects should consider these three important design features while building over a mountain. In order to provide an ideal view, glass curtain walls must be transparent to enable users to view the surrounding in free angles of sight. Accessing entrances can be from the peak of mountains with providing a parking lot for cars. Circulation elements should be diverse and attractive to allow maximum benefit to view the surroundings. These elements can be (ramps, staircase, escalators, travellators, cable-cars, panoramic elevators, lifted platforms).
- Preferable typologies of projects to be built over mountains are resorts, hotels, museums, art galleries, mountain sport facilities, rest-areas, restaurants, and pavilions. These typologies target touristic and entertainment purposes for attracting visitors.
- Existence of sloped contour lines can be employed to be a potential not a threat, but that requires skillful architects, experts of structural engineers, and bold decision makers with innovative vision.

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