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INTEGRATION OF ARCHITECTURE AND LANDSCAPE ON SLOPING SITES: A SUSTAINABLE APPROACH TO BUILDING DESIGN

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ABSTRACT

This paper investigates the adaptation of sustainable architectural designs for sloping sites by building in the natural context. While sloping sites can create certain design restrictions, they can also be a source of design innovation that takes advantage of the existing topography. The present research aims to determine design approaches, which build both visual and functional equilibrium to the buildings, while efficiently providing comfort and ecological nature of the buildings. The use of qualitative analysis of four case studies, Ncaved House in Greece, UCCA Dune Art Museum in China, La Escondida Apartments in Mexico, and Private House in Thusis in Switzerland reveals that the successful integration of buildings into the landscape is aided by the usage of local materials, use of daylight and cross-ventilation and shelter from extreme weather conditions among other factors. Each case study looks at how the design resolved the challenge of a sloped site and perspectives of ecology and aesthetics. These insights are important for designers as they address the issue of how to maximize the design's ecological sensitivity and beauty, without shunning sloped sites but instead using them as positives in the overall architectural design scheme.

Keywords: ***landscape integration, local materials, natural lighting, sloping sites, sustainable architecture***

INTRODUCTION

The relationship between architecture and topography is one of the most interesting topics which has received a lot of attention in recent decades, as the need for nature-oriented design becomes increasingly important. Architecture on slopes involves some unique technical as well as aesthetic considerations, especially in terms of structural integrity, energy use, and incorporation into the environment. On the one hand, maximal potential for design innovation exists in sloping sites allowing the architects to create spaces that integrate into the landscape or the topographical features absent in the horizontal planes. On the other hand, the unequally distributed topography even though most of the time adds sandwiched construction & design complexity and cost also requires special design and construction methods to prevent environmental damage.

Present-day perspectives on landscape architecture across the globe indicate a growing interest in sustainability designs that ensure that structures seamlessly coexist with their environment. Nevertheless, such approaches have not been completely embraced when it comes to practice on slopes, especially in developing nations that are still grappling with cost-effective mass solutions of eco-friendly design technologies. The technical challenges that are faced when designing such as soil e stability, drainage management and provision of access in sloping sites are more extensive hence the need for more complex design solutions. Furthermore, due to global warming, there are climate patterns that result in higher rains and more frequent landslides which necessitate sustainable design approaches that are optimal to the natural conditions.

According to Leatherbarrow (2004), the landscape has been a prevailing theme in architectural considerations, and this has helped to erode the boundaries that separate the two practices (Leatherbarrow, 2004). Thoren (2005) elaborates on this view by discussing the contrasting perceptions of buildings about their surroundings- as additions in the former and as opposites in the latter (Thoren, 2005). The geographically grounded elements in the architecture have also been highlighted by Norouzi & Khademi (2021), where the critics regard regionalism as the answer to the defects of modernism (Norouzi & Khademi, 2021). Ford (2014) examines the fascination architects have had with geographical studies for centuries, while Girot (2018) mentions the tendency to bring nature within the building walls through its exteriors (Ford, 2014; Girot, 2018). The historical and geographical range of the Federated States of Micronesia's architecture is analyzed by Morgan (2008) about sustainable architecture practice. All these show that there is an increasing tendency to theorize and practice that overlaps the disciplines of architecture and landscape topology (Morgan, 2008).

Building on sloping sites presents difficulties as far as the construction process components are concerned. Such irregular topography necessitates a particular design strategy that seeks to meet functional and aesthetic needs without compromising on structural integrity. Research has shown, that land that is not flat has its effects on the degree to which construction is completed, the cost of construction, and even the designing process (Booth, 1989).

The various sloping land treatment methods include: blending with the contour and laying back the slopes, to putting up the building underneath the ground. These options are selected for use not only because of their effectiveness in achieving the intended goals but

also in consideration of how they will look or affect the environment. As an example, the Casa Brutale project by Open Platform for Architecture (OPA) shows how the extreme embedding of a building into the side of the cliff facilitates the integration of the structure into the existing environment while limiting the negative sight as well as ecological impact (Strom et al., 2013).

Besides the technical difficulties, the sloping terrain also provides its advantages, especially in the exploration of designs. Solutions that go with the natural land can be worked out which are better and more beautiful. For instance, in designs that take into consideration the existing natural slopes, the aspect of the buildings and the landscapes is well portrayed as made possible by the use of natural lighting and ventilation (Xu et al., 2021).

Thus, the main purpose of this study is to develop design strategies that will help in the better connection of architecture and the surrounding area on sloping sites with special emphasis on eco-friendly techniques. So, the main focus is the enhanced structural integrity of the buildings, use of natural light and air for energy saving, and sheltering of the building from unfriendly climatic conditions that these, especially other slope lands are prone to. With the help of case studies from architectural projects across the globe, this research also aims to define design strategies that are reasonable to use in more advanced areas and also in less developed ones.

Many scholarly texts have analyzed the relationship of architecture and landscape within the built environment. However, few have studied the conditions and design issues of sloping ground. Studies such as those by Leatherbarrow (2004) and Thoren (2005), advocate for the integration of landscape in architecture, but their emphasis is mainly either on flat sites or cities. In addition, while the topic of sustainability in architecture is a wide field, few studies address how this concerns the problems that one finds on sloping sites. Hence, this research seeks to investigate the architectural design of sloping sites in a sociological sense by turning towards sustainability, landscape integration, and coping with the existing landform.

Through the exploration of four projects that use different approaches to slope management, this paper aims to identify the key factors that determine the success of these projects. With in-depth analysis, it is expected to provide some practical recommendations for architects, planners, and developers on how to deal with difficult landforms. Not only this study is concerned with the technical issues, but also the environmental and visual impact of each method used (Ruhig & Ruhigová, 2024).

In this regard, the contribution of the present study is the analysis of successful architectural projects on slope land from the point of view of sustainability. Moreover, it broadens the scope further by including discussions of ecology and climate extremes within the practice of architecture for slopes which have been discussed in that context sparingly. Therefore, this research not only provides design solutions to the architect or the planner but also expands their perspective on the solutions to the experienced problems through the nature responsive design.

METHODS

The present study seeks to give qualitative evidence about women's architectural projects whose sites are on a slope. The selection of the qualitative methods is based on the nature of the research which aims to investigate exhaustively the design process, the ecology to the architectural work as well as the other structural problems related to building natural landscapes. This will enable a more thorough examination of the relevant case studies than what would be possible with more quantitative but less well-suited approaches in looking towards the design contexts.

First, undertake a detailed literature review of the ArchDaily website and search for “sloping plots,” “hillside architecture,” “topography” et al. Among the results of this search, we chose fifteen projects that are the most representative of the various kinds of approaches towards slope management. These projects are selected according to some rationality such as design novelty, people and environmental acceptance, and even durability (Delaqua, 2023).

From upward and downward slopes, each examined case is studied towards the understanding of the design philosophy towards stabilizing the slope. This understanding involves analysis of site analysis, building envelopes, construction materials, and processes used. Further to this, the ecological as well as productive values of each case are also analyzed to depict the balance between architecture and extreme topography (Solà-Morales, 1997).

Four Case Studies have been chosen as the research subjects: Ncaved House in Greece, UCCA Dune Art Museum in China, La Escondida Apartments in Mexico, and Private House in Thusis, Switzerland. These case projects are chosen with the following considerations:

- Topographical Significance: All the projects are executed on slanted surfaces with varied topographical aspects, comprised of steep hill slopes and dune, among others.
- Innovative Design: The selection of the interactive energy concept projects was because they showed great creative images in the use of the existing topography for constructing the buildings, such as the local materials used, the extreme weather adaptations, and the natural lighting and ventilation.
- ‘Green’ Approach: Each project was selected due to the use of ‘green’ architecture in the design and also how the structures are built and operated.
- Local Context: These projects are not all from the same region, thereby exposing their contributors to different ecological systems and cultures, and allowing for maximum study of local adaptation.

To further enhance the credibility of the research we also examine how the outcomes of these projects relate to established bodies of knowledge regarding architecture and topography. The references used include concepts from Leatherbarrow (2004) regarding the primacy of the landscape approach in architecture and also critical regionalism with modernism by Norouzi & Khademi (2021). In conclusion, while the findings of this research are drawn from practice on selected case studies, the research is logical due to attendant theories and concepts within architecture and landscapers (Leatherbarrow, 2004; Norouzi & Khademi, 2021).

The data for this research included both textual and visual data which comprised architectural details (such as drawings, site maps, and pieces of buildings), project evaluations on major architectural platforms like ArchDaily and Dezeen, as well as other related scientific publications. Visual documentation was preferred owing to the fact it contains very useful details concerning the integration of the structure with its topography and the neighboring environments. Moreover, to augment the existing information, several secondary sources were utilized including interviews with the project architects.

The analysis is executed manually and does not use any advanced software. Each drawing about the building together with site plans, a plan, cuts, perspectives drawings, etc. is visually analyzed to extract significant design elements that relate to landscape integration and structural stability as well as sustainability. Manual interpretation procedures involve studying specific design elements, including the orientation of the building, the material used in the building, and how buildings are modified to suit the climate and natural environment of the site in question. The architectural drawings are then taken to the scale to determine the effects of these aspects on both the function and beauty of the structure given that the terrain is a sloping one.

Further, a literature and project descriptive analysis was conducted to examine what architectural approaches were employed. Each case study is evaluated based on a structure comparison, for instance, design breakthrough, sustainability, and suitability to the site's topography. This constrains the research in a way that general rules that may govern such design projects are established for future use.

RESULT AND DISCUSSION

Sloping surfaces, due to their topography, are quite challenging for architects and even construction workers. The uneven land surface calls for a special design that has to be different from that of a plain surface, both in graphics and engineering. Below are some of the main issues that one encounters when developing projects on a crescent sliding landscape.

Designing buildings on a slope is considered troublesome due to the inherent risk of losing stability. When a construct is built on the existing soil with a considerable slope, the sloped soil poses a big problem in stability especially when the bearing strength of the soil is low or there is the possibility of a soil slip. In such situations, reinforced deep foundations may be required and soil nailing techniques may be considered including soil retaining structures or fabric encasements (Moraru, 2017). If the building is to be occupied, adequate structural stability must be obtained for the safety of both the structure and the occupants inside it.

This is because drainage and water management can be complicated in a sloping area too. On sloping soil, rainwater seems to move faster which can cause soil washout and raising flooding chances at the lower end of the slope. Therefore, to alleviate these problems, drainage planning has to be incorporated at the design stage as one of the key issues. It is important to design drain systems in a manner that all the effluent wastes will be drained away without risking soil erosion, and without causing any water damage to the

building (Thompson & Sorvig, 2000). In some instances, the application of terraces or underground drain pipes is effective in directing water resources.

Accessing and constructing structures on sloping sites can be quite a difficult undertaking. Sidewalks, staircases, and vehicular sidewalks are all necessary elements that are sometimes required to accommodate significant vertical rises in elevation without compromising comfort or safety. The features considered in the design problems influenced access to use at times causing problems among the users especially those with limited mobility, (Lavery et. al. 1996) so it is essential to design circulation layouts that can serve the purpose and are also safe and accessible.

Sloping land is generally found in areas with high ecological or aesthetic value, examples include; hilly, mountainous, or even steep coastal cliffs. Therefore, one of the main obstacles is how to develop the activities with minimal environmental degradation yet still maximize the development in the beautiful landscape. Patterns of development that follow natural lines and are made with on-site materials can mitigate the effects of development on the environment (Leatherbarrow, 2004). It is necessary to create a concept of architectural projects and their plastic solutions, which will not only fit in but work together with the surroundings, also, eliminate the excess aesthetics and help preserve nature.

Another issue is usually the higher cost and complexity of construction on sloping sites, which presents additional challenges. Specialized equipment and more sophisticated building methods are often necessary during construction on sloping sites, which may make the budget for the project soar. In addition, adverse site conditions may lead to an extended construction schedule and may expose site workers to dangerous activities (Amangeldi, 2020). Stamping out the additional costs as well as the potential risks often associated with development on sloping lands is possible through careful design and modern construction methods. In the course of this research, how design is used in dealing with topography in architectural projects with slopes is studied and analyzed. The selected case studies include a variety of projects from all over the world available in one of the most prestigious architectural websites ArchDaily. Each of these projects explores a distinct approach to how architecture integrates, or rather overcomes, the difficulties presented by the elements without sacrificing beauty and usability. The analysis considers many factors, including, but not limited to, landscape incorporation, materials locality, and the use of green technologies. The findings of this research have been tabulated in Table 1 as a summary of the examined projects and their primary characteristics and design principles employed.

Table 1: Research Findings from Case Studies

No.	Project Name	Location	Year	Design Approach	Area (m^2)	Key Features
1	La Escondida Apartments	Puerto Escondido, Mexico	2020	Utilizing terraces for optimal visibility	8310	Cross ventilation system, private pool, use of local materials
2	Ncaved House	Agios Sostis, Greece	2020	Embedding the building into the slope to protect from strong winds	360	Wind-resistant structure, natural lighting, landscape integration with a green roof

No.	Project Name	Location	Year	Design Approach	Area (m^2)	Key Features
3	Private House in Thusis	Thusis, Switzerland	2020	Blending with the topography, connecting the building with the natural landscape	1000	Dry stone walls, natural ventilation, layout utilizing natural contours
4	UCCA Dune Art Museum	Qinhuangdao, China	2018	Embedding the building into the sand to create interaction with the landscape	930	Organic concrete structure, natural lighting, reducing summer heat load

Source: Adapted by the author from ArchDaily Delaqua, (2023).

In Table 1 illustrated above, the table shows the variation of design approaches in architectural projects on sloping land. In this respect, it is apparent that the theme of integration between built forms and the environment is gaining prominence, with most building projects adjusting the shape and orientation of the buildings to the view's advantage while maintaining an ecological balance. Furthermore, how many case studies emphasize the use of eco-friendly materials and system technology. Such insights suggest that the positive outcome of architectural over-slope lands cannot only be ascribed to technical solutions. It also requires the skill of observation and adjustment to the already existing conditions.

As regards, the analysis conducted on the case studies briefed in Table 1, several research questions about architectural projects on slopes. These areas demonstrate varied methods and tactics in overcoming the topographic issues at hand and how buildings are designed with the environment. One such finding examines in-depth the logic of architecture in difficult terrain and how every given project can obtain a balance between functionality, beauty, and nature. In addition, Table 2 presents the overview of the themes that have emerged from the case studies evaluated – key issues in each of the themes, as well as examples of projects demonstrating these issues.

In Table 2 focused on the major themes that emerged during the case study analysis. Several themes such as integration with the landscape, landscape optimization, use of local materials, and natural lighting and ventilation have reoccurred in different projects. These

Table 2: Key Themes from Case Study Findings

Theme	Description	Project Examples
1. Integration with Landscape	Architectural approach that blends with the natural topography, minimizing visual and ecological impact	Ncaved House, UCCA Dune Art Museum
2. Landscape Optimization	Building design that utilizes land contours to maximize views from each unit	La Escondida Apartments
3. Use of Local Materials	Use of local materials to ensure harmony with the surroundings and enhance sustainability	La Escondida Apartments, Private House in Thusis
4. Natural Lighting and Ventilation	Design that prioritizes natural lighting and ventilation to create thermal comfort and energy efficiency	Ncaved House, UCCA Dune Art Museum
5. Protection Against Extreme Conditions	Architectural and environmental design strategies for mitigating the impacts of harsh weather elements, for instance, strong winds and hot temperatures.	Ncaved House, UCCA Dune Art Museum

Source: Author, (2024).

results underscore the need for an ecological and contextual approach to architectural design especially in this region where the slopes have presented unique challenges. These themes enhance the knowledge of the architects and planners in creating an all-encompassing and responsive design that optimizes the surrounding conditions to produce enduring and aesthetically pleasing works, rather than mere beautiful works only.

Integration with the Landscape

The Integration with Landscape, which is the first theme of Table 2, is an architectural practice that aims to achieve a balance in the design of a building and the natural features of the site on which the building is situated among others, topography. This line of thinking is not solely aimed at reducing the structural and environmental effects of a building, but enhancing how that building interacts with its surroundings.

In projects like Ncaved House and the UCCA Dune Art Museum, Integration with the Landscape is achieved through designs that follow the natural slopes of the ground. House Ncaved was built deep within a tectonic crack within a steep slope of Serifos, a Greek Island. Such an approach shelters the edifice from the biting cold winds and scorching sunlight while providing panoramic views of the ocean. Consequently, the dwelling does not disrupt the scenic beauty of the environment but instead is immersed within it and transforms into a landscape in itself.

Of all these exemplary instantiations, Ncaved House on the Greek Island of Serifos, is an example that fits well under Theme 1: Integration with the Landscape. MOLD Architects designed this project, which illustrates how a building can sit within its site without disturbing the exterior.

The first design problem that the Ncaved House project encountered was how to protect the house from its exposed location to extreme weather conditions, particularly from the strong north winds. The answer was to embed the house into the steep slope of land located just above a small, sheltered bay. Rather than being elevated on the ground, facing the wind directly, the structure is ‘buried’, or sunk into this slope so that its surface is almost parallel to the surrounding earth. It not only lessens the windward side elevation as is viewed from the front but more importantly, it shields the elevation from being battered by strong winds.

This method of landscape integration is also noted on the buildings in the area through the geometric grids used to incorporate building designs into sloping terrains. In this case, the grid forms a three-dimensional ‘chessboard’ pattern of solids and empty spaces, each of which yields to the various functions in the house and contours of the ground. For instance, the wind-protected and noise-shielded zones are located deep inside the slope, while the noise-oriented zones such as living rooms with expansive views are widely placed in spaces with the appropriate orientation for the views of the ocean.

Great care was also put in the selection of the materials that were used in Ncaved House to enhance its landscape integration. The long walls of the building are dry stone quarried in situ, thereby reinforcing the visual and material context of the Structure to its environmental conditions. Also, there is a slim, open-able, glass enclosure on the transverse walls enabling the Eastern side of the house to be fully opened allowing for maximum

Figure 1. Exterior and interior of Ncaved House. Photo credit: Yiorgis Yerolymbos, Panagiotis Voumvakis *Ncaved House / MOLD Architects | ArchDaily*, (2020).

natural light and air circulation whilst ensuring the beautiful views of the ocean are not hindered.

As conclusion, Ncaved House performs not only the functions of a warm and comfortable shelter but can also be considered as part of the peculiar landscape. This revealing attitude illustrates the objectives of much of contemporary architecture – to create structures that do not simply occupy space but enhance the quality of the natural space within which they are placed, construct balance between built forms and nature's creations, see below Figure 1.

The Ncaved House both externally and internally is shown in Figure 1, indicating how careful the builders were in designing the house to fit into the natural landscape. The image suggests that the house is set deep into a slope which is on top of a small bay. The placement of the house makes it sheltered from strong winds and also lessens its intrusion into the natural scenery. The long walls of the house incorporate a stone structure, which helps them to be more effective as an architectural feature and as a means of what is inside the building seamlessly blending with the outer earth surrounding it. Balancing dry stone, with sea-view facades shows an architectural integrity that respects environmental aspects. The simply furnished yet stylish interior of the house also supports the idea of minimalism in designing a house amid nature whereby every space is intended to offer views and allow in light but devoid of disturbing the house occupants, the needs of nature are focused on integrating out rather than obliterating the structure's Ncaved House is a great model, which showcases how structure can co-exist within the landscapes to achieve balance in both artificial and natural beauty. The images are designed shapes, they are oriented plans and sections which have been worked out from figure 2 below.

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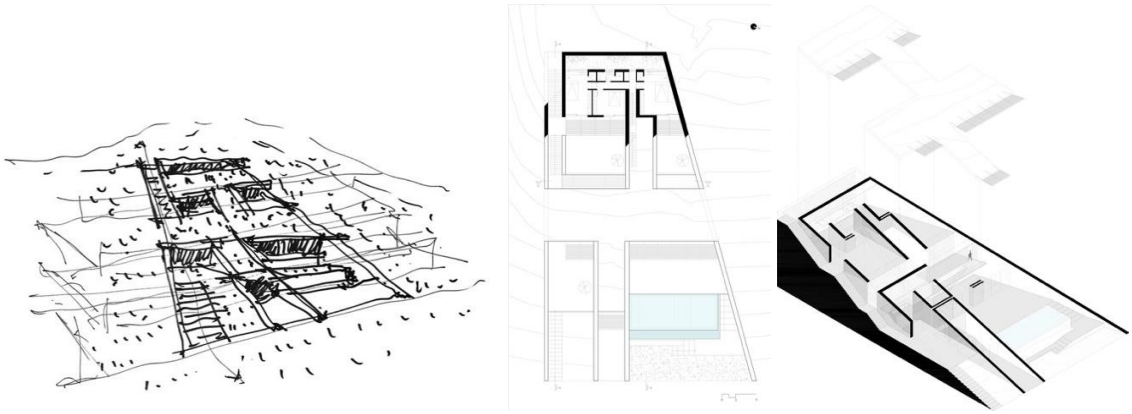

Figure 2. Concept sketch evolving into the plan and isometric view of Ncaved House. Photo credit: Yiorgis Yerolymbos, Panagiotis Voumvakis
Ncaved House / MOLD Architects | *ArchDaily*, (2020).

In the meantime, the UCCA Dune Art Museum in Qinhuangdao, China, adopts similar strategies but in a contrasting context. The museum is carved directly beneath a dune, hence almost remains out of sight over a distance. This strategy helps protect the delicate dune system while ensuring that the visitors enjoy a different type of experience as if they are entering some underground world connected to the seashore.

This kind of approach to landscape integration strives to redefine the conception of architecture; it states that architecture goes beyond being just a building. With the above, when attention is paid to the inherent qualities of the site and the insertion of the building is carried out, structures like in Figures 3 and 4 were able to attain visual and ecological balance along with enhancing the experience of the users and visitor in the case of the structures.

Figure 3. UCCA Dune Art Museum. Photo credit: Qingshan Wu, Nan Ni
UCCA Dune Art Museum / OPEN Architecture, (2018).

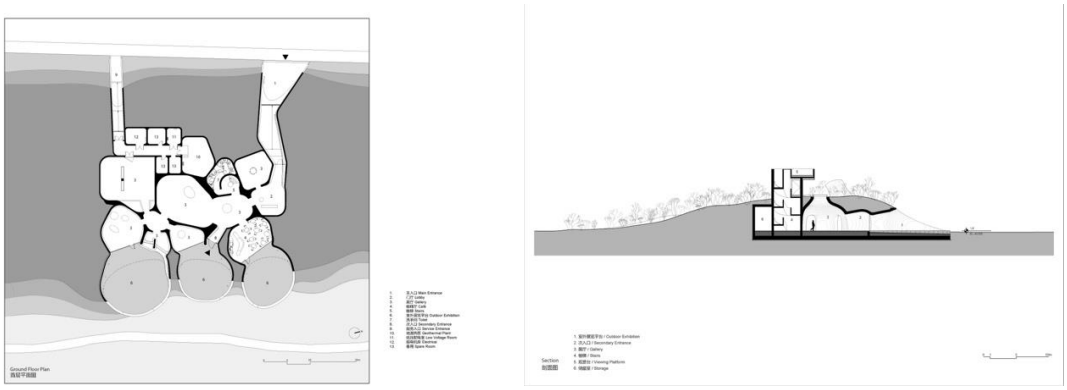

Figure 4. Site plan and section of UCCA Dune Art Museum. Photo credit: Qingshan Wu, Nan Ni *UCCA Dune Art Museum / OPEN Architecture*, (2018).

Figure 3 illustrates an instance of the principle of landscape assimilation to architecture in the case of the UCCA Dune Art Museum. In a spirit similar to that emulated at the UCCA Dune Art Museum in Qinhuangdao, China, buildings have been carved under the dunes, almost out of sight but very much part of the coastal terrain. Both of these works demonstrate how structures are an enhancement of the natural environment and create useful spaces that are also pleasingly appropriate to the context. This exemplifies a design narrative where there is an awareness of the role of nature in human development, and thus the aim is not to conquer but to engage with that nature.

Landscape Optimization

The optimization of the landscape is one of the fundamental principles of architectural design, especially for projects on a slope of the land such as the La Escondida Apartments, Puerto Escondido, Mexico. This aspect is concerned with how the design of the building incorporates the existing landscape to enhance the views from each unit of the building; so that every person living in the house can appreciate the surrounding nature.

La Escondida Apartments has an accent in design that creates the impression that buildings are swaying with the natural terrain as the coastal land rises. So all these apartment units enjoy the sea views without interception from the separate units. The terraced or stepped design that is put to use allows each floor or unit to be at a different level giving rise to a spacious viewing area without blocking the privacy or views of other units. The end product is a house that provides not only the comfort of habitation but also captures beauty, making one understand why every resident longs to be close to the ocean and the sights around.

This configuration also enhances the flow of natural light and air as each unit can face the sea directly allowing sunlight to penetrate and the cool breeze from the sea to refresh the interiors. Also, the positioning of the building which follows the topography of the site minimizes the amount of excavation work required hence making the project not only beautiful but also eco-friendly.

Generally, La Escondida Apartments is a successfully designed project for the use of local landscapes and architectural forms for the benefit of residents and the environmental state. This practice proves that even a slope, which is often considered a drawback, can with adequate diligence and imagination become a source of breathtaking design ideas.

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Use of Local Materials

In architectural design, the incorporation of local materials is a key issue that enhances the sustainability of the structure and ensures that the building is in conjunction with its landscape. For example, in the cases of La Escondida Apartments in Mexico and Private House in Thusis in Switzerland, the goal of the projects puts great emphasis on the use of local materials that strengthen the relationship between buildings and the nature which usually envelops them as well as the cultures associated with those landscapes.

The apartments at La Escondida are constructed with materials almost entirely sourced from the local vicinity. By employing materials such as natural stone and local wood, there is a reduction in the emissions associated with long-distance transport of construction materials, thus enabling the edifice to fit in within the distinctive coastal landscape. The color and texture of the material are sourced from within the immediate environment, This apartment appears to be naturally fitting within the environment and does not interfere with the already existing calm natural scenery but enhances it. Also, these local materials are more suited to the local climate conditions, which, in turn, reinforces the sustainable aspect of the project.

La Escondida Apartments, designed by Francisco Pardo Arquitecto, is a residential project that makes the most of the natural topography of the location in Puerto Escondido, Oaxaca, Mexico. Located just 50 meters from the majestic Pacific Ocean coast, the apartment is designed on top of a cliff with a slope between 20 to 40 degrees, making it a challenging yet potential project in terms of scenery and integration with the surrounding nature.

One of the main characteristics of La Escondida Apartments is how the design adapts to the existing topography, not against it. By following the natural slope of the ground, the building not only maximizes residential density but also ensures that each unit has privacy and unobstructed views, especially 180-degree views towards the Pacific Ocean. This arrangement is done through a series of terraces, rotations, and patios (inner gardens) strategically placed between the apartment units. This design allows all units to get maximum natural light and ventilation, while also offering a unique experience for each resident. See Figure 5 below.

Figure 5. Site plan and elevation of La Escondida Apartments. Photo credit: Onnis Luque, Mauricio Guerrero *La Escondida Apartments / Francisco Pardo Arquitecto*, (2020).

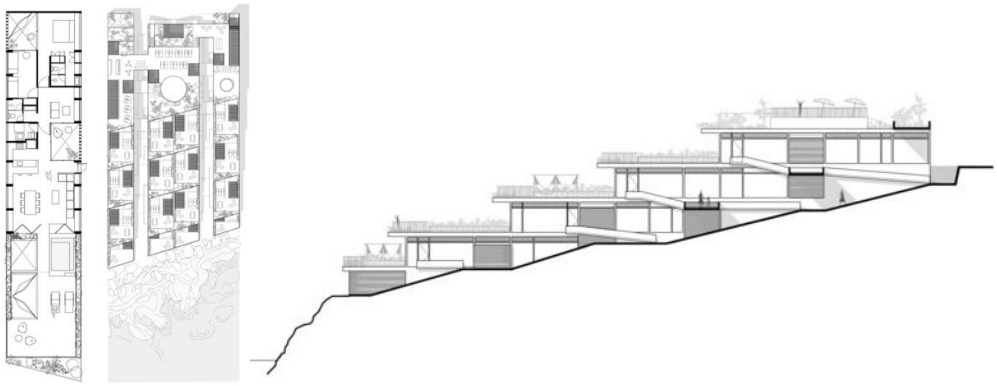

Figure 6. Floor plan and section of La Escondida Apartments. Photo credit: Onnis Luque, Mauricio Guerrero *La Escondida Apartments / Francisco Pardo Arquitecto*, (2020).

Each unit in La Escondida Apartments is designed to provide a more home-like experience rather than a regular apartment. Although all units share the same floor plan, their position with nature, scenery, and topography creates a different feel in each unit. The spacious private terrace, approximately 70 square meters, enhances the ocean views while providing privacy for its occupants. This privacy is obtained through the placement of plants around the perimeter of the terrace, which also helps in filtering out the sea breeze and increasing comfort.

The project is built with a simple structure of reinforced concrete, block walls, cement, sand, and reinforced corrugated slabs. This system is not only efficient in term of construction in the area but also provides the sturdiness necessary sturdiness to deal with frequent earthquakes in the region. The main finishes, both inside and outside the unit, use local materials such as “Macuil” wood and Chukun, which is a plastering technique with fine cement and local sand. The use of these local materials not only supports sustainability but also helps the building blend in with the surrounding environment. See Figure 6 below.

In addition to the private facilities in each unit, La Escondida Apartments is also equipped with three types of communal areas located on the roof of the building. The eastern zone (the highest level) has a bar and lounge, the central zone includes the main swimming pool with a sun deck, and the western zone is a small pool for kids. The earth walkways linking these structures at common zones are also sculpted to the gentle slope of the land ensuring an easy reach to the sea, while conducting several winds thus doing away with air conditioning services due to the currents of wind and cross ventilation.

In La Escondida Apartments, nature is paramount, and this explains the architectural design of the apartments. Every detail in the construction namely the terrain, the building materials, and the designs employed is all aimed at ensuring that there is a sufficient relationship between the people using the building, the building itself, and the beautiful scenery out there. This innovative design bears testimony to the fact that architecture can be and should be livable without degrading the environment and can instead enhance and elevate the well-being of the residents.

The design approach of the house, Private House in Thusis takes into account the availability of locally sourced materials. The stone used to construct the house was quarried onsite which helped the building camouflaged with the stiff mountain rocks. Such local stone material adds to the visual page quality but also functions thermally in Switzerland’s

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Figure 7. Exterior view of Private House in Thusis. Photo credit: Schaub Stierli Fotografie
Private House in Thusis / Angela Deuber Architects, (2020).

chilly climate. Because the edifice employs substance already permeating the environment, a solid and real location is attained by the building while lessening the environmental costs in the course of the construction works. Note Figure 7 above.

The two projects demonstrate how nature can be integrated into architecture instead of working against it by the local materials employed in both projects. The La Escondida Apartments and the Private House in Thusis illustrate how a beautiful design need not compromise on ecological principles by opting for materials sourced from the vicinity.

Natural Lighting and Ventilation

In architectural design, Natural lighting and ventilation are some of the basic principles that seek to enhance thermal comfort and energy efficacy. These two principles come with benefits in that they not only reduce the level of cooling system and artificial lighting impacts but enhance residents' quality of life by taking advantage of resources that occur naturally. The Ncaved house in Greece and the UCCA dune art museum in China are the well-known application of this approach.

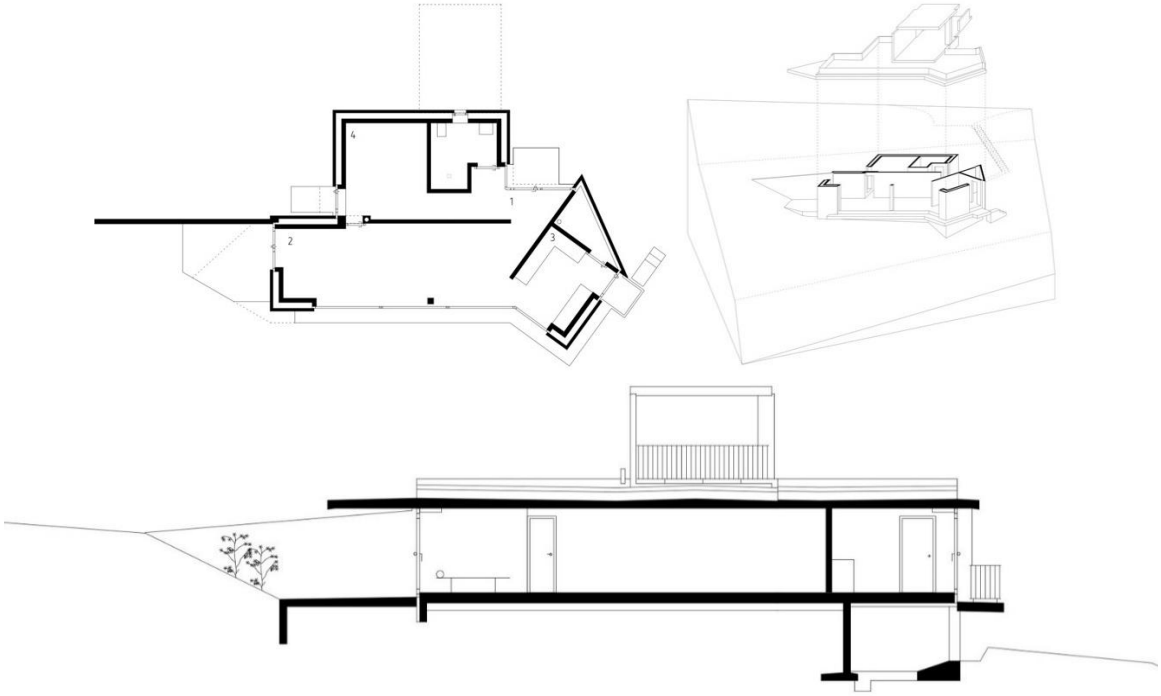

Figure 8. Plan, isometric and cut in Private House in Thusis. Photo credit: Schaub Stierli Fotografie
Private House in Thusis / Angela Deuber Architects, (2020)

Ncaved House is built in a way that maximizes natural lighting and cross ventilation made possible by the sea facing shape of the building. Long glazed surfaces provided along the transverse walls allow for entry of a great amount of light, and, with the design opening up towards the cool sea, helps in natural ventilation as well. The stone walls used are also considered as thermal mass, absorbing heat during the day and releasing it at night, hence maintaining a comfortable thermal regime without the necessity of any active cooling systems.

Similar in a way to the UCCA Dune Art Museum which is just about completely underground in the dunes, natural lighting and ventilation have been made the priority for the thermal comfort of tge museum. There are skylights in a few of the gallery spaces which enable the even penetration of light, without the danger of overheating the rooms. The trans hygric strategy prevents the excessive artificial cooling of the interiors even during the hot season as it allows to maintain comfortable temperatures within. This solution enhances not only energy efficiency but allows for a more organic spatial experience and one that is harmonious with its geographical context.

Protection Against Extreme Conditions

Another central aspect of architecture is the protection against adverse climatic conditions and the ability for buildings to perform comfortably without succumbing to such elements as strong winds, hot temperatures, or other terrains. The Ncaved House and UCCA Dune Art Museum have different ways of addressing this problem.

In designing Ncaved House, it was assumed that nearly all its structure would be embedded in steep slopes to shield it from the regular intense winds of the area. This design, thus, enables the house to be sound and pleasant even in the middle of the extreme and sever conditions of the weather. Ncaved House also utilizes local heat-resistant building materials such as stone, ensuring that the heat in the building is retained within, despite the drastic changes in temperature that occurs from day to night in the region.

The UCCA Dune Art Museum, in contrast, has made the provision of extreme weather in its design by being located under the dunes which controls both the overheating of the building and the effect high winds from the coast. The dunes protect the building from extreme weather elements while an efficient cross ventilation and skylight system maintains comfortable conditions inside the museum. As a result, the museum does not require any equipment for air conditioning as the air movement relies on purely architectural passive methods only. This indicates that the modern architecture that is sensitive to the climate achieves not only energy efficiency and comfort in buildings, but also their ecological sustainability and integration with the environment. Ncaved House and UCCA Dune Art Museum clearly depict the use of this approach where slope and unfavorable environmental conditions exist.

In this research, the scope comprises the understanding of how architectural forms can adapt to the surrounding environment while tackling the challenges presented by the building site in the analysis of four case studies architectural projects on hilly sites. Despite the fact that each of the projects faces analogous challenges, within several critical areas for example the employment of regional materials, integration with the surroundings and the climate, and the extremes of seasons different design strategies of each architect vary.

Case Study Comparison

One of the projects analyzed, the Ncaved House in Greece, catches attraction with its strategy of placing the building deep within the extreme slope. This approach provides some natural defense against the high winds frequently experienced in this part of the world, as well as creating a wonderful space open to the maximum height of the glass wall which faces the sea. In contrast to Ncaved House, La Escondida Apartments in Mexico employs a stepped terrace design, which enables three hundred sixty degrees view of the ocean from each apartment unit. These terraces also assist in controlling the flow of rainwater and reducing the effects of slope erosion.

On the other hand, the UCCA Dune Art Museum, which is situated in China, also makes use of natural sand dunes to shield the structure from intense sunlight and coastal breezes. With the building being almost completely sand operated, one can hardly spot it from the outside, allowing amazing interaction of the structure with the coastline. Likewise, the Private House in Thusis Switzerland, employs the stones present in the area, to integrate the structure with the terrain and provide effective insulation due to the cold nature of the region. This comparison indicates that while all four of the projects are situated on sloping land conditions, the approaches taken in their design vary owing to different climate and topography of the projects.

Project-Specific Analysis

Every undertaking exhibits a varying resolution to the problem of terrain. The Ncaved House managed to achieve a balance between the structure and the natural environment through the use of a system of geometric grids which carried the slopes through the building creating a three-dimensional matrix of solids and voids. These voids serve not only to separate spaces but also allow for effective natural ventilation by drawing in cool sea breezes to every area of the house.

Meanwhile, La Escondida Apartments incorporates local materials such as stone and wood in its design, creating harmony with the coastal environment. The stepped plan not only provides optimal visibility but also ensures each unit gets maximum cross-ventilation and natural lighting. Unlike Ncaved House, which is more closed to the outside environment, La Escondida Apartments is more open, creating a strong visual connection with the sea.

At the UCCA Dune Art Museum, visual elements of the site plan show how the building utilizes the dunes as a natural protector while reducing the visual impact on the surrounding landscape. The use of skylights in some galleries creates controlled natural lighting so that the indoor atmosphere remains cool even in hot climates.

Private House in Thusis uses dry stone materials from the surrounding mountains to blend in with the rocky landscape. The plan is designed to connect the building with the surrounding natural scenery, while the orientation of the building follows the natural slope, allowing natural light to enter the room and create a strong visual connection with the surrounding environment.

In-Depth Visual Analysis

In terms of layout, Ncaved House uses an open plan that allows for integration between interior and exterior, with an open façade overlooking the sea. Illustrations of the ground plans and building sections depict such spaces positioned according to the existing topography of the slopes to achieve a balance of the structure with its surroundings.

In La Escondida Apartments, the graphical representation of the building design and elements explains how the edifice is oriented in the slope. Each apartment is designed on different levels to maintain privacy, while spacious terraces on the seaside provide a clear view. The building elements illustrate the way the cast in situ structural frame follows the natural terrain for enhanced strength and heat retention.

This illustrative account substantiates that the relationship between the buildings and the environment they are in is not only significant for purposes of beauty, but it also helps to address some of the problems that may arise due to the contours of the landscape. Each such project shows how site plans, sections, architectural details, and other visual materials are crucial in ensuring that the project adheres to the principles of sustainable design and is in tune with the natural environment.

CONCLUSION

This research indicates that a design adapted to the given slope becomes an expressive and efficient solution that can be called innovative. In comparison with the other three case studies, the key strategy ideas that were applied to the designs of the buildings include local materials used, the concept of building on the existing landforms, and the use of daylighting and cross ventilation designs as well. These results indicate that architectural projects in a sloped site are successful only to the extent that it is possible to ‘sit’ the structures in the surrounding environment resulting in visual and functional balance that is conducive and environmentally friendly.

Given these results, it is suggested to the architectural practitioners that topographic analysis evaluation be conducted from the very early phase of the design to reengineering aspects. It is recommended that the design attempts to state and maintain the degree of bend of the land play an appreciable role in reducing the negative effect on the environment. Further, passive design, local sourcing, and locally available environmentally friendly technologies such as natural drainage design and daylighting and passive ventilation should not be ignored in the design process. In this way, careful and environmental design will ensure that all the aesthetics and other functions of the slope will be attained by the architects.

In the course of the research, it is suggested to look into the application of new technologies such as design simulation software for modeling the landscape-building collision better under different weather and terrain conditions. Moreover, the economic considerations regarding the application of a green building design on a slope in a more developed manner should also be considered to give a thorough picture to the developers and other interested parties especially those operating in the regions with fewer resources. Also, the research may be conducted in various types of cultures and societies to identify how different designs can be adapted to the existing conditions.

REFERENCES

amangeldi, K. T. (2020). Building A House On A Slope And Difficult Terrain. *Студент Года 2020*, 128–133. Https://Elibrary.Ru/Item.Asp?Id=42470801

Booth, N. K. (1989). *Basic Elements Of Landscape Architectural Design*. Waveland Press.

Delaqua, V. (2023, October). *Architecture And Topography: 25 Projects With Different Approaches To Relief | Archdaily*. Https://Www.Archdaily.Com/924149/Architecture-And-Topography-15-Projects-With-Different-Approaches-To-Relief?Ad_Medium=Widget&Ad_Name=Misc-Article-Show

La Escondida Apartments / Francisco Pardo Arquitecto. (2020, July 21). Archdaily. Https://Www.Archdaily.Com/944040/La-Escondida-Apartments-Francisco-Pardo-Arquitecto

Lavery, I., Davey, S., Woodside, A., & Ewart, K. (1996). The Vital Role Of Street Design And Management In Reducing Barriers To Older Peoples' Mobility. *Landscape And Urban Planning*, *35*(2–3), 181–192. Https://Www.Sciencedirect.Com/Science/Article/Pii/016920469600309X

Leatherbarrow, D. (2004). Topographical Premises. *Journal Of Architectural Education*, *57*(3), 70–73.

Moraru, I. (2017). Topographical Architecture When Architecture Turns Into Landscape. *International Multidisciplinary Scientific Geoconference: Sgem*, *17*, 851–858.

Morgan, W. N. (2008). *Earth Architecture: From Ancient To Modern*.

Ncaved House / MOLD Architects | Archdaily. (2020). Https://Www.Archdaily.Com/955138/Ncaved-House-Mold-Architects?Ad_Medium=Gallery

Norouzi, M., & Khademi, S. (2021). Geography: A Hidden Antidote To Rescue Modern Architecture. In M. Krevs (Ed.), *Hidden Geographies* (Pp. 295–312). Springer International Publishing. Https://Doi.Org/10.1007/978-3-030-74590-5_14

Private House In Thusis / Angela Deuber Architects. (2020, August 12). Archdaily. Https://Www.Archdaily.Com/945581/Private-House-In-Thusis-Angela-Deuber-Architects

Ruhig, R., & Ruhigová, E. (2024). The Impact Of The Orientation Of Family Houses On A Slope On The Environment. *MATEC Web Of Conferences*, *396*, 08002. Https://Www.Matec-Conferences.Org/Articles/Matecconf/Abs/2024/08/Matecconf_Wmcaus2023_08002/Matecconf_Wmcaus2023_08002.Html

Solà-Morales, I. De. (1997). *Differences: Topographies Of Contemporary Architecture*. MIT Press.

Strom, S., Nathan, K., & Woland, J. (2013). *Site Engineering For Landscape Architects*. John Wiley & Sons.

Thompson, J. W., & Sorvig, K. (2000). *Sustainable Landscape Construction: A Guide To Green Building Outdoors*. Https://Trid.Trb.Org/View/680366

Thoren, R. J. (2005). Topographical Stories. *Journal Of Architectural Education*, *59*(2), 66–67. Https://Doi.Org/10.1111/J.1531-314X.2005.00021.X

UCCA Dune Art Museum / OPEN Architecture. (2018, December 13). Archdaily. Https://Www.Archdaily.Com/907596/Ucca-Dune-Art-Museum-Open-Architecture

Xu, Y., Zhao, S., & Fan, J. (2021). Urban Planning Construction Land Standard And Its Revision Based On Climate And Topography In China. *Journal Of Geographical Sciences*, *31*(4), 603–620. Https://Doi.Org/10.1007/S11442-021-1861-9

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