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Settling the Curve: Planning and Design strategies in concurrence with Environmental sensibility on Hilly sites from Antiquity to the Middle Ages

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ABSTRACT: One fifth of the earth's landscape is covered with mountains which are a home to 600 million people. While difficult, hilly areas have one of the most interesting topographical contexts for construction. The hilly terrain is characterized by high altitudes, cold temperatures, steep slopes and breath-taking views. Construction on such areas, is constrained by numerous factors such as such as complex geography, demanding topography and vulnerable ecology.

According to some studies, a contoured or a hilly terrain has a profound effect on the aesthetic judgement of human beings. Building on the hills requires a skilled consciousness of the environment, the existing geological structure and knowledge of structural and slope stability. Therefore, architects throughout history have been and continue to be sensitive to designing and planning in hilly areas. There are some very interesting and outstanding examples of buildings on hill sites throughout history of human civilisation which reflect the sensitivity and genius of the builders.

The paper attempts to study these Hill settlements and the ingenious environmentally sensitive planning and design strategies employed by them.

Key words: Hill Architecture, Urban Design, Environmentally sensitive planning, Greek Architecture

I. INTRODUCTION

Hilly areas are excellent repositories for tourism, recreation and resources like water, mineral and biological diversity. These are fragile ecosystems that are highly vulnerable to disturbance with an insufficient capability of bouncing back and healing after the damage which makes it imperative for construction on such areas to be as minimally evasive as possible.

Since time immemorial, humans have preferred settling on hilly areas, secondary only to fertile floodplains. This is due to various reasons like pleasant climatic conditions, easy availability of resources like water, beautiful surroundings and most important of all, the natural topographical barrier the hills provide against invasions.

As early as 2000 BC, extensive civilizations have developed on the mountains devising ingenious construction and planning techniques to conquer the demanding topography.

II. KNOSSOS AND PHAISTOS

The earliest example of hill architecture are from the Minoan Civilisation during 20th century BC, namely the Crete palaces of Knossos and Phaistos, both of which are located on low hills in the Mediterranean basins.

Unlike the traditional definition of palaces, these are palatial complexes, they are designed not just to serve as the living quarters of the royal family but as a civic, religious and economic centre.

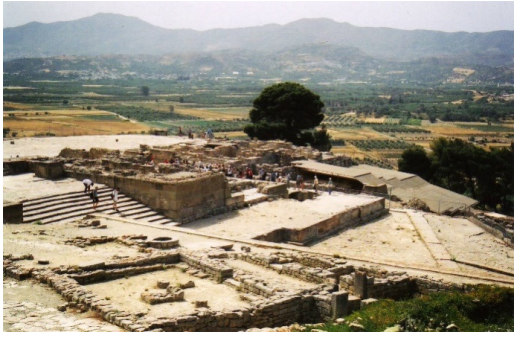

Fig. 1. Palacial Complex at Phaistos [1].

Despite being made to serve the same purpose, both these complexes differ from each other in their approach towards the design. The palatial complex at Knossos with an area of 2 hectares, is built on a low hill whose top was levelled and previous structures removed, while Phaistos was built on a steep ridge with fortifications.

Unlike Knossos, the palatial palace at Phaistos was built with due consideration of the environment and the topography. The site was a steep ridge rather than a flat mountain top which couldn't have been levelled like its counterpart. The complex is hence built along the contours of the hill with courtyards built in terraces. Another notable feature is the theatres built on the hillside taking advantage of the natural slope, forming steps on the terraces.

The materials used are local, rubble, red brick and white limestone. The buildings were the epitome of technological advancement at the time, they had complete indoor plumbing as well as a natural air conditioning system with windows and doors placed strategically to direct air inwards. They were constructed in a way that the open areas always had palace walls on one side and an open view of the mountains on the other, it was designed to be functional, as well as ensure full aesthetic advantage of the beautiful locations.

III. ACROPOLIS OF ATHENS

The next notable example of hill Architecture can be seen at the Acropolis of Athens, In Greece during 5th century BC.

Fig. 2. The acropolis of Athens[2].

The word acropolis is derived from Greek word 'Acro' which means edge or extremity whole 'polis' simply means high city. The word acropolis refers to a city built on a high hill. Unlike the Minoan palaces, the acropolis is not meant as a living quarter for the common folk. Here, the natural height is used symbolically to place temples of god at a higher ground than the rest of the city.

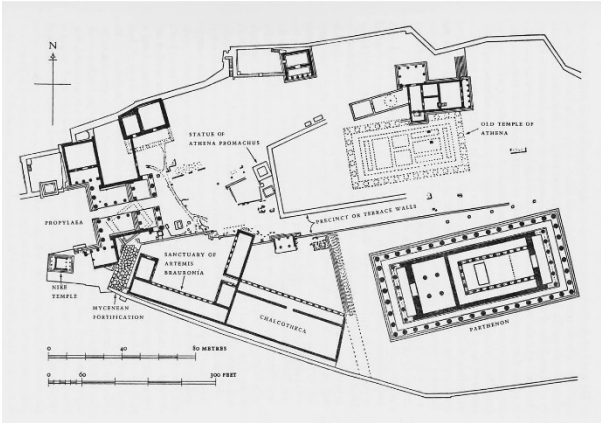

Fig. 3. Plan of Athenian Acropolis[3].

The acropolis is a great example of adapting to the natural site. The major part of the acropolis is located at the top of a flat hill, with the sloping sides providing suitable sites for construction of famous Greek theatres. In line with Greek architecture, the plan consisted of the Propylia (The Grand Entrance), The Parthenon (Central Monument), The Erechtheion, and the Temple of Athena.

Another interesting fact is that unlike most ancient buildings, the buildings constructed at the acropolis have managed to survive over a period of 2500 years. According to recent studies, the buildings on the acropolis were specifically designed in order to be protected from earthquakes. According to the studies, *"The modular columns, other than the fact that they were made to be constructed and transported more easily, they are designed so that they have excellent seismic performance properties." In effect, the columns were built to withstand earthquakes. [4]*

IV. PRIENE AND PERGAMON

Priene is another notable example of ancient Greek Architecture and Urban Planning. The city was built on terraces and steep slopes distributed over a vertical distance of 380 metres.

The city is the first example of the Hippodamus's rational grid plan applied to such a terrain. Interestingly, the plan continues to demonstrate its function even when laid on a very different terrain than the one it was intended for. The Hilly site, instead of constricting the grid plan, ensures easy navigation and convenient access to various sites throughout the city.

Instead of the customary Greek acropolis, the acropolis was given up in favour of a broad sloping terrace. The topmost of the mountain was no longer reserved for the gods.

Instead, the whole city was systematically planned with residential areas scattered around the public buildings.
The plan included public buildings distributed around the market place (agora) at the centre, the agora was bound by the colonnaded (Covered portico) on the north and the temple of Zeus on the south. Other public buildings included The Bouleuterian (Senate), the assembly hall and a small theatre. Northwest of the Agora lies another temple, Temple of Athena. The remaining area consisted of housing blocks. At the end of the slope, below, the gymnasium and stadium was constructed using the valley as the stage facing the steps on the mountains.

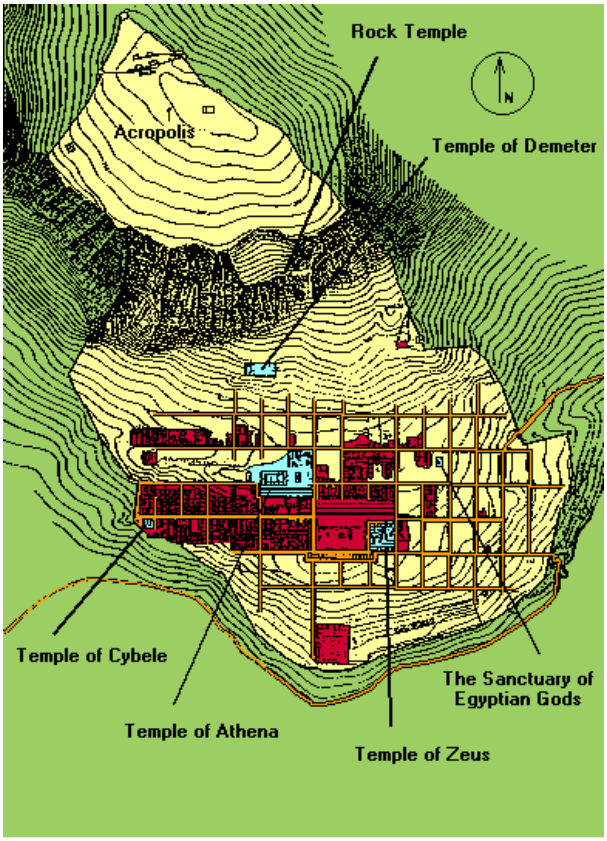

Fig. 4. Priene Plan[5].

One of the most impressive aspects is the futuristic conception of the agora, a wide central area was kept unsettled according to macro-scale urban estimation and in time evolved into the central market place.
The wider roads were built along the contours while the narrower ones were built as staircases across the contours.
On the residential level, a simple courtyard plan was mostly followed. This satisfied two basic needs in the ancient Greek house, the need for privacy and climate control. The entry to the house was a narrow passage leading to a door set back from the street. The door led to an open courtyard. On the north of courtyard was the main part of the house (The megaron). The megaron was oriented towards the south and was mainly used as the living room.
The construction techniques used include façade and interior treatment with bossed ashlar masonry, walls made with sun dried bricks, use of stucco to imitate marble. The roof form was mostly pitched which is the most favourable form of construction in hilly areas.
Much like the contemporary times, the ancient Greeks feared fuel shortages and hence started to think on lines of sustainable design techniques that focus on maximizing heat gain and heat retention especially during winter months. This can be seen in Priene as a primary example of passive solar orientation. The city backed up to the mountain, providing protection from the north wind, with all homes facing south to capture the winter sun. Eventually, the Romans went a step further and started using glass on the windows of their buildings to retain more heat gathered during daytime.
Another example of a rich and powerful City from ancient Greece in **Pergamon**. The city was built onto the slopes of Kale Hill, utilizing the spectacular topography with terraces and grand monuments. The urban space consisted of buildings following the same functions but is not planned on a rigid grid like Priene.

Fig. 5. Theatre of Pergamon[6].

*Roger Ling calls it the finest architectural composition of the Hellenistic age, dispensing altogether with orthogonal patterns and growing organically out of the landscape in a fan-like series of terraces in which the auditorium of the steep hillside theatre forms "a kind of valve".*We see most clearly in the plan how stoas and courtyards of the city seem to have been constructed to radiate like rays of the sun from the demountable wooden stage-house of the open-air theatre far below. It is as if the city itself were the "audience" in a highly theatrical architectural composition. [7]
Like other Greek cities, the theatre at Pergamon was built onto the hillside with stadium seating of 10,000 that overlooked the dramatic city and its neighbouring countryside.

This is the steepest theatre in the ancient world and a notable example of use if dramatic and theatrical architecture.

V. CAPPADOCIA, TURKEY

"Most architecture is created by adding material – bricks, stone, wood, and concrete, roofing, etc. – in order to bound space in various ways. In Cappadocia, Turkey, architecture has for the past 3.000 years been created by removing material"[8]

Fig. 6. Uchisar Village ,Cappadocia[9].

Cappadocia, Turkey is an unconventional example of construction on the hills where the earliest civilisations carved out huge spaces in the rock to create spaces for living. Over the years, these dens were enlarged to accommodate the growing population including morphing some for public uses like churches. The landscape slowly developed into what we see today as extensive underground cities connected by labyrinth of tunnels.

Columns, vaults and arches as well as other architectural features were carved into these cave dwellings as symbolic pieces rather than for a structural purpose.

The classical definition of Architecture in terms of creation of spaces is adapted to creation of spaces by hollowing out solid matter. Nature acts as the link between the forms above and below the ground. It forms one of the best examples of man's symbiotic relationship with the earth.

Interestingly, around the same time that these cities were built, examples of similar rock-cut architecture can be seen in India in Ajanta and Ellora caves, but unlike in Cappadocia, the purpose of those was solely for religious purpose.

VI. MACHU PICCHU, PERU

Machu Pichhu is an Inca citadel situated on a hilly site at an altitude of 2430 metres. On this steep slope, the Incas designed a complex which was not a conventional city. Approximately 200 buildings were arranged on terraces along the contours around an east-west central square.This ancient city does not have a fortress around it but the strategic location allowed the Incas to observe potential enemies way before they could come close to the city. Also, the city is not designed for military defence because it was primarily a shrine, with minimal residential areas around it.

Not unlike Greek cities, we notice recurrent use some typical Inca architectural elements that integrate the magnificent architecture with the natural surroundings. The built form is on various levels connected to each other with stairways that were sometimes intricately carved. There are some notable features in the buildings that suggest the Incas has knowledge of building earthquake resistant structures. The windows and gates are trapezoidal in shape , corners are usually rounded, inside corners incline slightly into the rooms, outside corners are often tied together with L-Shaped stones, walls are slightly offset from row to row and the roof are light structures made of straw (Icchu); all giving rise to a more stable structure.

Fig. 7. Machu Picchu, Peru [10].

It is interesting to note than the no mortar was used in the construction of the citadel, only dry stone masonry where blocks of stone are cut to fit together perfectly, was used. Individually shaped carved granite stones were used in such an early era while in comparison, such techniques remain complicated to execute today even with modern technologies at our disposal. The materials used were all locally available with grey granite quarried from the ridge itself.

The rooftops are also designed to be in line with the climatic conditions, they are sloped at a suitable angle to protect the roof from heavy rainfalls.

The city boasted of an extensive plumbing system that consisted of a system of interconnected ponds and water fountains with channels carved in the rock itself.

The city has been planned with informed consciousness of the site with the flatter areas having denser construction than the peaks.

The plan consists of two sections, Agricultural and Urban. The agricultural part consists of terrace farms while the latter is made of streets, stairways, water channels and other buildings. There is a well thought out urban area with a 'pata' which is flat area like a park at the centre of the city.

VII. SIENA, ITALY

Fig. 8. Siena, Italy[11].

In the 13th century, urban design gained momentum in Europe as the cities became the centres of economic development. Siena, Italy is one of the most notable examples of medieval hill cities of the time with a well preserved urban landscape.

The city developed on three hills that are connected by three streets forming a Y. At the intersection of this, the public square of Piazza del Campo exists as one of the earliest examples of use of Public Square in the urban landscape. It is surrounded by a seven km long fortified wall with protected gates at strategic points. Inside these walls the city consists of tower houses, churches and city fountains fed by an extensive plumbing system.

Around the 12-15th century, this predominately gothic city was designed as a work of art that blends into the surrounding. The town planning started with control of street designs and maintenance along with limiting building extensions on public right of way. Other controls included building materials, height restrictions and setbacks. Additionally, the shape of windows was also specified. This was the first time such controls and regulations were imposed in the medieval era and strikes a common cord with ancient civilisations which almost always were homogenous in their use of architectural features. To maintain the predominant style of architecture, the use of Gothic architecture was mandated in some areas.

Siena embodies all the basic features of a sustainable medieval hill town with well-defined rural and urban connections and attempts to preserve the natural landscape.Several regulations along with a strong sense of connection to the rural side help with the same.

This is why, despite being a congested hill town occupied by a modern urban community in the contemporary times, the urban landscape still manages to approach the ideal urban sense of community.

In Siena, The urban design has been seamlessly adapted to topography. The centre of the city, the Pizza del campo is a landscape of stone, brock buildings and paved pathways. Although a car free zone, the streets have been designed with foresight to accommodate vehicular traffic unlike most Italian hill towns where the streets are too narrow for cars. The visual design along the slope ensures that vision is drawn to the Pallazo Pubblico, the seat of the government.

The organic planning of the city streets in sienna maintain the curves in line with the gothic architecture of its major buildings.

"The city is a masterwork of dedication and inventiveness in which the buildings have been designed to fit into the overall planned urban fabric and also to form a whole with the surrounding cultural landscape."[12]

VIII. THE OLD AND NEW TOWNS OF EDINBURGH, ITALY

Edinburgh, the capital city of Scotland provides a distinctive contrast of urban forms in the arrangement of the Old town and the New town. This remarkable juxtaposition of two very different hilly urbanscapes on adjacent ridges incorporate all the functions of a thriving capital city.

The old town was founded in the 12th century AD with the construction of the castle at the topmost part of the ridge in the east. A path led from this point to the Grassmarket in the south. Subsequent development took place along the east west corridor which functioned as the main spine of the city called the Royal Mile. This was the route between the castle at the top and Holy Rood abbey at the base of the mountain. Secondary streets branched out at right angles from this main streets giving the plan a 'fish bone' shape.

The streetscape is uniform with building forming harmonious frontages in terms of heights and architectural character. Behind these frontages, lie the more intimate and fragmented buildings.

In response to the topography and the biodiversity, there are enclosed gardens and construction in steps. Due to the restrictions imposed by narrowness of available sites, the old town of Edinburgh saw some of the first examples of high rise residential buildings.

As the population densities grew, the old town became more and more congested which also led to man-made disasters like fires destroying major parts of the city. Therefore, the resolution of building a new town adjacent to the old pas passed in the 18th century and the entries for the new urban plan were invited through an architectural completion.

Fig. 9. Old and New Town of Edinburgh [13].

The winning design was that of James Craig which was built on Georgian principles of urban design. This was a rigid grid plan, laid in a hierarchical order, consisting of rectangular plots interspersed with private gardens. There were three main streets that provided access to these plots and the secondary streets provided access to the backside of the plots. These were built in continuing terraces. The materials used were ashlar faced sandstone and slate roofs.

In contrast to the organic plan and narrow buildings of the old city, the new city is symmetrical and the building wider than narrow. Also, the primary material used in both is visibly different, dark granite in the old citadel and white sandstone on the new one.

However both embody unity and cohesion in their own ways and complement each other.

IX. SHIMLA, THE SUMMER CAPITAL OF COLONIAL INDIA

Shimla, the Capital City of Himachal Pradesh In India was also the summer capital of the British during colonial rule in India. Prior to its development into the hill station we see today, the site consisted of an obscure village without any substantial construction.

The area was discovered by the British in the 1800's who were looking for a site similar to their own homelands back in England. Shimla was the perfect site on a mountain with spectacular views of valleys around and a favourable climate for the British.

The town was hence developed by the British as a summer paradise for themselves. The colonial design was made with heightened ecological sensibility along with imperatives of life, work and play. The design however, followed a hierarchical system prevalent in colonial India with British residents at the topmost locations, commercial and public establishments of the middle altitude along the main spine (The Mall Road) and the residences of Indians on the lowest levels.

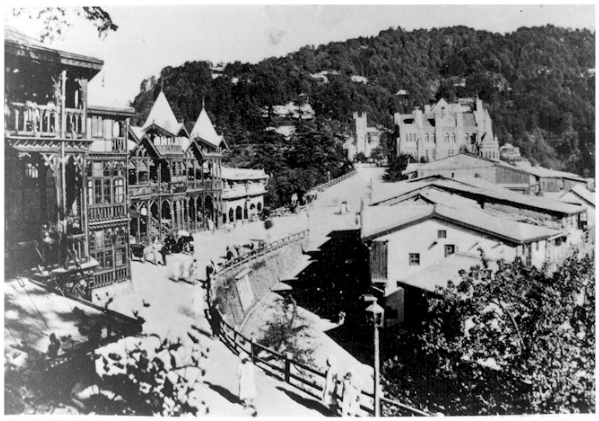

Fig. 10. Shimla, 1895 [14].

=Facilities like schools, hospitals were scattered around the urban landscape according to requirement. The road system was laid along the contours.

On a micro level, the buildings were oriented towards south side to gain maximum heat from the sun. Utmost care was taken is maintaining the spectacular views, ensuring that no construction was built above a certain height to ensure the views stay as they are.

The style of architecture was Victorian or Post Victorian architecture in an attempt to make it look more like England. The local practices and vernacular architectural traditions, if noticed were more or less ignored in favour of the same.

In the current scenario, years after the end of British rule in India, the consciousness with which the city was designed is slowly fading away with the ever increasing commercial and residential demands of the now densely populated hill station.

X. CONCLUSION

Civilisations have been and continue to develop over Hilly areas. The earliest documented examples are the palatial complexes of Knossos and Phaistos of the ancient Minoan civilisation. As early as 20th century BC, a consciousness of the environment can be seen in the design of these structures as they are developed along the contours in accordance with the site. The same is continued to the Greek civilisations where we see examples of cities like Athens where the height is used to divide the function of the urban sectors.

At the Greek city of Priene, and the first ever use of Grid Plan can be seen on a slope.

Along with a skilled planning system, the Greeks also built most of their structures to be earthquake resistant which is an important feature as most hill sites lie in earthquake prone zones and require greater structural stability.

These cities have a defined architectural character which can hardly be seen in present day modern cities, a trend which is followed in the later Inca citadel of Machu Picchu.

Another interesting feature of these ancient cities is the climate appropriate design with buildings facing the south which concurs with the cold climate associated with most hilly terrains. The materials used are mostly locally quarried and shaped.

Cappadocia, Turkey stands in contrast to these carefully planned cities with a city emerging from basic need of human shelter and developing over the years to form a vast underground city network. Nevertheless, the city appears to be as much in harmony with the environment as its counterparts.

In the middle ages, Urban Hill architecture takes shape in the form of the medieval city of Siena which imposed one of the first urban controls and developed a prototype for further Hilly urban plans.

The Old and New city of Edinburgh provide a case study of successful transition of a city from a medieval town to an urban one in line with the contemporary modern times.

Different requirements define planning of these cities with most being built around a central Public space like the Temples in Athens, The agora In Priene, and The palace in the Old City of Edinburgh. While others, are divided into sectors like Machu Picchu, New Town of Edinburg and Shimla, although major construction in Shimla Happens around the central street.

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