

## Responsive and sustainable architectural strategies for temperate regions

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### ABSTRACT

The paper will summarize the results of an extensive research on sustainable architectural strategies used throughout the history in all climates, but here the results of the temperate climate will be presented. The selected case studies were investigated, regardless of their cultural diversity, ranging from prehistoric to the current settlements, and they were cross-referenced and compared to each other. The relationship between their architectural patterns is examined from a climatic point of view. The design strategies which were implemented in the majority of habitats in a temperate climate is identified and recommendations drawn.

### 1. INTRODUCTION

Most settlers, from ancient to pre-industrial era, discovered the influence of climate on comfortable habitat, and these became factors, which affected the way they planned their build environment. Once these factors were clear and understood, then the principles were deduced and their designs were based upon them. For contemporary designers these principles, which were established on the basis of natural conditions, and were supported by trial and error over thousands of years, could become significant decision-making constituents for present and future developments.

The main goal is to observe the continuity or discontinuity by considering the influence of environment on the architectural form in the course of history, and specifically to identify strategies that had created more bioclimatically comfortable indoor spaces for the inhabitants. Morphology, density, arrangement, circulation,

roof form, surface, openings, shading device and material are selected as the main topics for design principle and architectural elements.

Each elements and principles according to its culture and history is unique, however, many of their physical patterns are similar to each other, specifically patterns of elements and strategies influenced by the environment. The results from the above process are the pieces which will be put together to provide guidelines for architectural configuration in temperate climate.

### 2. SELECTION CRITERIA AND METHODOLOGY

Architectural meanings are ultimately always set in history, advancement of knowledge and environmental context. Therefore, the three criteria that will define the entity of an urban centre and its architectural style are: *history*, *culture* and *climate*. They are considered in order to include fairly representative examples of architecture from various historical periods, climatic zones and cultures, in other words, to have a homogeneous and balanced distribution of the selected buildings in its urban context.

The methodology used to investigate the selected case studies is a comparative method, and the cases are cross-referenced to each other. This is to derive the strategies of sustainable design for the purpose of comparison to the architectural aspects of settlements in other climates. Such a method will help in achieving comprehensive results and in making recommendations.

#### 2.1 Climate

According to Köppen's generally accepted clas-

sification of the climate, temperate or warm-humid is abbreviated as "C" type climate, and is also called sub-tropical or Mediterranean, and is regarded as one of the four main "habitable climatic zones". These mesothermal regions with mild winters are mainly concentrated in the southeast of Asia up to the northern Indian Sub-continent, northern and eastern Mediterranean Sea up to the southern part of the Caspian Sea, most of Europe, north-west and southeast Africa, on the central, eastern, southeast and also central-west coasts of North America, southeast of South America and in some other middle-latitude regions of the world (Fig. 1).

Historians believe that one of the main area of urban civilisation, and many land occupied by human beings have been located in temperate climate. The Caucasians around the Caspian Sea area (North of Iran), and in the Southern region of Europe, the Minoans on the island of Crete are considered to be the people who settled and started urban civilisation in as early as the 2<sup>nd</sup> mil. BC here. The investigation of architectural form within the above region can be useful, since many developed and developing countries are located within this region.

In this study, buildings in urban centres like, Knossos, Priene, Pompeii, Silchester, Port Sunlight and Village Home, were analysed. The relationship between the building configurations from a climatic point of view was examined. The design strategies and elements which were implemented in the majority of urban centres in temperate climate is identified and presented.

## 2.2 History

The historical periods that are most suitable for the objectives of this research are those in which urban and architectural civilizations were al-

ready established and whose progress could be manifested in their culture. This study is not a review of the architectural history, but history is used as a conveyer of climatic influence upon their architecture. A more definitive distinction, especially one that has the merit of being universally valid, would serve well. Therefore, the following are the historical periods from which climate-oriented buildings were selected. They are not necessarily categorized according to the divisions or the denominations used by historians. Rather these periods are divided and named by their characteristics as a turning point in the history of climatic design. They are: Prehistoric (~5500 - ~3500BC), Ancient Time (~3500BC - 422AD), Pre-industrial Era (422AD - 1735), Modern Era (Industrial) (1735 - 1972), and Sustainability Era (1972 →).

## 2.3 Culture

The importance of cultural influence on architectural form need not be or re-emphasized in this paper, and there is already a large body of evidence and research in this area for further studies. There are many different and advanced cultures that could be considered in the selection of urban and architectural samples, and for the diversity of the study, most major cultures were included. Many cultures are non-existent, so-called dead cultures, but they have left their mark on the architectural civilization, or have left a legacy which should be studied and from which lessons can be learned. Some cultures existed in close physical or climatic proximity to each other, and had many common influences on the spatial characteristics of each other's architectural and urban form. There are buildings in different climatic regions but built by the same or similar culture. The study of this type of buildings has been an important aspect of the research in order to investigate how their morphology in the same culture was transformed and modified as different locations and/or climates were selected for the placement of settlements. East, Near-east, West, and Mesoamerica are the four cultures selected with regard to all the above considerations.

## 3. CLIMATIC PLANNING INDICATIONS FOR SELECTION (CPI)

The following is a set eight of questions consid-

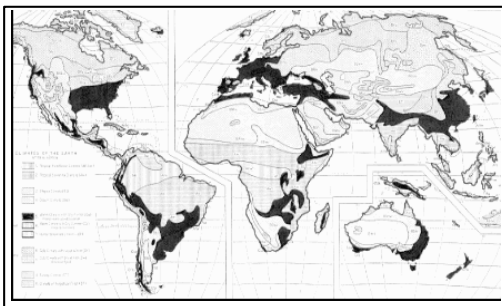


Figure 1: Temperate Regions of the World (shaded) (The map is adapted: Köppen's climatic classification).

ered in order to indicate the primary justifications of climatic urban and architectural form for the selected settlements. The questions are the requirements for further detailed analysis and are also the indications that a settlement and its architecture are sustainable. If the responses to the majority of the questions were positive and attainable, then climatic planning for architectural elements is certain. All parameters set in *heading two* should be met and considered before being tested against the following:

1. Is there any indication that a need for solar orientation and utilisation has been recognised?
2. Is there any protection against or promotion of heat loss and gain for indoor and outdoor spaces?
3. Is there any planning for use of shadow and/or composite-shadow?
4. Does the density of the settlement correspond to the climate?
5. Does the overall direction of the arteries, regarding sun and wind, indicate the climatic setting?
6. Is there any indication of planning for avoidance or promotion of prevailing wind?
7. Is there any relation between prevailing wind and indoor and outdoor spaces?
8. Does the overall orientation of the settlement correspond to the air movement?

For the purpose of demonstration, Pompeii is selected and analyzed as a pilot study. In the following, the responses to the climatic planning indications is displayed in the form of (Q.'X'), in which the integer 'X' corresponds to the question number, i.e. Q.2 is the answer to question two.

### 3.1 Pompeii

The town was founded originally as a Greek colonial city in the 6<sup>th</sup> C.BC, and rebuilt with a new layout with additions in about the 1<sup>st</sup> C.BC. This valuable historic town, uniquely preserved as a frozen moment of Roman history beneath the ash and mud from the Vesuvius eruption in 79 AD, provides a basis for investigation of Roman urban fabric and architectural form.

It is in the southern region of Campania of ancient Italy, 30 km, SE of modern Naples (Neapolis), at the latitude 40.8° N, and located on a ridge with 40 m altitude. It has temperate

climate, and the summer heat is extreme but bearable. It is located between the southern slope of Mount Vesuvius, to the west of the fertile area alongside of the Bay of Naples, and on the northern side of Sarno River. This extraordinary natural setting allowed Pompeii to emerge as the centre of commerce for its region. The economic base of the city was mainly agriculture, and Pompeii harbour was primarily used for the export of its goods and products.

The uniform town configuration (Fig. 2) was organically planned, and through time a semi-compact urban form was implemented to reduce the direct solar exposure, particularly during the summer time (Q.4). It had an E-W oval shape, 1,300 by 650 m, which covered an area of about 65 Hectares, and had a population estimated at 25,000 to 30,000 before its destruction. The town density also provided a network of shadow throughout the town and helped to reduce the absorption of solar radiation (Q.3). By the increase of shadow and composite-shadow, on the buildings as well as on the arteries and open spaces, the overheated months would have been more bearable. The general layout of the town is on a low-slope, with an orientation toward SSE, and the above strategies are considered to be the most appropriate for this type of climate. The selection of this orientation indicated that a need for optimisation of solar direction was recognised (Q.1).

Pompeii, as a regional cultural centre, was a pedestrianised town, in which vehicular axes were diverted from the public areas, and even the main central street from the forum. The main central E-W axis had a width of 9.75 m, and other main arteries in the same direction were about 8m wide. These axes, as the most used, were protected by their southern edge

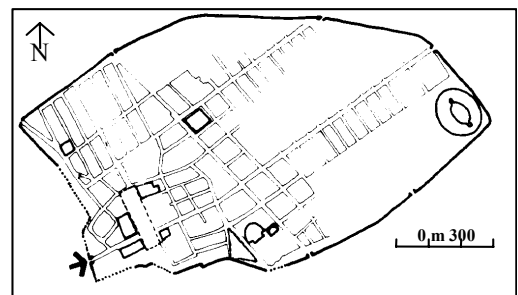


Figure 2: General Layout of Pompeii (Morris, A. E. J., "History of Urban Form", 1994, p.71.)

from the summer sun, producing shadow and, as a result, a better microclimate for the pedestrian (Q.5). The colonnaded forum was located roughly in the south west of the town, near the main gate from the harbour, and its longer axis was toward the SE. This direction may have been selected or evolved for the warming effect of the morning sun and for protection from the afternoon sun particularly in the summer.

The secondary arteries were for the residential axis, mainly toward the SSE, and had a width of 3.6 to 5.5 m. The northerly summer prevailing wind, assisted by the direction of minor streets, ventilated the main arteries and buildings. In the colder months these arteries were in the opposite direction to the wind and as a result were less influenced by the cold westerly winds (Q.6). These strategies indicate that the overall orientation of the settlement corresponded to the air movements (Q.8).

The houses in Pompeii followed a pattern where rooms usually faced into a central atrium, and had no opening or window on their exterior walls other than the main entrance to the house. The atrium as a nucleus space was located in such a way that allowed the light and air to enter into the interior spaces. Houses were mainly designed for summer use, due to the long summers, to allow the inhabitants to escape from the heat and not from the cold. Therefore, the houses were dark and enclosed to reduce indirect heat gain and daylight glare. The living rooms usually had high ceilings, the reason being that the heat could rise and dissipate. Most winter and evening rooms usually had a SW exposure since they needed sunlight to warm the space, and rooms, which were used during the summer, had an eastern exposure. The configuration of houses indicates a high level of protection against heat gain, as with the exterior open spaces (Q.2). It cannot be concluded that these houses had adequate ventilation in their indoor spaces, but it is almost certain that the central courtyard encouraged air movement. In warm-humid weather, cross ventilation is crucial for comfort, and this can be best achieved by locating proportional opening(s) in all indoor spaces, although there is not much evidence of this in most houses (Q.7).

Pompeii is excellent example of ancient sustainable design and architecture, which provided physical and psychological comfort through

consideration of its climatic and geographic setting. It might well have been a highly prosperous urban centre now, had it not been destroyed by the volcanic eruption.

#### 4. DESIGN STRATEGIES

The above pilot study, illustrates the two stages: the Selection Process and Climatic Planning Indicator. The answers to the majority of the eight questions of the second stage are attainable and positive. Consequently, by applying the two stages of the methodology for selection, Pompeii is demonstrated to be a suitable settlement for the climatic analysis of its configuration.

Table 1 summarises the findings about the selected urban centres in C climate and answers to the eight questions of Climatic Planning Indications for Selection (CPI). This matrix can also be used for comparison.

#### 5. ARCHITECTURAL ASPECTS

The followings findings are the main architectural strategies and elements that have sustained the existing comfortable environment for the inhabitants of temperate regions for many millennia:

1. Extroverted to introverted building morphology in different shapes and spatial layout were feasible: To take advantage of the existing and inhabitable microclimate.
2. Medium compact configuration was common: To provide a balance between the surfaces and volume, and to assist equilibrium

Table 1: CPI Matrix for the Selected Urban Centres

Question No.*	1)	2)	3)	4)	5)	6)	7)	8)	Date of Origin
Knossos	Y	?	Y	N	Y	?	Y	?	~1900 BC
Priene	Y	Y	Y	Y	?	Y	Y	Y	~340 BC
<i>Pompeii</i>	Y	Y	Y	Y	Y	Y	N	Y	~100 BC
Silchester	N	Y	Y	Y	?	N	Y	N	~50 AD
Port Sunlight	N	Y	N	?	Y	Y	Y	Y	1888
Village Home	Y	Y	Y	Y	Y	Y	?	Y	1973
	Y	4	5	5	4	4	4	4	71%
TOTAL	?	0	1	0	1	2	1	1	14.5%
	N	2	0	1	1	0	1	1	14.5%

\* For the content of questions see heading 3

between the heat gain and the contact with prevailing winds for different seasons.

3. Free and open arrangement between functional spaces was possible: To be compatible with the climate of the surrounding environment.
4. Moderate internal circulation and volume was planned: To allow some interior air movement and moderate contact between the spaces.
5. Roofs, primarily in the shape of flat or sloped were used over closed or semi-open spaces: To allow better rain removal.
6. Many different building surfaces were used: To allow some contact with air movement, and to allow some heat gain, depending on the region and the condition of the seasons.
7. Windows were positioned on the east, south and west facades: To permit some penetration of insolation during the underheated periods.
8. Moderate window areas facing all directions were located, particularly on the windward and on leeward facades: To achieve cross-ventilation by the prevailing breeze during the overheated periods.
9. Horizontal shading devices or awnings on the south side and vertical shading device on the east and west sides were employed: To control insolation, and to filter the daylight.
10. Medium density construction materials were applied: To retain some heat for cooler nights.
11. Some degree of porosity in building material was important: To facilitate the dissipation of heat during overheated periods.
12. Lighter or medium weight materials were used for outdoor structures: To dissipate heat, and to reduce heat gain, particularly in the overheated periods.

## 6. THE RESULTS

The results from the above aspects are put together to provide a guideline-chart. The buildings in the temperate climate may be hundreds of kilometers apart, but similar urban form and architectural morphology, climatic design principles and physical appearance, with variable depth, are evident and transparent. The selected buildings in their context might differ in size, texture and scale, and might have different cul-

ture, but their spatial climatic organization binds them together. The following findings (Table 2) are brief results from investigation which has been summarized.

This is a summary of the findings for the C climate zones, categorized by the nine principles and elements. The investigated buildings were a few samples from the vast and rich variety and represent a good spectrum of the *culture, history*

Table 2: Summary of the Architectural Aspects

Architectural Elements	Design Principles in temperate climate
MORPHOLOGY	<ul style="list-style-type: none"> <li>• Extroverted to introverted building morphology in different shapes and spatial layout were feasible.</li> </ul>
DENSITY	<ul style="list-style-type: none"> <li>• Medium compact configuration was common.</li> </ul>
ARRANGEMENT	<ul style="list-style-type: none"> <li>• Free and open arrangement between functional spaces was possible.</li> </ul>
CIRCULATION	<ul style="list-style-type: none"> <li>• Moderate internal circulation and volume was planned.</li> </ul>
ROOF	<ul style="list-style-type: none"> <li>• Roofs, primarily in the shape of flat or sloped were used over closed or semi-open spaces.</li> </ul>
SURFACE	<ul style="list-style-type: none"> <li>• Many different building surfaces were used.</li> </ul>
WINDOW	<ul style="list-style-type: none"> <li>• Windows were positioned on the east, south and west facades.</li> <li>• Moderate window areas facing all directions were located, particularly on the windward and on leeward facades.</li> </ul>
SHADING DEVICE	<ul style="list-style-type: none"> <li>• Horizontal shading devices or awnings on the south side and vertical shading device on the east and west sides were employed.</li> </ul>
MATERIAL	<ul style="list-style-type: none"> <li>• Medium density construction materials were applied.</li> <li>• Some degree of porosity in building material was important.</li> <li>• Lighter or medium weight materials were used for outdoor structures.</li> </ul>

*and climate.* The principles and elements of design were identified and explored for the region. The results were obtained, the findings were analyzed and the aims were identified to establish a comprehensive perspective for the sustainable architectural design.

In the study, the systematic organization of the outcomes and their overall result was the main goal, in order to extract the strategies and elements, which would be beneficial for establishing the final recommendations. Some of the strategies, in certain climates, played a more significant character than others, and some elements were not as substantial. However, the evidence of the expansive effect of climate on the architectural configurations was illustrated, their design crystallized, but with a different degree of intensity for various regions.

## 7. CONCLUSIONS

The flexibility that is admissible by the conditions of temperate regions has resulted in a limited degree of similarity in the physical aspects of the selected buildings and settlements. The main architectural elements which have shaped the spatial form of the settlements are usually in harmony with the surrounding features and climate, whether these settlements are located in Asia or Europe.

The microclimates of outdoor spaces of the majority of urban centres in the temperate climate are usually within the comfort zone for most of the year, and as a result, indoor spaces are climatically comfortable. The above evidence together with its climatic planning indications verifies that Pompeii was a well-planned town which harmonised well with the climate in order to achieve physical comfort for its citizens. The overall physical appearance demonstrates typical design and planning for the warm-humid climate of this part of the world.

The results of analysis of the cases and others demonstrates similarity and contrast in elements and principles, differing in history and culture but being similar in climate, and also differing in climate but being of the same culture.

It is important to emphasize, as the conclusion of the research, that indigenous architectural styles are defined less by national frontiers and more by environmental considerations. Climate has played and should play a significant

role in determining the overall architectural form and fabric of the future sustainable urban areas and livable living style. In other words, vernacular and sustainable architecture in all climatic regions are mainly born out of the environmental conditions.

*Sustainable Life thrives only in favorable environmental and climatic conditions.*

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