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CLIMATE CHANGE AND PUBLIC AWARENESS

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ABSTRACT

Climate change is already harming people and ecosystems. Its reality can be seen in melting glaciers, disintegrating polar ice, thawing permafrost, changing monsoon patterns, rising sea levels, changing ecosystems and fatal heat waves. Climate change poses a risk to the human rights of millions of people--such as their rights to life, health, food and water. The risks are highest in developing countries, where extreme weather events, crop failures and other emergencies related to climate change are projected to occur with greater frequency.

Scientists are not the only ones talking about these changes. From the apple growers in Himachal to the farmers in Vidharbha and those living in disappearing islands in the Sunderbans are already struggling with the impacts of climate change.

This is just the beginning. We need to act to avoid terrible climate change. No one knows how much warming is "safe". There are now different tools and techniques available to guide the designers and users to have a multifaceted approach in building design involving- climate responsive architecture, materials with low embodied energy, reduction of ecological footprint, efficient structural design, recycling and harnessing renewable energy to meet the energy needs of the building etc.

In this paper, form finding is employed as an approach for designing environmental friendly “green rated” buildings integrating energy-related design aspects as one of its main boundary condition. This method is employed in the context of various climatic zones in the country. In order to bring about parity and for standardizing, the same building typology is used throughout the zones. This paper deals with the relation between building form and envelope and its energy consumption in hot dry climatic zone of the country.

KEYWORDS: Climate, Climatic Zone, Energy, Environment

INTRODUCTION

It is well accepted that climate change is caused by human beings. The Intergovernmental Panel on Climate Change (IPCC) has confirmed in several reports climate change is manmade and caused by the excessive emission of greenhouse gases (GHGs) since industrialization. A change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.

The purpose of this paper is to find the relation between appropriate building form in hot dry climate zone in India given the considerations of energy efficiency. The focus is mainly on building form and envelope; the use of passive techniques for heating and cooling are not applied here prominently. This design research paper refers to the various primers and manuals that exist for energy efficient buildings in India to arrive at an appropriate building form and then compares it with a base condition. Both considerations for comfort and energy efficiency are accounted for in the building.

Form finding in Architecture with various boundary conditions has been studied in the past by various researchers. Sigrid et al studied the form generation of high performance based architectural systems driven by solar radiation control and structural efficiency. The façade based systems thus generated explores elastic deformations for shape changes, reducing actuation requirements and could also improve the environmental performance of a building. In another study, daylight uniformity was the factor taken to generate curvilinear ceiling forms algorithmically.

Hence, for developing countries, by and large, achieving sustainable development remains the primary and overriding national policy objective to which all other policymaking should contribute. This is also the reason why, in the climate change negotiations, developing countries have been insisting on ensuring that any agreed outcomes be balanced and reflect the essential development concerns and interests of developing countries – not only in order to reflect the treaty foundations of these processes but also to ensure that there is no intended or unintended foreclosure of the sustainable development prospects of developing countries as a result of such negotiations.

Sustainable economic development – that is, a development pathway that provides adequate economic opportunities and a decent quality of life in a manner that is equitable and environmentally sustainable – is needed. The poor in developing countries simply cannot afford to see development in their countries be constrained by climate change. Development is also urgently needed in order to minimize and mitigate climate change risks by improving developing countries' adaptive capacity. Furthermore, developing countries would be in a better position to participate in global efforts to address climate change if the basic economic needs of their populations are already met. Sustainable development as the overriding priority of developing countries must be placed at the heart of the global climate change discourse.

EFFECTS OF SMALL TO MODERATE WARMING

- Rise in sea level due to melting glaciers and the thermal expansion of the oceans as global temperature increases.
- Massive release of greenhouse gases from melting permafrost and dying forests.
- A high risk of more extreme weather events such as heat waves, droughts and floods. The global incidence of drought has already doubled over the past 30 years.
- Severe regional impacts. Example: In Europe river flooding will increase and in coastal areas the risk of flooding, erosion and wetland loss will increase substantially.
- Natural systems, including glaciers, coral reefs, mangroves, Arctic ecosystems, alpine ecosystems, Boreal forests, tropical forests, prairie wetlands and native grasslands, will be severely threatened.
- The existing risks of species extinction and biodiversity loss will increase.
- The greatest impacts will be on the poorer countries least able to protect themselves from rising sea levels. There will be spread of disease and declines in agricultural production in the developing countries of Africa, Asia and the Pacific.

At all scales of climate change, developing countries will suffer the most

Solutions for the Climate

- Developed countries must make cuts of 40 percent on their 1990 carbon emisisons by 2020.
- Developing countries must slow the growth of emissions by 15-30 percent by 2020, with support from industrialised nations.
- Protect tropical forests with a special funding mechanism - forests for climate.
- Replace dirty fossil fuel energy with renewable energy and energy efficiency.
- Reject false solutions like nuclear energy.

THE INFLUENCE OF FORM ON THE BUILDING ENERGY CONSUMPTION

The radiation hitting a building can increase energy requirements for cooling up to 25%. Studies identify the hemispherical shape as the most suitable shape for the building. Other studies have also revealed that H form and L form shapes of the plan as good in terms of energy efficiency. In addition the presence or absence of a courtyard also helps in lowering the ambient temperature thereby reducing the heat energy inside a building.

FACTORS EFFECTING BUILDING FORM AND ENERGY USE

The variables that are related to building shape and which influence heating and cooling requirements are the following:

- Compactness Index
- Shape Factor
- Orientation
- Climate

Compactness

In all buildings, the ratio of enclosure area to floor area is important, and hence simple shapes are preferred (as well as being less expensive to build and maintain). In Europe, the ratio of volume, V, to surface area, S, is a typical metric, labeled Compactness C:

Compactness C = Volume / Surface Area

The German energy code goes as far as prescribing higher R-values for buildings that are less compact than others.

The heating load of small buildings (e.g., houses) can vary by around 25% (Gratia and De Herde 2003) from the most compact (high C) to the most sprawling (low C) designs (Figure 1). Most ultra-low energy single-family houses have V/S ratios of around 1.0 or larger.

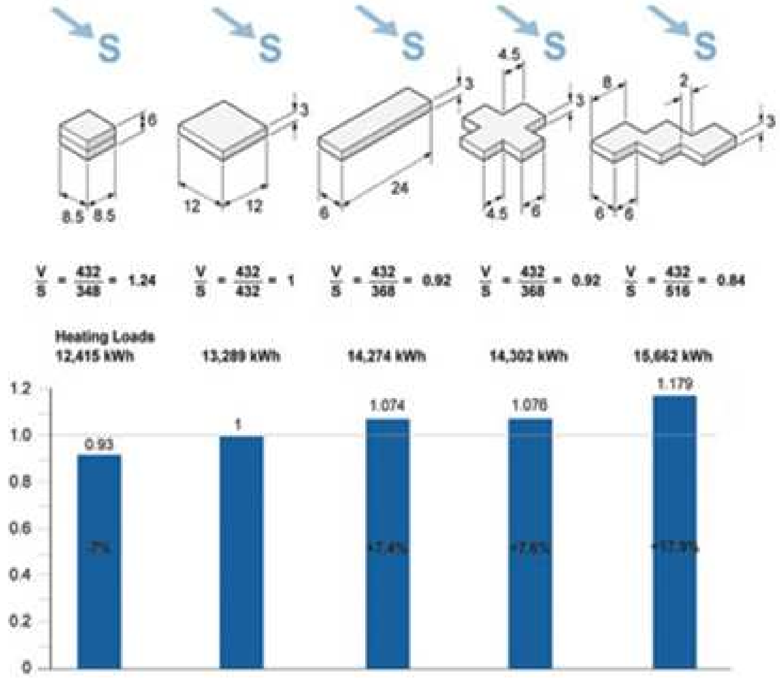
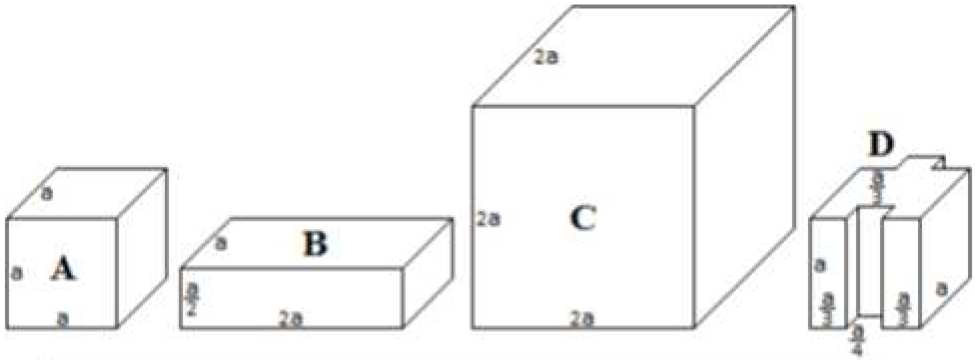


Figure 1: Impact of Building Shape on Annual Heating Energy for a Small 144 m^2 (1500 ft^2) Building in a Cold Climate [Gratia & De Herde 2003]

A building with a smaller ratio of area to volume or a high volume/surface ratio is desirable. The Compactness index is the ratio between the volume and the outer surface of the building facade. It is related to the building's capacity to store heat and avoid heat loss through its facade. A very compact building is one that has a high volume/surface ratio, where the surface exposed to possible heat losses or gains is as small as possible.

Shape Factor

The shape factor of a building is a measure of the building's compactness and expresses the ratio between the building's thermal envelope area and its volume. The thermal envelope area is the area that separates between the conditioned and unconditioned areas or alternatively, the indoor and the outdoor environment. As a result, the heat losses through the thermal envelope account for large percentage of the total final energy use of a building in cold climates. Buildings with a higher shape factor are less compact and therefore have a larger thermal envelope area in proportion to their volume and therefore larger heat losses. The value of the shape factor depends on the shape of the building for a given volume as illustrated by building A and B in Figure 2. Both buildings have similar volume but different thermal envelope areas, which results in different shape factors. The size of the building also influences the shape. A larger building with similar shape will have lower shape factor as illustrated by building A and building C in Figure 2. Irregular façades with trenches and bulges, e.g. heated balconies that extend beyond the façade, may also increase the shape factor as illustrated by buildings A and D in Figure 2.



	A	B	C	D
Volume	a^3	a^3	$8a^3$	a^3
Thermal envelpe	$6a^2$	$7a^2$	$24a^2$	$7a^2$
Shape factor	6/a	7/a	3/a	7/a

Figure 2: The Shape Factor of Buildings with Different Sizes and Shapes. The Parameter 'a' Symbolizes a Unit of Length

However the impact of the shape factor varies considerably for buildings with different thermal envelope properties and for different climate conditions. For the scenarios used in this study the change in specific heat demand for a unit change of shape factor in the design of the building varied from 12 to 52 kWh/(m2 year). The shape factor has higher impact on the specific heat demand in buildings with lower thermal envelope properties and buildings that are located in colder climates. The impact of the shape factor found to increase in regions with higher average wind speed as well. Sensitivity analysis found minor changes in specific heat demand caused by differences in window-to-floor area ratio.

The building orientation determines the amount of radiation it receives. If the variations of solar radiation intensities on a horizontal surface and the vertical walls of different orientations are graphically compared.

Orientation

Orientation of the building is the way the building is placed on the site in alignment to the sun and wind movement (so as to allow or avoid sun/wind). In buildings without insulation and with different shapes, a heating energy saving rate of 1-8% was obtained depending on the orientation of the building.

Solar access' is the term used to describe the amount of useful sunshine striking glass in the living spaces of a home. The desired amount of solar access varies with climate.

The sun is a source of free home heating.

Variations in orientation towards east and west can have advantages in some climates and for some activities. For example, in cold climates, orientations west of north increase solar gains in the afternoon when they are most desirable for evening comfort, but east of north can warm the house more in the mornings, improving daytime comfort for those who are at home then. In warmer climates, orientations east of north can allow better capture of cooling breezes.

Poor orientation and lack of appropriate shading can exclude winter sun and cause overheating in summer by allowing low angle east or west sun to strike glass surfaces at more direct angles, reducing reflection and increasing solar gains.

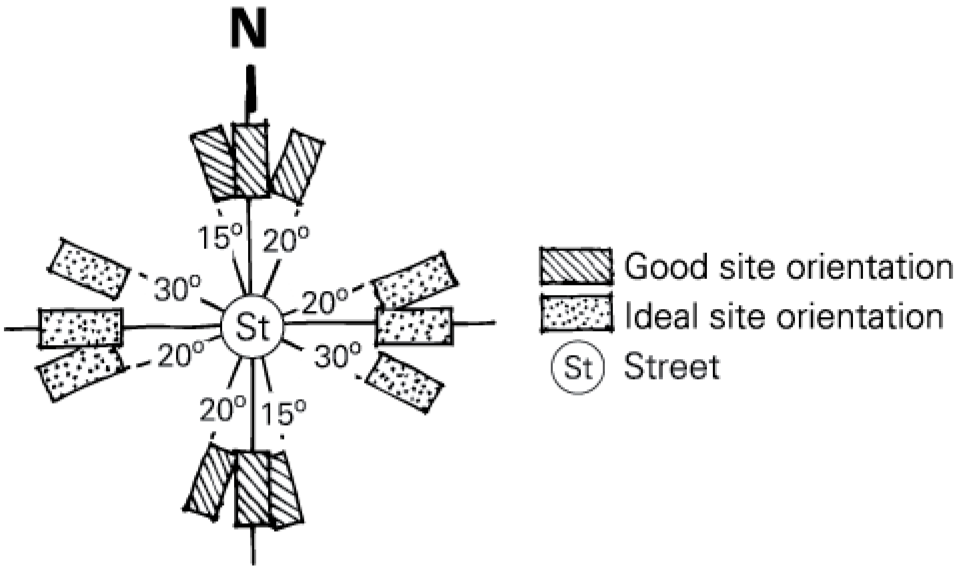


Figure 3

Orientation does not have to be precise: there is a degree of flexibility.

After decisions on site and orientation the next considerations are

Relocate living areas to take advantage of winter sun and cooling summer breezes.

Maximize north-facing daytime living areas where passive solar access is available.

Use smaller, well shaded windows to increase cross-ventilation to the south, east and west.

Avoid west-facing bedrooms to maintain sleeping comfort.

Locate utility areas (laundries, bathrooms and garages) on the south or west where possible.

Avoid placing obstructions such as carports or sheds to the north.

Plant shade trees in appropriate locations; landscape to funnel cool breezes and block or filter harsh winds.

Prune vegetation that blocks winter sun; alternatively plant deciduous vegetation that allows winter sun in but provides summer shade.

BUILDING FORM IN HOT DRY CLIMATE

Characteristics of the Climate

The hot and dry climate is characterised by very high radiation levels and ambient temperatures, accompanied by low relative humidity. The summer day time can be a peak of 40-45 degree C and the night time temperature can fall down to 20-30 deg C. The diurnal range of temperature is high. The annual precipitation is less than 500mm.Example of a city in this region is Jodhpur.

Heat Resistant Construction

The main aim is to resist heat gain — Proper orientation decreases exposed surface area. Increase shading by overhangs, projections and surface reflectivity by providing light-coloured finish. Increase thermal capacity (time lag) by cavity walls and thermal resistance by insulating the building envelope. Increase buffer spaces. Decrease air exchange rate (ventilation during day-time) by scheduling air changes

Promote Heat Loss

Provide ventilation by windows and exhausts. Increase air exchange rate (ventilation during night-time) by courtyards, wind towers and arrangement of windows. Increase humidity levels by trees, water bodies and evaporative cooling.

Design Considerations for Day-Lighting in Hot and Dry Region

Smaller openings that are efficiently shaded. Building with compact internal planning having courtyard, with dense grouping so that the east and west walls are mutually shaded. High-level windows (with a sill above the eye level) or light shelves, which would admit reflected light to the interior. Low-level windows are acceptable if they open towards a shaded and planted courtyard. Vertical strip windows at the corner of the room to avoid excessive brightness and provide a light 'wash' on the walls.

Designing a home in a hot and dry climate takes a very particular approach. Not only do you want the home to be visually appealing inside and out, but it must also be designed to keep cool and conserve the water supply. Most people will live in this climate year-round, so with no escape to greener pastures, you've got to figure out how to make it comfortable under these less than ideal conditions. For hot climates taking advantage of solar PV systems is a good way to conserve energy and use the sun's energy. For best results, you must start from the ground up. That means how the walls are constructed, the design of the plumbing, where the home is positioned on the property and even how you can use the climate to your advantage with green construction.

Choosing Building Materials

First off, consider the building materials you are going to use. A hot and dry climate will require thick walls to keep the temperature out. Adobe is a great option that has been used for as long as humans have been constructing dwellings, specifically for its thermal properties. It's incredibly environmentally friendly, but will also keep the heat out, and retain heat in the winter or the cold nights often found in those climates.

Next, think about your windows and doors. You'll want all of the construction to be as air-tight as possible, since the residents will be using air conditioning for significant stretches, and you don't want to waste that energy with cool air escaping through improper seals. Any exterior doors should be as thick as the walls, and if you take it a step further and insulate them, they'll keep out additional heat. Any windows will stay cooler if they are inset in the walls. If that's not possible, design them with awnings, to keep off the worst of the sun. If you have the budget for it, go with double-panes, for added insulation. And you can take it a step further and treat the glass with UV-resistant chemicals, which will certainly help cool the house.

Considering Air Flow Design

How the air flows through the home will also be a serious consideration. Floor plans in hot and dry climates should always be open, for maximum air flow from room to room. If you can design it with windows at each end of the house, the residents could take advantage of a great cross breeze if they want to shut down the air conditioning for a while. Adding a vaulted ceiling will give the hot air somewhere to escape well away from the people. And certainly add in windows on both the south and north sides of the home, for a great cross breeze in the evening.

Courtyard

Courtyard as the best type of external space in this type of climate as the pool of cool night air can be retained in the inner space as it is cooler and so heavier than the surrounding warm air. If the courtyard is small, where the width is not greater than the height, even breezes will leave such pools of cool air undisturbed. Hence the courtyard is considered as an excellent thermal regulator.

Shading

Shading from the effects of direct solar radiation can be achieved in many ways:

- Shade provided by the effect of recesses in the external envelope of the building.
- Shade provided by static or moveable external blinds or louvres.
- Transient shading provided by the orientation of the building on one or more of its external walls.
- Permanent or transient shading provided by the surrounding buildings, screens or vegetation.
- Shading of roofs by rolling reflective canvass, earthen pots, vegetation etc.

However, the following design recommendations generally hold true:

- Study of the sun angles is important for designing the shading devices. An understanding of sun angles is critical to various aspects of design including determining basic building orientation and selecting shading devices.
- Fixed shading devices, using correctly sized overhangs or porches, or design the building to be “selfshading”should be installed. Fixed shading devices, which are designed I o a building, will shade windows throughout the solar cycle. Permanent sun shades may be built into the building form. They are most effective on the south-facing windows. Awnings that can be extended or removed can also be considered for shading the windows. The depth and position of fixed shading devices must be carefully engineered to allow the sun to penetrate only during predetermined times of the year. In the winter, overhangs allow the low winter sun to enter south facing windows. In the summer, the overhangs block the higher sun.
- Limit east/west glass. Glass on these exposures is harder to shade from the eastern morning sun or western evening sun. Vertical or egg-crate fixed shading works well if the shading projections are fairly deep or close together; however, these may limit views. The use of landscaping can also be considered to shade east and west exposures. North-facing glass receives little direct solar gain, but does provide diffuse daylight.
- In hot and dry climates, the movable blinds help to reduce the convective heat gain caused by the hot ambient air. In warm and humid climates where the airflow is desirable, they impede ventilation. In composite climates, the light colored/reflective blinds block the solar radiation effectively.

- Internal shading, in the form of blinds or curtains, is often used to block the unwanted solar gains coming through a window. The effectiveness of any shading device located inside the window is a function of how well it reflects short wave radiation back out through the glass. Darker blinds or curtains may reduce solar penetration into the space and may be helpful, but not as effective as exterior shading because it still convert most of the sunlight into heat within the building envelope since heat has already penetrated the building.
- Any shading device will affect the view out of a window and this maybe a crucial factor in favouring one form of shading over another form. If shading devices are used, they will have a major, if not an overwhelming affect upon the external appearance of a building, and therefore they need to be considered at the outset if they are tobe used.

Shading by Trees and Vegetation

The following points should be considered for summer shading:

- Deciduous trees and shrubs provide summer shade yet allow winter access. The best locations for deciduous trees are on the south and southwest side of the building. When these trees drop their leaves in the winter, sunlight can reach inside to heat the interiors.
- Trees with heavy foliage are very effective in obstructing the sun’s rays and casting a dense shadow. Dense shade is cooler than filtered sunlight. High branching canopy trees can be used to shade the roof, walls and windows.
- Evergreen trees on the south and west sides afford the best protection from the setting summer sun and cold winter winds.
- Vertical shading is best for east and west walls and windows in summer, to protect from intense at low angles, e.g. screening by dense shrubs, trees, deciduous vines supported on a frame, shrubs used in combination with trees.
- Shading and insulation for walls can be provided by plants that adhere to the wall, such as English ivy, or by plants supported by the wall, such as jasmine.
- Horizontal shading is best for south-facing windows, e.g. deciduous vines (which lose foliage in the winter) such as ornamental grape or wisteria can be grown over a pergola for summer shading.

RECOMMENDATIONS

- Building orientation changing the orientation of the building with respect to the base case does not affect its thermal performance.
- Glazing type A single pane reflective coated glass increases the yearly comfortable hours by 10.3% compared to plain glass (base case). This type of glazing is, therefore, recommended.
- Shading Reduction in solar radiation by shading windows can reduce the heat gain and consequently increase the comfort. An increase of 12.6% in the number of comfortable hours can be achieved, if windows are shaded by 50% throughout the year.
- Wall type A concrete block wall increases the yearly comfortable hours by 2.8% compared to the brick wall (base case). However, wall insulation is not recommended.

- Roof type Insulating the roof using polyurethane foam insulation (PUF) increases performance by 2.2% as compared to a roof with brick-bat-coba waterproofing. However, an uninsulated roof i.e. plain RCC roof having a higher U-value decreases the number of comfortable hours by about 16.8%

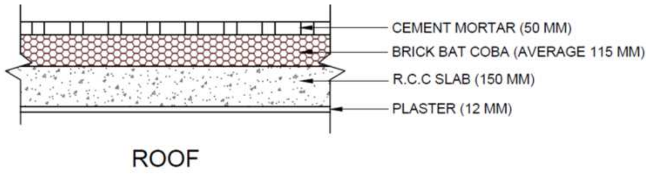


Figure 4

- Colour of the external surface White and cream colours are desirable compared to puff shade (base case) or dark grey. The percentage increases in comfortable hours compared to the base case are 4.8 and 3.0 respectively.

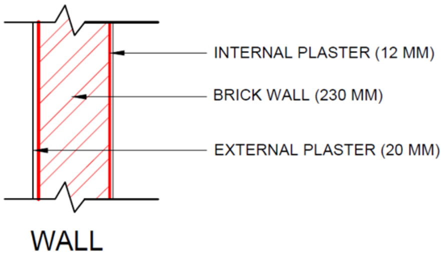


Figure 5

- Air exchanges An air change rate of 9 ach is better than 3 ach (base case), giving an improvement of about 11.9%. An air change rate of 6 ach gives an improvement of 9.4%. The reduction of air change rate below 3 ach is not desirable. (b) Operational Parameters (i) Internal gain the lower the internal gain, the better is the performance. The performance increase is about 5.1% if the internal gains are reduced by 50%. Thus, energy efficient lights and equipment should be employed to reduce internal gains and subse.

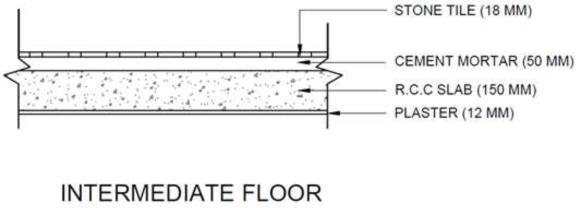


Figure 6

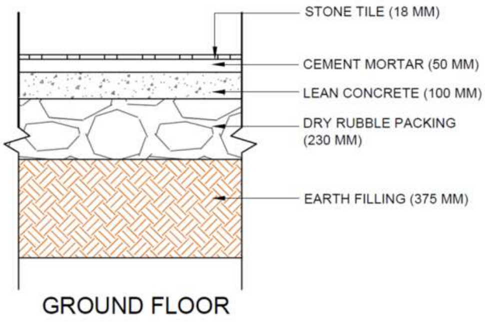


Figure 7

CONCLUSIONS

Analysis of various building forms in hot dry climate reveal that the with higher compactness index the energy efficiency of the building is enhanced. However, having a courtyard arrangement of living spaces also brings down the internal gain considerably. The roofs are the most important building element that helps the building gain less heat and lose more in such climates. Hence the material selection of the roofs and the shading property has to be given utmost priority. Selective shading during day time and its removal during night time also helps in lower heat absorption and faster heat radiation. Moveable shades that are operated during summer and rolled back in winters also help in permitting the sun rays which are desirable in the winter.

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