HOUSE INSPIRED FROM VERNACULAR BUILDINGS OF KERALA

A PROJECT REPORT

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DECLARATION

We hereby declare that the project report **HOUSE INSPIRED FROM VERNACULAR BUILDINGS OF KERALA** is based on our own work carried out during the course of our study under the supervision of **Prof. Sreedevi A R**.

By including this statement, we the authors of this work, verify that:

- We assert the statements made and conclusions drawn are an outcome of our work.
- We have followed the guidelines provided in writing the report.
- We hereby certify that no part of this assignment/product has been copied from any other student's work or from any other source except where due acknowledgement is made in the assignment.

ACKNOWLEDGEMENT

Firstly we would like to thank our guide **Prof. Sreedevi A R** who gave us the valuable suggestions and ideas whenever needed and encouraged us to work on this project.

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We would like to thank Almighty for giving me the strength and opportunity for completing the project successfully.

We are immensely grateful to all involved in this project as without their inspiration and valuable suggestions it would not have been possible to develop the project.

ABSTRACT

Kerala Architecture is one of the most exciting examples of preservation of traditional and vernacular styles and sustainability. We can find the parameters of architectural sustainability and find a way into in the present and future. It is important for modern house construction to take clues and information from the vernacular styles of construction. Appropriate use of materials and adoption of suitable traditional architecture is required for a sustainable and energy efficient construction.

This project deals with the design of a residential building inspired from the traditional buildings of Kerala based on resource conservation and cost efficiency. The traditional *Nalukettu* style construction is analysed and a sustainable construction technology is devised befitting modern day civil engineering practices. AutoCAD model of the house is represented followed by the three dimensional model using Revit software. A brief cost analysis of the building is performed.

Keywords: traditional, naalukettu, nadumuttam, sustainability, Vaasthushastra, stack effect

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CHAPTER 1

INTRODUCTION

1.1 GENERAL

"Environmental sustainability has been defined as meeting the needs of the present, without compromising the ability of future generations"

The traditional architecture of Kerala is unique with architectural character as well as climate control and comfort features. The understanding and appreciation of environment and climate is reflected. The objective of vernacular and traditional architecture is also based on local needs, local building materials, and reflecting the local traditions. It gives solutions that are in perfect harmony with nature. Control of the indoor environment is always an important aspect of traditional architecture. Vernacular and traditional systems of construction are ecologically responsive and energy efficient. The transition in life style which knowingly or unknowingly change the character and sustainability of architecture.

The traditional *Nalukettu* style is typically a rectangular structure where four blocks are joined together with a central courtyard (*Nadumuttam*) open to the sky. The materials used for construction is mainly wood. The attic constructed in this manner provides required ventilation and are also energy efficient structures.

1.2 OBJECTIVES

The primary objective is to design a residential building inspired from the vernacular buildings of Kerala. This project evaluates traditional Kerala architecture in terms of sustainability and cost effectiveness, how and what way they were sustainable. Major factors affecting the sustainability and their applications in contemporary principles of construction were analysed.

- To understand the reasons and methods of traditional ways of construction in Kerala.
- To optimize the use of locally available materials.
- To attain energy efficient deconstruction and recycling of materials.

- To conserve energy, materials.

1.3 SCOPE

Kerala architecture is primarily based on the principles of *Thachu Shasthra* (Science of carpentry) and *Vaasthu Shasthra* (Science of architecture and construction). Vernacular and traditional systems of construction are ecologically responsible and energy efficient. It is important for modern house construction to take clues and information from this vernacular style of constructing buildings. The form and planning of traditional houses ensured adequate cross ventilation, a natural method of cooling by providing single row of rooms accessible from verandahs.

The project studies the features of architecture in the traditional residences (especially the *Naalukettu*) which contributed to a sustainable living and analyze them to formulate guidelines which will contribute to the sustainability of future residential buildings.

1.4 LIMITATION

The pitched roof of a Naalukettu is technically sloping roofs on all 4 sides. But in Revit software it is not possible to create such a roof directly as a slope towards the interior of the building is not defined. Thus, in the model, the roof was made separately as a three plus one roof, ie. , the roof was created on 3 sides and then the 4^{th} side was created as a separate roof. This can be observed as a distortion in the sectional view of the Revit model.

CHAPTER 2

LITERATURE REVIEW

The areas of study covered in literature review includes:

- Sustainability in traditional architecture.
- Architecture of Kerala
- Naalukettu
- Other elements of Naalukettu

2.1 SUSTAINABILITY IN TRADITIONAL ARCHITECTURE

Sustainability in architecture holds an important role in today's life. There is a need of alternate strategies of optimizing and correcting the ways of using limited existing resources, seeing provision of needs and welfare and also causing minimum damage to the environment and life.

In every place, the functional needs and environmental conditions leads to some situations being provided by the local people which can be regarded as successful examples of adaptation with the needs , concerning all the aspects of environmental conditions, on the basis of the existing natural facilities. It is purely natural evolution of adaptation according to the needs and resources available. They tend to evolve means, techniques and principles for the betterment of living conditions which never harmed the nature. This architecture can be called traditional architecture of that place.

Traditional architecture has useful points in their methods of architectural adaptation regarding the existing needs for today's architects and architecture. It had its own character and beauty within itself as it was much close to nature ensuring sustainability in every aspect of life and environment.

2.2 ARCHITECTURE OF KERALA

The architecture, environment and culture of Kerala stand in marked contrast to that of rest of India. The understanding and appreciation of the environment and climate is

reflected in traditional architecture. It was characterized by simplicity and boldness of shape, form and character; dominated by sweeping, red tiled roofs.

Just north of Cochin, extending all the way up north, there are deposits of laterite, used throughout Malabar for the walls and foundations of both houses and temples. This is allowed to build the double storey homes with the sloped roof seen throughout the north.

In southern Kerala, wood was the primary building material, and homes remained single-storied until the end of 19th century.

2.3 NAALUKETTU – A comfortable house close to nature

Houses in Kerala can be well explained by the principles of planning and structure of a *Naalukettu*. *Naalukettu* is a complete residential building with reference to Vaasthuvidya.

The plan form of a *naalukettu* can be well explained as a rectangular or square on with a central courtyard with livable rooms on its four sides and four corners. This plan imparts security, natural lighting and ventilation; the prime focus of such construction is to be at par from nature.

The basic module of vernacular residential building of Kerala is known as *Naalukettu*, basically four built around an open courtyard. Generally rectangular or square in plan with blocks topped with a sloping roof on all four sides having central courtyard left open to the sky, letting air and light. The internal verandah around the courtyard also contributed for protection from rain and sun.

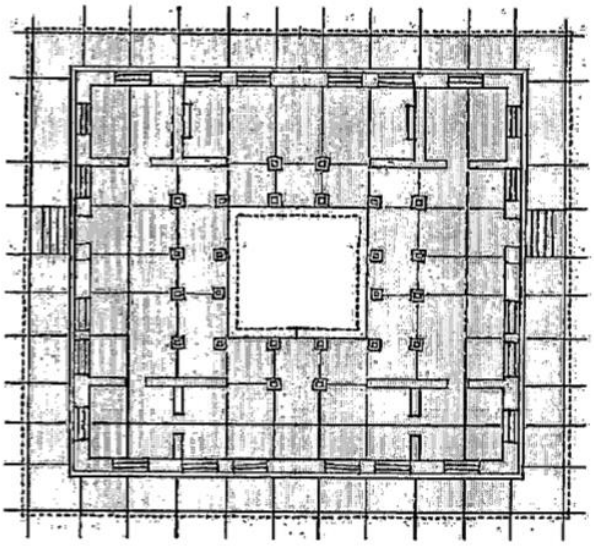

Figure1: House grid with sloping roof and open courtyard

The courtyard (***nadumuttam***) and the blocks around are laid out according to the rules of dimensions, scale and proportions. Depending on the size and importance of the household, the buildings may have one or two storeys or further modules with enclosed courtyards. Thus the basic proportions were based on human scale and additions of modules made a bigger residence.

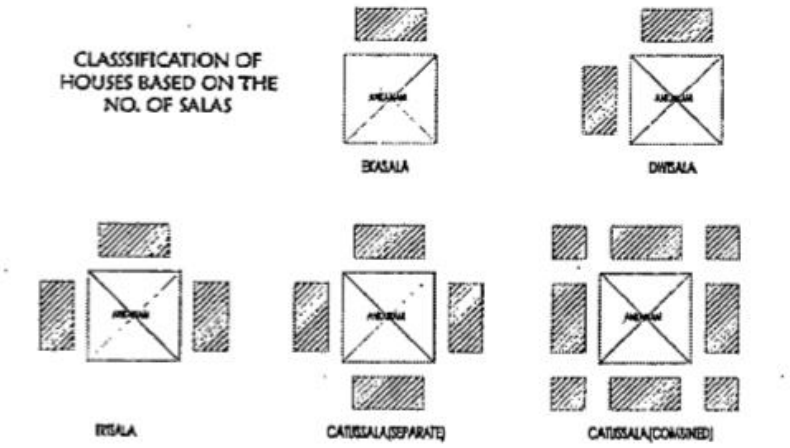

Figure 2: Classification of houses based on number of shalas

Figure 3: The central courtyard (nadumuttam**)**

2.4 OTHER ELEMENTS OF NAALUKETTU

- **Padippura:** It is a structure containing a door forming part of Compound wall for the house with a tiled roof on top. It is the formal entry to the compound with the house. Usually, tiled roof is provided preferably with a traditional type lamp below the roof. In a present-day approach, to provide access to vehicles, larger doors can be provided for the Padippura.

Figure 4: the ornate gateway provided at the outer boundary walls of the property

- **Poomukham:** It is the prime portico soon after steps to the house. Traditionally it has a slope tiled roof with pillars supporting roof.
- **Chuttu verandah:** From the Poomukham, a verandah to either side in front of the house through open passage called Chuttu Verandah. Chuttu verandah will have hanging lights in equal distance hanging from its slope roof.

Figure 5: Wood carvings and chuttu verandah in Kerala Architecture

- **Charupady:** By the side of Chuttu verandah and Poomukham, wooden benches with carved decorative resting wooden pieces for resting the back are provided. This is called Charupady.
- **Pooja room:** Pooja room should preferably be in the North East corner of the house. Idols can be placed facing east or west and the person praying can face west or east respectively. At present, wooden panelling is done on Pooja room walls and there is a standard design for Pooja room which can give the rendition of a traditional Pooja room.

CHAPTER 3

METHODOLOGY

This project discusses the traditional architecture of Kerala in terms of sustainability. This will lead to a conclusion that reflects the major factors regulating the sustainability principle in today's context.

The project goes through the following processes:

- Understand the reasons and the methods of Traditional ways of construction in Kerala.
- Understand the factors better, through analyzing traditional and modern context with respect to Kerala Traditional Architecture.
- Analyze the major factors affecting the sustainability and their applications in contemporary principles of construction.
- Devise a sustainable and cost-effective construction technology befitting modern day Civil Engineering practices.
- Design the house using AutoCAD and Revit software.
- Perform a brief cost analysis of the building.

CHAPTER 4

CONSTRUCTION MATERIALS

A judicious use of appropriate materials and adoption of suitable traditional techniques in construction is required for a sustainable, energy efficient and comfortable human life. Hence the methods and techniques adopted in the Kerala vernacular residential architecture can be effectively used in contemporary constructions for warm-humid regions.

The building materials used for vernacular construction in Kerala are mud, laterite and granite stone blocks, lime mortar, wood, bamboo, clay roofing tile and coconut palm leaves. Though granite stone is a strong and durable building material, due to its limited availability mostly to the highlands, the use of granite is limited to the foundation of buildings as rubbles. Laterite is the most commonly used building material in Kerala, which can be easily cut, dressed to be used as building blocks. Its durability and strength enhance with exposure to atmospheric air.

From literature reviews it was reckoned that within Kerala, from north of Cochin, extending all the way up north, there are large deposits of laterite, used throughout Malabar for the walls and foundations of both houses and temples. Thus, laterite foundations and walls are seen throughout the Northern Kerala. In southern Kerala, wood was the primary building material.

The vernacular architecture gives solutions that are in perfect harmony with nature. Control of the indoor environment has always been an important aspect of vernacular constructions. The effective use of materials and the techniques used in the construction of walls and roof ensures better thermal performance.

The model was proposed for Thiruvananthapuram where the availability of laterite is limited. These days timber is no longer a sustainable material owing to its limited availability. Thus, rat trap bonds with interlocking mud blocks having minimal mortar requirements were chosen to replace the traditional laterite walls. Walls will be unplastered and treated with pidicrete to prevent any leakage that might occur.

Figure 6: Interlocking blocks

Source: www.indiamart.com

Figure 7: M.P. tiles laid over steel truss

Traditional houses had pitched roofs covered with burnt clay tiles, thatch, etc. ensured protection against heavy rains. To achieve thermal insulation, wooden ceiling (tattu/machu) is provided under the roof as attic space. The large air space at the attic acts as insulation layer against the conduction of external heat through the roof. Attic is well ventilated by the jallies. The breathing space between the clay roofing tiles further helps in ventilating the underside of the roof reducing the temperature. Roof tiles were inevitably laid on timber trusses. In the model, the roofs are high pitched, covered by Manglore pattern tiles laid over steel trusses. The truss will be made of G.I. steel tubes with welded joints. A bamboo false ceiling will be provided beneath it to act as tattu/machu. Bamboo can be treated to improve its strength, durability and water resistance.

Timbers and panelling are salvaged from the demolition of old houses, cleaned up, resewn if necessary. It reduces landfill waste and is nontoxic & recyclable. Recycled timber is used for doors, window panels, door and window frames. Using products with a high

recycled content, such as recycled cement in concrete, along with fly-ash, in the construction of beams columns and slabs; saves project cost and reduce waste.

Filler slab construction would be adopted for the first floor's floor of the model. Other structural members include brick columns & R.C.C. beams. Columns can be divided into base, shaft and capital. In the proposed model the base and shaft of columns would be made of brick and capital will be R.C.C. Atangudi tiles, Granite slabs and red oxide flooring can be adopted.

CHAPTER 5

MODEL

5.1 PROJECT DESCRIPTION

From the analysis of traditional houses of Kerala and their constructional tenets, the ways by which they achieved sustainability and efficient use of energy by climatic responsiveness of built and surrounding environment were identified. We spent 90% of our time in building, either office or home. To explore its possibilities in the present-day constructional practices, a model was developed with the aid of Autodesk Revit and Autodesk AutoCAD software comprehending these principles. A 2 storeyed residence was designed for a fictious plot of 10.3 cents with the building occupying 5.3 cents.

Vernacular architecture is the style of architecture which takes into account all the needs and requirements of the residents, nature, construction materials and also mirrors the traditions and culture. The uniqueness of traditional architecture of Kerala lies in features such as steep roof framework supported by pillars erected on a raised plinth, projecting eaves to ensure protection against sun and rain for the outer walls and veranda.

In addition to the traditional aspects of sustainability and cost efficiency, several other features were also included in the model. Solar panels on roof-top takes care of energy demands and the Rain water harvesting system replenishes the ground water reserve. Biogas plant is installed which is an eco-friendly cooking alternative.

The most remarkable feature of a typical traditional residence of Kerala is an internal courtyard (Nadumuttam) and patio accompanied by a running veranda that functions as a microclimate modifier. This microclimatic effect of courtyard is referred as “stack effect”. It allows solar access to all parts of the building and enables better ventilation of internal spaces. The courtyard gets heated up during the day due to the sun. And as there is built up space all around, hot air from the courtyard is forced to rise up and as a result, cold air from all the four sides moves to the central courtyard space. After sunset also the phenomenon continues until the air in the courtyard cools fully by convective air flow. As the variation in the temperature, this movement of air takes place throughout the day. Therefore, such houses prove to be entirely comfortable as far as our physical comfort levels are concerned.

5.2 PRINCIPLE

Traditional houses were designed considering Vaasthuvidya. Traditional buildings of Kerala are oriented strictly according to the Cardinal directions as per Vaasthushastra. This allows the building to be comfortable in all seasons. The house creates balance in all the eight directions from the courtyard and it drives in positive forces from the nature. Design principles are timeless. Vaasthushastra have guidelines for the planning of human settlements and construction. From the level of site analysis, this shastra has put up systematic approach in planning, design and construction from the concept, definition of form to its detailing.

The entry to the house is provided from the East or South. To use thermal advantage to its best the north and south sides have rooms that are used during the day time while those used during night are on the Western side.

Strategic features of the model include:

- The house is an example of Chaturshala (Nalukettu; a central courtyard with activity areas on all four sides) style construction.
- Running veranda on all 4 sides
- Kitchen is placed on North-East corner.
- The building is oriented to the South justifying the orientation of the plot and road.
- Adequate ventilations are provided to the interiors by cross ventilations, in addition to the central courtyard.
- Irrespective of the shape and scale of the building, the roof has a uniform slope, adding beauty to the elevation.
- The roof is high pitched with 120cm overhangs
- The roof is clad by Manglore tiles over rows steel tube of rafters. Rectangular GI steel tubes were used.

5.3 PROPOSED MODEL

The site and building plan were prepared according to the building rules specified for residential buildings by Kerala Panchayat Building Rules, 2019.

Figure 8: Revit Model of the designed building (rendered view)

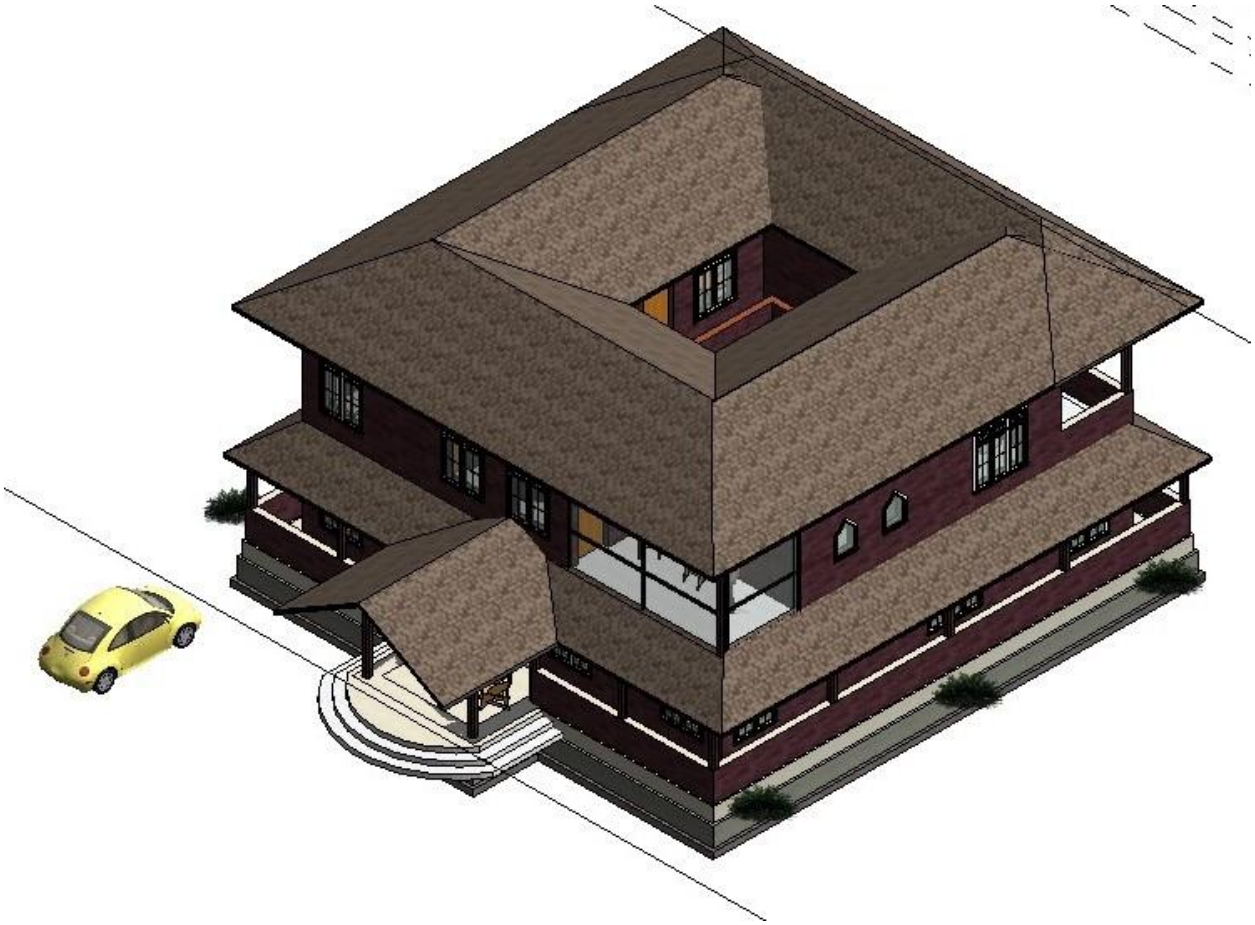

Figure 9: Revit model of the designed building

5.3.1 SITE PLAN

While preparing the site plan it was decided that the building will be 3m away from the front road. 1.5m was left at all sides. Water is drained from Nadumuttam to the exterior of the building via. a PVC pipe.

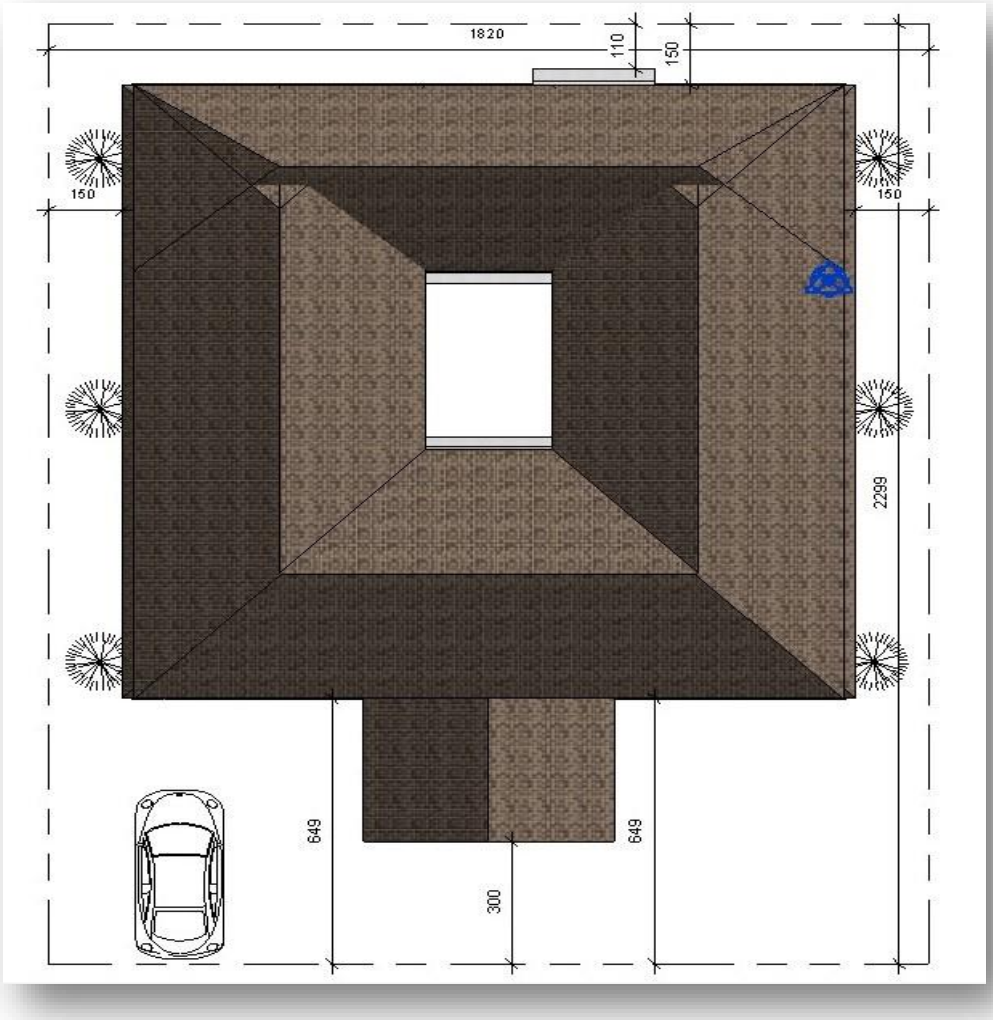

Figure 10: Site plan; Revit model

5.3.2 GROUND FLOOR

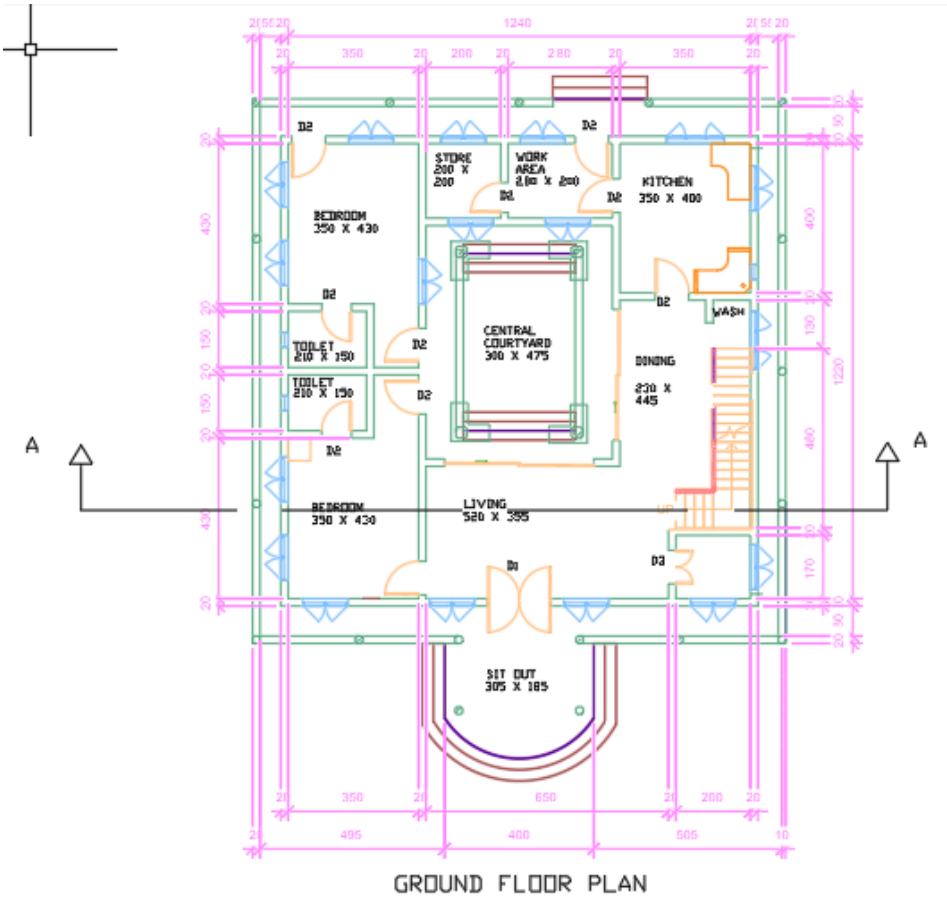

Figure 11: Ground Floor Plan; AutoCAD Drawing

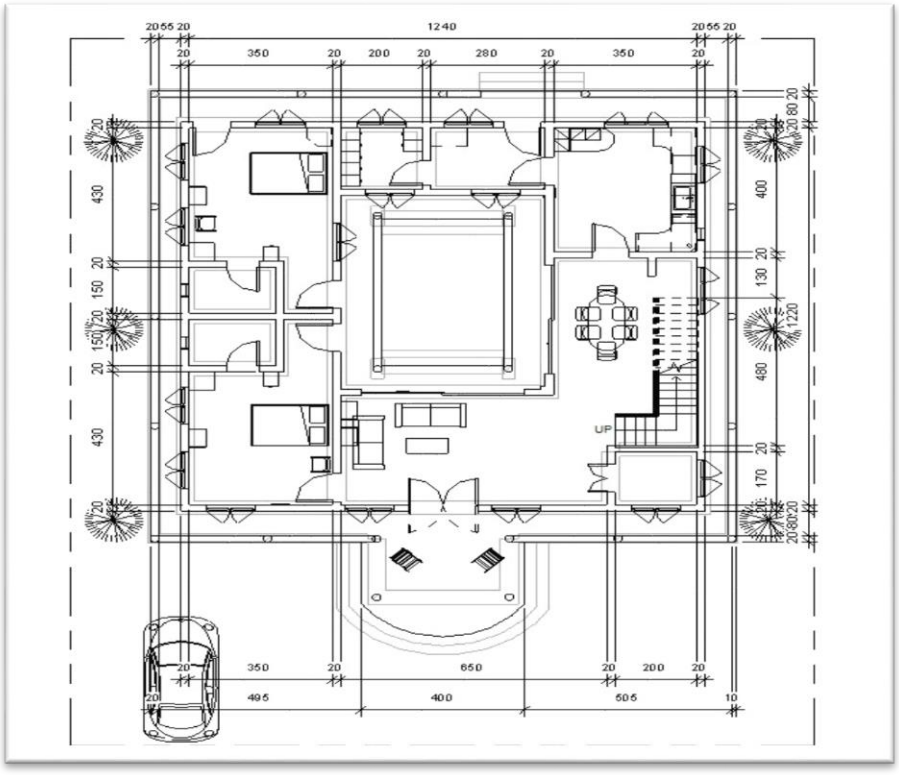

Figure 12: Ground Floor Plan; Revit Model

Figure 13: Revit Model showing Ground Floor

5.3.3 FIRST FLOOR

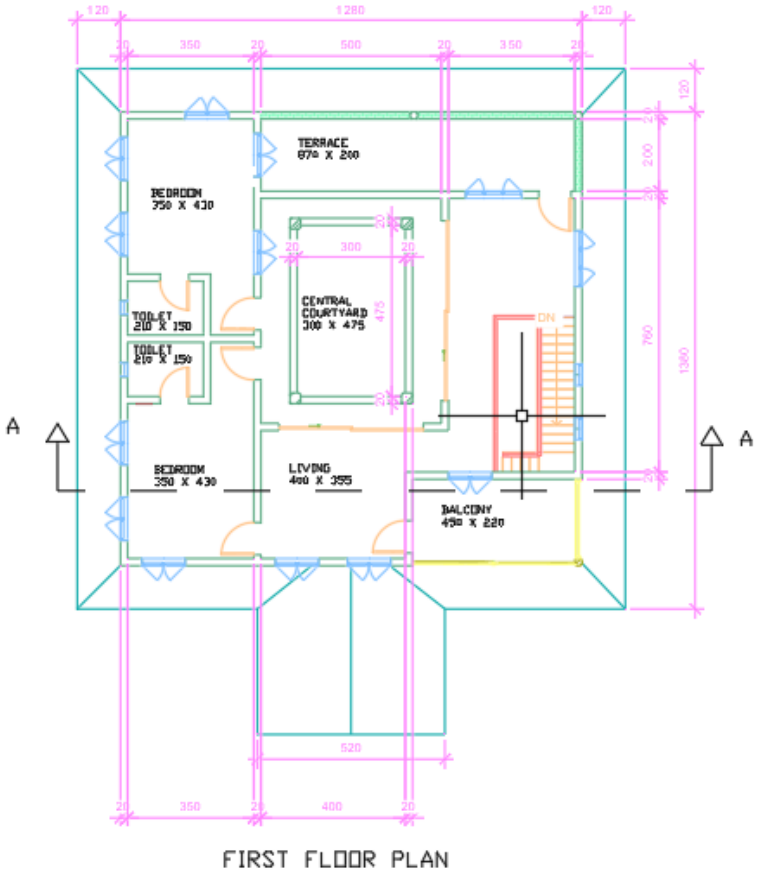

Figure 14: First Floor Plan; AutoCAD Drawing

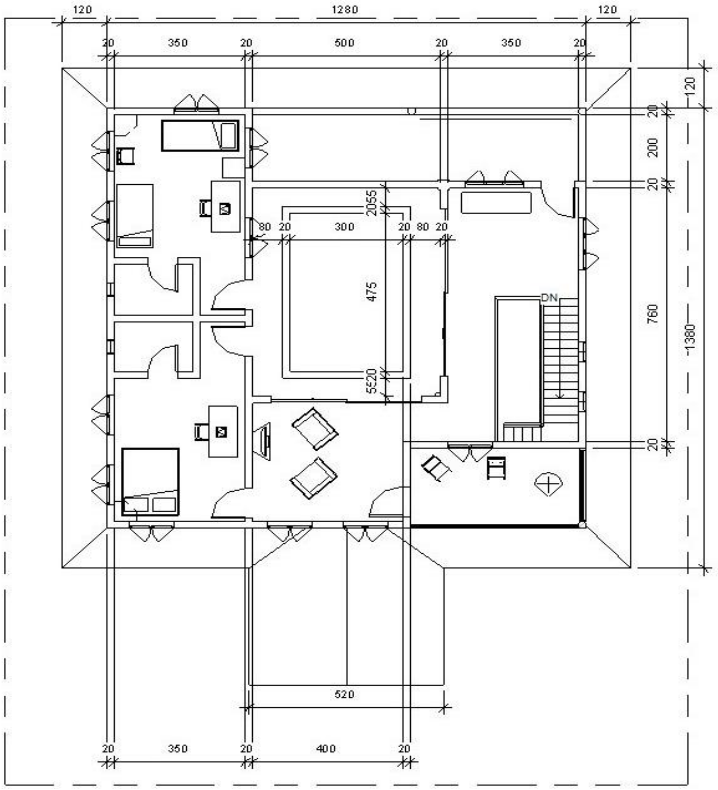

Figure 15: First Floor Plan; Revit Model

Figure 16: Revit Model showing First Floor

5.3.4 ELEVATIONS

5.3.4.1 SOUTH-FRONT

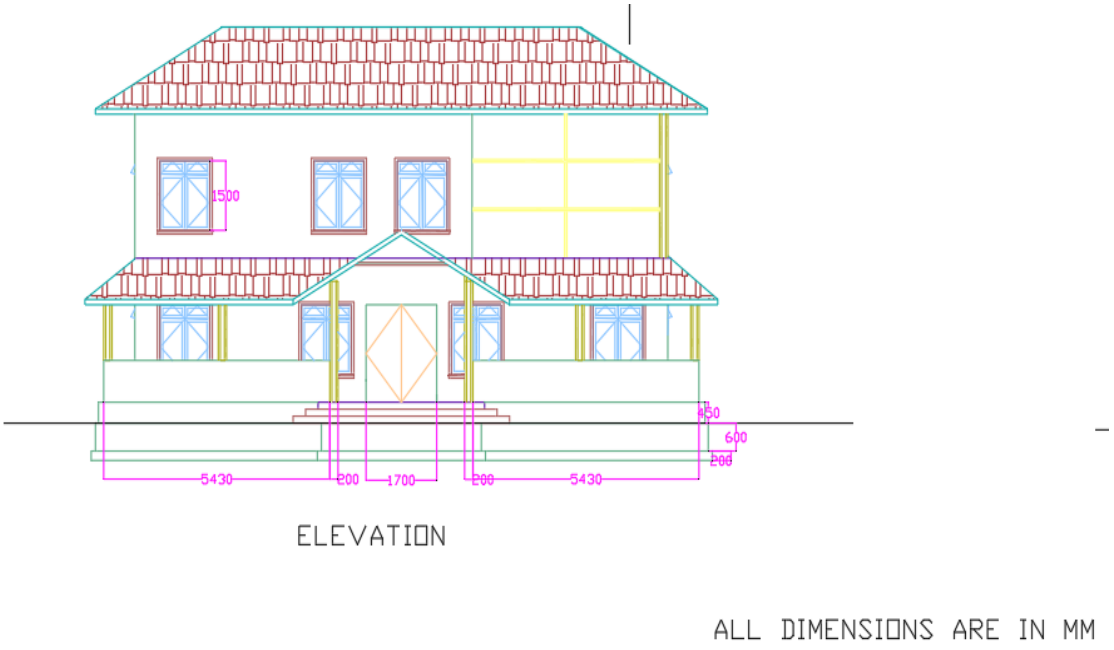

Figure 17: Front Elevation; AutoCAD Drawing

Figure 18: Front Elevation- South; Revit Model

5.3.4.2 EAST

Figure 19: Elevation- East; Revit Model

5.3.4.3 NORTH - BACK

Figure 20: Elevation- North; Revit Model

5.3.4.4 WEST

Figure 21: Elevation- West; Revit Model

5.3.5 SECTION

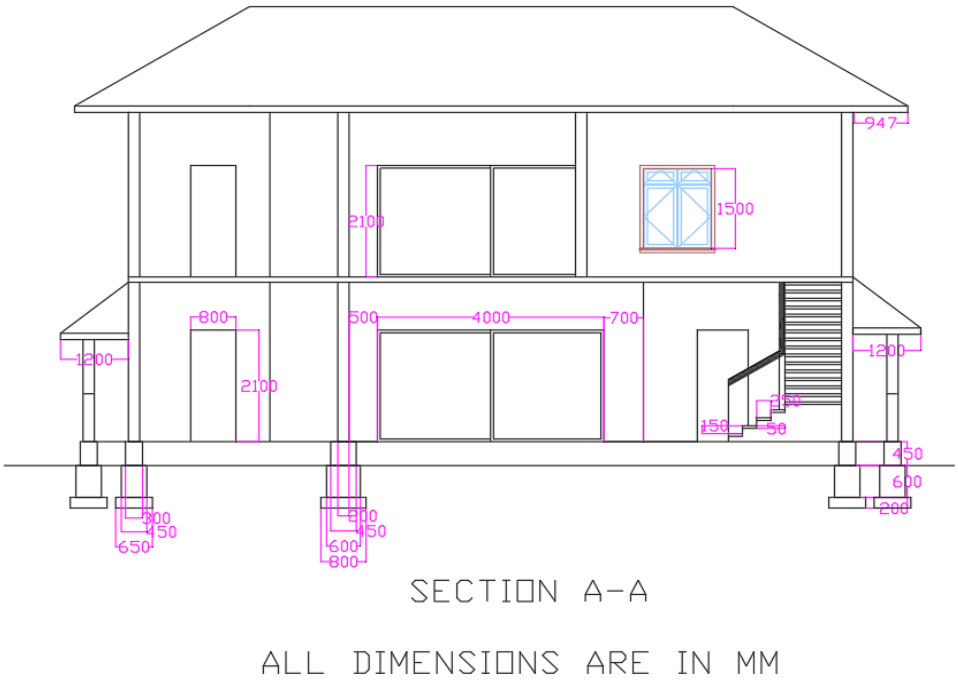

Figure 22: Section A-A; AutoCAD Drawing

Figure 23: Section A-A; Revit Model

Figure 24: Sectional View; Revit Model

5.3.6 JOINERY DETAILS

ALL DIMENSIONS ARE IN CM

JOINERY DETAILS		
DOORS	D1	170X210
	D2	80X210
	D3	90X210
WINDOWS		120X150
VENTILATION		44x65

Table 1: Joinery Details

5.3.7 FOUNDATION

The foundation was designed to be a simple footings provided below the walls. For the outer veranda, a basement of 30cm×30cm, is provided for a depth of 45cm below which a footing of 45cm×45cm is provided for a depth of 60cm using random rubble masonry. A P.C.C. layer, 65cm×65cm for depth 20cm is provided below it. For all other walls, a basement of 45cm×45cm, is provided for a depth of 45cm below which a footing of 60cm×60cm is provided for a depth of 60cm using random rubble masonry. A P.C.C. layer, 80cm×80cm for depth 20cm is provided below it.

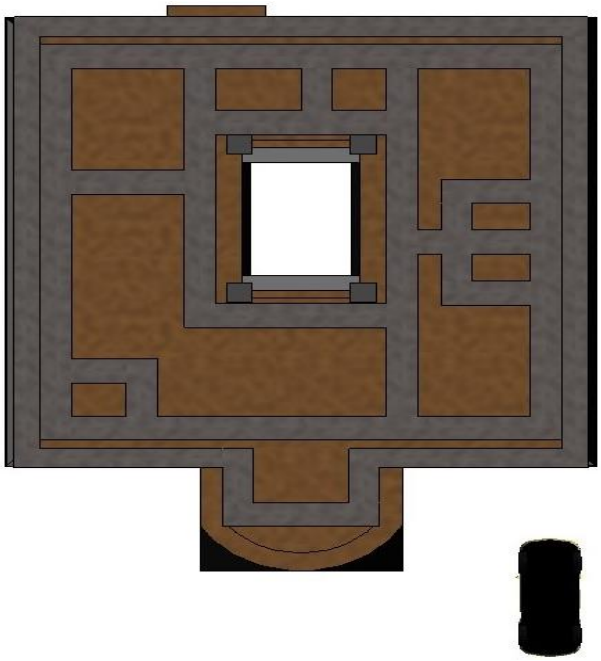

Figure 25: Plan of foundation- Revit model when viewed from beneath

Figure 26: Foundation viewed from beneath

5.3.8 RENDERED OUTPUTS OF THE MODEL FROM REVIT

Figure 27: Nadumuttam; Rendered output from Revit

Figure 28: Kitchen; Rendered output from Revit

Figure 29: First Floor Living Room; Rendered output from Revit

Figure 30: Front View- South; Rendered output from Revit

5.3.9 RAINWATER HARVESTING SYSTEM

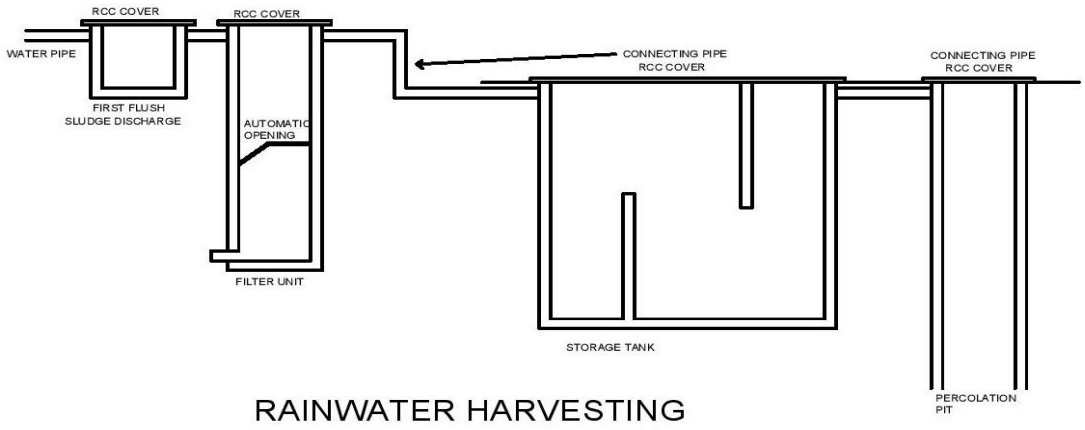

Figure 31: Rainwater harvesting system layout- AutoCAD

5.3.10 SEPTIC TANK

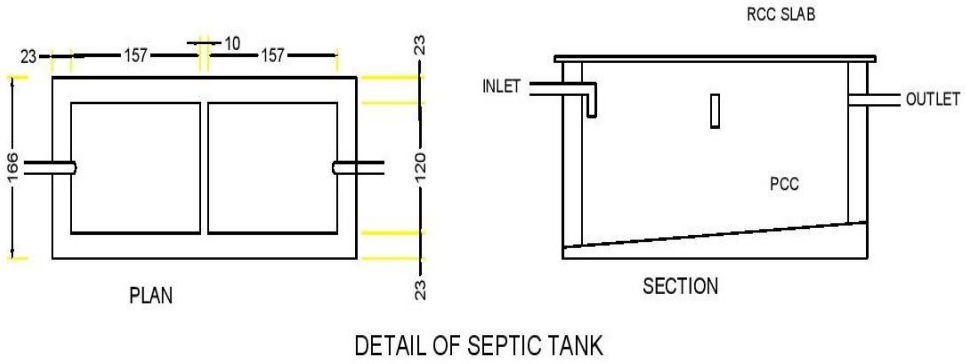

Figure 32: Septic tank layout; AutoCAD

5.4 COST ANALYSIS

Cost analysis of the model was performed to compare it with a contemporary residential building.

Cost analysis of brick walls

Total volume of brick work needed = (total volume of brick walls) – (volume of door and window openings)

Total volume of brick walls =6410900cm^3

Volume of door openings =711900cm^3

Volume of window openings = 549790cm^3

Total volume of brick work needed =5789920cm^3 =5.78992m^3

Size of 1 brick = 90mm×90mm×190mm

Mortar used = 1:6 mix

Mortar thickness = 10mm

No. of bricks needed = 2748nos.

Cement (33 grade) required = 8.025bags

Volume of M sand needed = 1.762m^3 = 62.224443cubic ft.

Interlocking bricks are used, cost of 1 brick = Rs.33

Total cost of bricks =Rs.95535

Cost of 1 bag of cement = 450

Total cost of cement =Rs.3806

Cost of 1 cubic feet of sand = Rs.55

Total cost of sand =Rs.3433.34

Total cost for brick walls = Rs.1,02729

Water proofing pidicrete = Rs.76 per 0.20kg

CHAPETR 6

CONCLUSION

The vernacular architecture of Kerala gives solutions that are in perfect harmony with nature. Control of the indoor environment is always an important aspect of vernacular architecture. The presence of internal courtyard within the living spaces and optimum window openings provided for a continuous air movement, highly insulative building envelop for thermal protection, provision of verandah for protection of external walls from solar radiation and the pitched roof for protection from heavy rain together contribute to a passive environment control system in Kerala vernacular residential architecture.

A judicious use of approximate materials and adoption of suitable traditional techniques in architecture is required for a sustainable, energy efficient and comfortable human life. Hence the methods and techniques adopted in the Kerala vernacular residential architecture can the effectively used in the contemporary architecture.

REFERENCES

Journals:

Dr. Kasthurba A K. 2013. “Sustainable Development of Urban Heritage at Fort Kochi, Kerala, India.” AEI 2013: *Building Solutions for Architectural Engineering*. pp. 924-933 © 2013 American Society of Civil Engineers.

Kavitha S, Praveen D Dethan, Hrithuparna S H. 2018. “Traditional Architecture of Kerala and Sustainability.” *International Research Journal of Engineering and Technology*. Volume: 05 Issue:10. pp.1929-1930.

Vijesh Kumar V. 2014. “Representation of Traditional Architecture in the context of Sustainability: A case of Traditional Kerala Architecture.” *Journal of International Academic Research for Multidisciplinary*. Volume:02 Issue:05, pp.282-291.

Dr.K.Thirumaran, R.Reshmi. 2017. “Analyzing Green Building Technologies in Indian Vernacular Architecture: A Case Study of Kerala**.**” *International Journal of Innovative Research in Science,Engineering and Technology***.** Volume:06, Issue:05, pp.9001-9009.

Peter O. Akadiri, Ezekiel A. Chinyio, Paul O. Olomolaiye. 2012. “Design of A Sustainable Building: A Conceptual Framework for Implementing Sustainability in the Building Sector.” *Buildings.* Volume:02, pp.126-152.

Books:

CPWD Guidelines for Sustainable Habitat, March 2014.

Kerala Panchayat Building Rules, 2019.

Websites:

https://civilplanets.com

https://indiamart.com