CHAPTER-1
INTRODUCTION AND LITERATURE REVIEW

1.1 INTRODUCTION:

The layout of buildings in rural areas is such that buildings are abutting each other i.e. they are enclosed and having common walls either on both sides or even on three sides. Due to such layout pattern, practically it is not possible to provide windows in such common walls. Thus the buildings in rural areas remain poorly ventilated, creating unhygienic, uncomfortable conditions directly affecting the health of the habitants. Traditionally the small opening or a duct open to sky is provided in the roof of building for ventilation purpose, but it proves to be insufficient. The habitants use the technique innocently without thinking about its inconvenience. Also the practicing Engineers and Architects in urban areas are less interested to practice in rural areas. Thus the problem remains unsolved even today. Social awareness and competence among practicing Engineers and Architects to work out some viable, feasible, and maintenance free solution to this problem is the need of TIME.

Even today the buildings are constructed conventionally without paying much attention towards the principles of planning. In rural areas the labor contractors executes the construction work as an engineer, valuer and even structural designer also i.e. whole and sole all in one consultant. The people living in rural areas blindly rely on them for the construction activity and are least aware about the importance of principles of planning, new trends in construction techniques, indoor hygiene, required day light and ventilation etc. This is not the case in urban or city areas. The layout pattern in urban areas is plot system i.e. individual owner has a separate plot for building construction. Secondly buildings are constructed as per prevailing bylaws and regulations leaving marginal spaces from the boundaries of the plot. Due to the marginal spaces, windows can be provided in all external walls of the building thus achieving proper light and ventilation. All the principles of planning are taken into considerations while planning the building so that the habitants enjoy the natures gift i.e. sunrays, breeze, daylight etc. The problem can be solved by adopting the construction technique of Natural ventilation of enclosed buildings in rural areas which is the topic of this research thesis.
1.2 LITERATURE REVIEW:

Buildings, as they are designed and used today, consume excessive energy and other natural resources contribute to serious environmental problems. Energy intensive solutions for building construction and heating, cooling, ventilation and lighting cause severe depletion of valuable environmental resources to meet demand for its sought, because the close connection between the consumption of energy in buildings and environmental damage arises. However, the buildings which reduce energy and resource consumption level of thermal and visual comfort for the occupant's can be designed to meet the need. New constructions energy resource efficiency by adopting an integrated approach to the design, production may be affected. Lighting, space conditioning and ventilation in a nutshell, energy efficient building energy use of a building, passive solar design strategies to balance all aspects of energy efficient equipment and renewable energy sources by providing an optimized combination. Use of materials with low embodied energy also forms a major component in energy efficient building designs [1]. From the above discussions one can comment that energy efficient buildings shall be designed such that those buildings will require minimal energy for HVAC system. The construction cost of energy efficient building for the common men living especially in rural India will not be affordable. The socio economical status of the common people living in the rural areas is not very luxurious; they are in the lower middle class or at the most in the middle class. Their expectations about comfortable house are least. Thus the use of an optimized mix of passive solar design strategies, energy efficient equipment in designing energy efficient buildings for HVAC system may not be affordable in rural parts of India if adopted at an individual level.

Cracks, small holes through the building openings such as windows and doors allows movement of fresh outdoor air to indoor is the traditional method. Today due to centralized air conditioning and the desired privacy, the habitants opt for minimum use of windows to achieve ventilation, thus infiltration is the only alternative for natural ventilation in buildings. The rate of air tightness of the building, the outdoor temperature and wind depends on the unpredictable natural infiltration. During mild weather, some of the buildings may lack adequate ventilation to remove pollutants. Most of the houses are built entirely with inadequate ventilation. Some energy experts often quote “seal tight to ventilate right” as recommended approach for building
ventilation. This reveals that to reduce infiltration buildings must be tightly sealed [2]. From the above discussions one can be say that Natural ventilation means uncontrolled infiltration of air through vents, windows, doors etc to replace indoor air. But the question about Natural Daylight remains unanswered. Secondly according to the whole house ventilation system “seal tight means ventilation right” is not feasible for rural houses in India where they are abutted and enclosed to each other, practically making it impossible to provide windows in common walls. Thus where windows can’t be provided the question of seal tight windows doesn’t arise at all.

Considerable amount of fossil fuel based energy can be saved by natural ventilation thus reducing the need for mechanical ventilation, and air conditioning. Considering the site layout, building form and design of buildings in the direction of the prevailing winds in the summer, wind direction in contact with them is maximized. Design the prevailing wind direction to form narrow plan buildings. Feel a sense of coolness, or near a building with water features. Horizontally near the floor level openings for ventilation purposes, are more effective than vertical openings. Plan deep storey buildings with natural ventilation outlets in the ceiling, but the ceiling fans in the summer thermal comfort away from the perimeter zone is required. The minimum size of openings for ventilation purposes is specified by building regulations, but no guidance is available about the maximum size opening. In consideration for the hot humid conditions, such as solar control, security, privacy and the potential loss of heat in the winter or taking other requirements, the air inlets should be designed for individual comfort. In the summer the prevailing wind conditions in order to receive breeze windows should be located which ideally provide cross ventilation in occupied spaces on both sides [3]. From the above discussions one can say that by constructing naturally ventilated building the fossil fuels which are going to deplete very soon can be conserved to a large extent since the energy required for cooling, heating and lighting of such building will be definitely less as compared to the conventional building. Orienting buildings to the prevailing summer wind direction to maximize their exposure is practically not suitable in rural Indian context because the habitants in rural houses are living there for generations and are not ready to part with their ancestral place if told to do so for orienting their buildings to the prevailing summer wind direction to maximize their exposure. Wetted surface of the front wall of the incoming air passes through the hot, dry weather or
disable the use of evaporative cooling systems, cooling water, creating a sense of the extent of the features, or building a house near the air passing through the facility, giving the, all above suggestions are practically not feasible to implement for enclosed buildings in rural areas, the reason being the walls for such buildings are common walls on two or even on three sides. By planting trees on front and back side of such buildings to, Modify the external wind direction and to increase ventilation to cool incoming air can be achieved effectively. The horizontal openings near floor level can be provided only in road abutting face of the building. The regulatory authorities don’t talk about maximum dimensions of openings for ventilation hence the sizes of openings have to be designed as per the requirement of the client and according to the purpose of the building. The cross ventilation in case of enclosed and abutted buildings in rural areas can be achieved only through windows placed in road side walls.

“Many researchers and designers rely on ASHRAE Standard 55 for the air conditioning need to examine major, important, cultural, and social context. The research demonstrates that the occupants in buildings with central HVAC systems are finely tuned to the indoor narrow range temperature and develop high expectations for cool temperatures. They get irritated very soon if the thermal conditions don’t match with their expectations. On the contrary the habitants of naturally ventilated buildings are much tolerant and patient about the indoor thermal conditions and prefer wider range of temperature [4]. The ASHRAE Standard 55 has not considered the important cultural, social, economical factors round the globe. The cultural background and social, economical factors in different countries are variable. All the parameters quoted in reference no. 4 are for the developed countries whereas the same for developing countries are totally different. The living standard, health, behavior, thinking pattern are totally different throughout the globe. The climate in the different parts of the globe is variable. The use of ASHRAE Standard 55 to achieve thermal comfort standards globally especially for the enclosed residential buildings in the rural areas of tropical countries like India needs to be rethink.

One can save energy and money by ventilating home using the air conditioner on a hot day. Moving air can remove heat from our home. Moving air also cools our body that creates a wind chill effect. Ventilation, cooling, usually from trees and window treatments, ceiling reflectivity (light colored roof) in the shade provided by
the energy conservation measures are related to each other. For drier climates, this will mean ventilating at night, and closing doors, windows and window coverings during the day. Due to the chimney effect, cold air enters a house on the first floor or basement in a room, and exits through the window to the top. The lower level, which draws air in through the windows, creates a partial vacuum. Natural ventilation or cool summer nights and cold climates work best with regular waves [5]. From the above discussions one can draw the conclusion that for increasing thermal comfort, mechanical means of air ventilation can be used along with Natural ventilation, but in rural areas due to load shading declared by Power department for almost 12 hrs during day time practically it isn’t possible to go for this option. Secondly the majority of people living in rural areas can’t afford to have alternate power generation systems like inverters to operate bulbs, fans, air conditioners etc. The chimney effect suggested is a good option for Natural cooling and reduces energy consumption required for mechanical cooling. The measures such as tree plantation on windward direction, white colored roof and the window treatment are really appreciable.

According to the temporal variation of indoor thermal comfort, indoor and outdoor climate can be controlled and improved significantly by opening the windows and the doors. Habitants of this uncomfortable condition are dissatisfied with some corrective actions such as personal adjustments such as changing clothes and adjust their clothing, drinking more water and opening windows and door for having thermal comfort [6]. To enhance indoor air velocity one has to open doors and windows, but in case of enclosed abutted buildings in rural areas, only door can be opened the reason being that windows can’t be provided in common walls, the question of opening them doesn’t arise.

To assess the natural ventilation and energy for the development of sub urban households in Thailand, certain guidelines for the construction of residential buildings are developed. In order to achieve thermal comfort conditions, instead of mechanical air-conditioning systems natural ventilation is possible especially in the winter. The experimental research has been divided into two parts. The best environment is that which covered with large trees. Computational fluid dynamics studies on common houses or cross ventilation is more effective than the two side ventilation. In general, increasing the size of openings improves the effectiveness of natural ventilation. The research concluded that the size of the home building trends and factors that lead to
the home evaluation method has been successfully tested with different types of homes. The natural ventilation can be generated by two methods. It is only by means of evaporation that helps transfer heat from the indoor air velocity which is sufficient to generate low wind speeds. The wind-based natural ventilation is easy to achieve. In this study it reveals that average temperatures can drop the effect of natural ventilation if the large trees are covered with hot hours of the day [7]. One can say that the Natural ventilation of buildings in general can be achieved by tree plantations around the periphery of the building, by proper orientation of the building and by increasing the area of openings i.e doors and windows. This is true and practically possible in the cases of isolated buildings or detached building where the marginal setbacks are provided as per prevailing byelaws. Trees can be planted, proper orientation of the building can be provided, and also the sizes of doors and window openings can be increased. But all these means of achieving Natural ventilation are not feasible in rural areas where the buildings are constructed without leaving any marginal setbacks as per the bylaws and are abutting each other having common walls on three sides. At the most trees can be planted only on one side of the building i.e abutting road. Also the sizes of door & window openings can’t be increased due to restricted width of the site especially in rural areas where buildings are abutting each other.

Design of new buildings that have been developed over the centuries in the past should be integrated in a compact urban structure. The compact morphology, however, by means of passive thermal comfort in hot and humid climate is a necessary component of the building design. Natural ventilation and thermal comfort is enhanced in new courtyard buildings. Compact urban environment, natural ventilation and thermal comfort research, however, is rare. In Cuba and many other tropical and humid regions, the majority of the population cannot afford air-conditioning use. In the current global energy crisis, sustainable solutions to people’s quality of life has increased the energy consumption. In the new courtyard buildings, natural ventilation and thermal comfort is enhanced without increasing energy consumption [8]. From the above discussions it is clear that to achieve thermal comfort and Natural ventilation at affordable cost, open courtyard buildings is one of the alternatives. But in the urban compact housing pattern and in the rural areas where the building site is just a narrow strip of 2.0m to 3.0m width and considerably larger
depth of about 15.0m and more, it is not possible to provide open courtyard building. The courtyard even if provided, the Natural Daylight may hardly reach the interior parts of such enclosed compact building.

It is through the application of natural ventilation, thermal comfort of indoor environment for residential buildings is by facade design. The study of the thermal comfort needed for indoor air velocity based on the facade design guidelines are developed. In the residential and office buildings, mechanical systems, including HVAC systems, energy consumption is a significant contributor. Natural ventilation concept is well accepted by the people and designers [9]. One can say that Natural ventilation in buildings can be achieved by optimum façade design and the energy consumption can be substantially reduced in the mechanically ventilated residential and office buildings. The system may be suitable for the detached residential and office buildings in urban areas, but might not suit the housing pattern in rural areas especially in rural India where buildings are abutting each other compelling to construct common walls on almost three sides. No doubt the problem of passive cooling can be solved by optimum façade design but the problem of Natural Daylight in such enclosed buildings in rural areas remains unsolved.

Dwellings in rural areas of the developing countries do not have artificial systems of cooling or heating. These buildings, especially in hot-dry climate, are provided with natural cooling systems. Parameters which influence Natural cooling of such buildings can be classified as (I) surrounding environmental factors and (ii) parameters associated with the buildings. The paper describes influence of above parameters in providing natural cooling of residential buildings in general and in hot-dry climate in particular. In most of the developing countries like India, more than 50% of the population, stay in rural area where their houses do not have artificial systems of cooling or heating. Even more than 50% of the houses in urban area also do not enjoy these facilities. This is primarily due to poor economic conditions of the residents and secondly due to shortage of electric power to operate cooling and heating facilities. Thus, most of the residential buildings in urban and rural areas are provided with environment friendly designs to have the advantage of natural cooling during summer and heating during winter [10]. The environment friendly designs of the buildings in rural areas solve the problem of Natural cooling and heating. But the problem of Natural day lighting remains unsolved. The electric energy required for
lighting the tubes and bulbs during the daytime in enclosed buildings in rural areas may be manifold as compared to the buildings in urban areas. Due to power shortage there is always load shading in rural areas for almost 12hrs during the day time, therefore the habitants living in such buildings have to face uncomfortable and unhygienic conditions (due to no air change). Secondly the living standard of these people is such that they can’t afford inverters and even if they can, the charging of inverter batteries is not possible due to power cut.

Additional stack ventilated buildings are typical mechanically ventilated or air-conditioned buildings. It features simple and advanced naturally ventilated buildings that will be presented with a description of the classification of ANV buildings. Simple natural ventilation and advanced natural ventilation (ANV) absorption characteristics of the four common building types in two different formats for each one, a summary has been published. ANV buildings with central air supply and perimeter exhaust stacks. Each of these four areas has to offer a cross-sectional area to a central supply route (e.g. light well) to create a relatively simple, but necessary infrastructure for the supply of air around it to get to the opening areas, especially deep and densely occupied buildings with floor plans [11]. From the discussions in above paper one can say that to design ANV (Advanced Naturally Ventilated) Building it is necessary to study the environmental design considerations to workout required structural cross section areas for Natural ventilation. Indoor air quality provision, the surrounding environment and climate change tolerance protection degree of central air supply and perimeter exhaust stacks system allowing any ANV building can be achieved. The central supply route (light well) of sufficient cross-sectional area plays vital role in achieving Natural ventilation for detached buildings sites. But for constrained building sites it might be difficult to achieve the required structural opening areas for the air inlets.

In the work on architecture in tropical and humid region, the investigation of natural ventilation efficiency in traditional architecture in Indonesia is studied and investigation is carried out with comparative method of architectural work in Java Island. It was selected on historical basis, starting from Islam proselytization period until the present architectural performance that has been developed till now. Traditional society gave data about the relation between building physical performance and climate condition. Researches about constituent component of
climate in tropical-humid area (such as air temperature, wind, sun radiation and humidity) are needed to harmonize building and its surrounding nature. The objective to be achieved from the study was to give explanation and description of tropical-humid traditional architecture history in tropical-humid region in Indonesia and the influence of technique progress on residential building design to solve environment problems. It will be the designer’s job to cooperate with urban climatologists and related experts to bear a comprehension about microclimate of immediate surrounding before applying it on the design. To face climate problem, architectural parameters such as building orientation, window opening, roof shape, building performance and vegetation planning must be considered seriously. Climate modification is also effective to obtain optimal temperature in building [12]. From the above paper it is understood that to ventilate the building Naturally one has to study the traditional architecture history, surrounding environment, climate conditions at site from climatologist and the related experts from various fields at the planning stage and execute accordingly. The current Indian situation in rural building industry is altogether different. The majority of the population in rural India is lower middle class and below. To implement the above all parameters in building construction initially one has to consult practicing Engineer or Architect practicing in the nearby town. Secondly the practitioners are least interested to give services in the interior parts of rural areas since they have no time from their busy practice in urban areas, also they are doubtful about getting their consultancy charges from rural clients. The financial status of majority of rural clients is such that they can’t afford to appoint consultant at their construction site. If at all anyone appoints the consultant anyhow, then skilled labors aren’t available locally. They have to be imported from urban areas by paying heavy labor charges. The house owner who wishes to construct Naturally ventilated building has to ride this cycle of hurdles to implement above studied parameters to achieve Natural ventilation. The mind state of the house owner becomes such that he forgets about the Natural ventilation of building and handover his site to the mason/artisan who behaves as if he is Engineer, Architect, Valuer, Contractor, builder…. and all in one consultant. To study and implement the traditional architecture history, surrounding environment, climate conditions at site from climatologist and the related experts from various fields at the planning and actual execution, there is need to study the real conditions of rural areas and then to apply traditional architecture to that situation.
Nowadays, most of the energy consumption in buildings increase awareness of the cost and environmental impact, despite the mechanical systems are well ventilated. In this context, HVAC energy consumption related to the operation, according to recent studies, the service and the total energy consumption in residential buildings can be attributed to almost 70% HVAC systems. Therefore, natural ventilation, thermal comfort, acceptable indoor air quality and satisfactory confirmation that provides both levels, can save energy used for ventilation. In addition, it is likely to attract interest in building designers. Mechanical drives can be relatively cost-effective option that appears interesting. Naturally ventilated building in the design due to the complexity of physical systems is a challenging task. In this work, emphasis is given to the differences in pressure caused by the wind to flow. Therefore, to optimize the design and naturally ventilated buildings around it within the account in the distribution of pressure is required to configure the details of the induced airflow pattern. Volume flow rate at the inlet of the intensity of the wind velocity due to its proportionality to the building air change rate plays an important role. In addition, the internal geometry of the building aerating volume flow rate does not change the fact that, despite all the internal regions of the refreshing, the rate of the building envelope is a very important parameter [13]. The paper discusses on Natural ventilation of detached buildings from the energy consumption point of view required for HVAC. No doubt, the energy consumption for the same in residential and commercial buildings is tremendous; however in naturally ventilated buildings the energy consumption is very less as compared to mechanically ventilated buildings. The question of Natural ventilation of enclosed buildings in rural areas remains unanswered. In rural areas the building layout is such that they abut on at least two or three sides having common wall with adjoining buildings. These buildings face severe problem of ventilation since windows cannot be provided in the common walls. The mechanical means of ventilation cannot be used due to 12hr to 16hrs load shading in 24hrs. The only alternative in front of the habitants is to construct naturally ventilated building.

In this work, emphasis is given to the differences in pressure caused by the wind to flow. Therefore, to optimize the design and naturally ventilated buildings around it within the account is required to configure the details of the induced airflow pattern. Volume flow rate at the inlet of the intensity of the wind velocity due to its
proportionality to the building air change rate plays an important role. In addition, the internal geometry of the building, aerating volume flow rate does not change the fact that, despite all the internal regions of the refreshing rate, the building envelope is a very important parameter that can be considered. Research findings suggest that goals are often contradictory to the indoor environment. For example, recent work has cooled down the temperature of the indoor air quality and one can reduce the ventilation rate. Reduced ventilation rates to reduce energy consumption, although cold temperatures either increase or decrease, depending on the heat of the situation. Recently the benefits of low enthalpy (a measure of Thermodynamic system) are learned environments in terms of perceived indoor air quality, but the question about elevated air speeds remains unanswered. Many practitioners of the air inside the air-conditioned space occupied zone of stability, poor quality dead air complaints that are associated with the report. Thermal comfort being more important, questions still need answers, and a new generation of researchers has to provide training to their needs. Just thinking out of the thermal comfort, improved environmental control, many people simply cannot agree on some of the more specific recommendations - reduce indoor pollution sources, to deliver air closer to the community. Existing standards in the "neutral" than the air temperature in hot or cold, the question still remains unanswered. Answer may depend on context - comfort, indoor air quality, energy, productivity. The life cycle of the building budget and environmental impacts are taken into account. It optimizes all results for all the people that can create an environment in which it is justified. Perhaps the most appropriate goal for people to control their own environment will provide a variety of means. Thermal conditions in the various areas within the building means to control local physical environment (Windows, local regulations, etc.), to meet, to relax, or to meet the dress code policy allows for a flexible workplace culture that can range from. One clear conclusion seems to emerge - the "one-size-fits-all" and "uniform conditioning" approach to indoor climate management and is fast becoming a curious but misguided fad of the last century [14]. The above discussion directly challenges the researchers all over the world to work out the "one-size-fits-all" and "uniform conditioning" solution towards the Natural ventilation of building. One of the major shortcomings of the above findings is that ASHRAE Standard 55 has not considered the case of Natural ventilation of enclosed buildings having common wall construction on three sides, which is very commonly observed housing pattern especially in the rural areas of
India. The indoor thermal comfort conditions, indoor air quality and Daylight intensity are much low as compared to those of in urban areas where majority of the buildings are isolated building. The indoor hygienic conditions are below substandard. For such sites in rural India a permanent, economical and user friendly solution will prove to be the need of the time.

Analytical models, empirical models, small-scale experimental models, full-scale experimental models, multi-zone models, zonal models and CFD models to predict the performance of the most popular methods of ventilation, is an overview of the public. They are the bread and butter of practical design tools, despite the contributions of analytical and empirical models which are around 5%. Small-scale and full-scale, most of the studies conducted in experimental models have been used for validation purposes. Multi-zone model to predict the performance of a wide range of ventilation throughout the buildings are used. Serious efforts are made to improve multi-zone models. Zonal ventilation performance prediction models have yet to receive their popularity and future course - grid CFD models can be replaced [15]. Analytical models, empirical models, small-scale experimental models, full-scale experimental models, multi-zone models, zonal models, and CFD models to predict the performance of the most popular methods for ventilation, seems a bit complicated to use considering the current housing scenario in rural India. The question of predicting ventilation performance is far away. Instead the user friendly, ready to use, and maintenance free construction technique easily executed by local artisan to achieve Natural ventilation is the need of the time. The power consumption required for mechanical ventilation of the enclosed buildings in rural areas can turn down to the greater extent by improving the thermal comfort inside the building.

The method for controlling air quality and ventilation in naturally ventilated poultry buildings consist of placing in controller parameters such as humidity and temperature in a building [16]. The present patent describes about the method of controlling air quality and ventilation in naturally ventilated poultry buildings. The patent being very specific does not throw any light on naturally ventilated enclosed buildings which is the topic of the research. From the references [17] to [31] one can say that the solutions suggested are really valuable but considering the socio economic situation in rural India, the financial affordability and the mindset of the rural habitants and the typical housing pattern in rural areas, the solutions from the above all the references
proves to be inapplicable for the natural ventilation of enclosed buildings in rural areas. However, the title of the thesis being very specific, little or rather no work has been done on this title.