

DESIGNING AND OPTIMIZATION OF SOLAR CHIMNEY FOR VENTILATION SPACES

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ABSTRACT :- The objective of this study is to develop a modeling method for optimizing the design of a solar chimney integrated solarium to maximize the ventilation rate in the solarium. A solar chimney, often referred to as a thermal chimney is a way of improving the natural ventilation of buildings by using convection of air heated by passive solar energy. In hot climates ventilation can be a useful means of cooling dwellings, if the outside air be cooler than that inside the dwelling. Often, in hot regions the outside air is so hot during the day that cooling by ventilation is of no benefit until the evening when the outside air gets cooler. Ventilation can then be beneficial, and can be promoted by a sun-warmed cavity.

Heat from the sun is stored within the walls forming the cavity and heats the air within. The cavity is closed at the top and bottom by dampers. These, when opened in the evening, allow the buoyant hot air contained within to rise, drawing cooler outside air into the building. This process continues until the stored energy is consumed. The performance of a typical cavity to induce ventilation into a house is studied experimentally and theoretically.

Keywords: Plywood, Glasses, Black Surface Mat, Temperature Indicator, Thermocouple and Its Wiring, Exhaust Fan's.

1.Introduction

The types of gear, materials or human action increment the contamination fixation inside the building, which influences to the indoor air quality. Toxin fixation can influence human wellbeing and profitability, which makes essential their evacuation. Generally the ventilation replaces the indoor air for open air, which has better quality.

Nowadays, normal ventilation is not just viewed as a straightforward approach to give outside air to the dweller's, it is important to safeguard worthy air-quality levels, additionally as a splendid vitality sparing approach to diminish the inside cooling heap of lodging situated in the hot area. As per the Farlex word reference ventilation is characterized as substitution of stale or poisonous air with natural air and ventilation is expected to give oxygen to digestion system and weaken metabolic contaminations where carbon dioxide and smell are the principle metabolic toxins.

The most elevated quality indoor air gives by supplanting of stale. Higher quality means control of temperature; recharge oxygen, dampness, smell, tidy, microscopic organisms and carbon dioxide. The straightforward ventilation implies outside air is blended with officially existing air in the walled in area to weaken the toxins or used to uproot the air by method for cylinder stream. The air change rate influences the course and new oxygen supplied for human solace.

The distinctive methods of advancing air trade are mechanical ventilation, which permits controlling the stream rate all the occasion, their quality and temperature; and regular ventilation, which has less support, makes less

clamor and does not utilize electric vitality to move the air. The sun oriented smokestack is a framework that uses the sun oriented radiation to move the air, enhancing the characteristic ventilation and now and again giving natural air to the building.

Aloof plan relies on upon the building outline and materials to control the natural conditions inside the inward spaces of the working without need of expending vitality. As it were, uninvolved engineering is that one of inborn natural concordance. Uninvolved engineering gets its possibilities from area, society, and human who connected naturally the least difficult standards of detached design since he began to assemble a house for himself and his family to shield them from the outside ecological conditions.

1.2 Problem definition:

Latent plan relies on upon the building outline and materials to control the natural conditions inside the internal spaces of the working without need of expending vitality. At the end of the day, detached design is that one of intrinsic natural agreement. Aloof design gets its possibilities from area, society, and human who connected naturally the easiest standards of detached engineering since he began to construct a house for himself and his family to shield them from the outside ecological conditions.

Neighborhood customary engineering was Usage of mechanical aerating and cooling as a dynamic cooling arrangement has vigorously extended as of late because of numerous reasons. Likewise, operation hours of aeration and cooling systems have expanded through summer season, and some of the time amid spring and pre-winter

seasons. This late substantial reliance on such dynamic answer for accomplishing warm solace has numerous perilous effects on indoor air quality and vitality utilization. Uninvolved techniques in

building outline may help minimizing the operation hours of dynamic arrangements in extremely hot districts like Egypt. Inside Egyptian hot summer atmosphere, proficient convective methodology that accomplishes agreeable warm conditions and high indoor air quality is absent. In this way, research will experience concentrating on the convective applications to assess the productivity of latent strategies of common ventilation in neighborhood hot atmosphere.

The sunlight based stack adds to building molding by utilizing sun based radiation to deliver convective wind stream. A study by Ekechukwu and Norton (1997) demonstrated that the lightness drive is relative to the air thickness variety between within fireplace air and outside air. The procedure hauls warm let some circulation into of the working, for this situation the solarium, supplanting it with cool air applying the natural uninvolved standards in building outlines that were an immaculate impression of the nearby life and society and of the monetary, social and climatic states of the locale. As a result of contemporary westernization, the neighborhood contemporary engineering showed up losing the standards of latent outline and congruity with the environment. This ecologically misshaped yield brings about guiding the clients to the dynamic arrangements that need more vitality just to give happy with living conditions.

2. LITERATURE REVIEW

This survey is to quickly highlight the past work and inquires about identified with detached cooling strategies, building envelope uninvolved plan, and outside openings arrangements. This audit was completed in the early phases of the study keeping in mind the end goal to illuminate the principle thoughts of this examination.

Impact of Building Envelope Design on Thermal Gain and Comfort, An approach for ecological outline of building envelope (M.Sc. theory, Cairo University, Cairo, 2003) This examination had contemplated the impact of engineering sun powered outline on building envelope, delivering a numerical way to deal with study the impact of window designs on warm behavior of building. Research also proposed an analytical methodology for designing the building envelope.

Passive Solar Architecture in Hot Climates, Economic Evaluation for its climatic medicines (M.Sc. theory, Cairo University, Cairo, 1994) This exploration had presented a hypothetical study for the impact of detached sunlight based components on building envelope with a scientific investigation of inactive strategies monetary assessment.

Consider closes with a philosophy for reenacting building envelope with sun based uninvolved techniques.

Architectural Approach to the Energy Performance of Buildings in a Hot-Dry Climate with Special Reference to Egypt (PhD postulation, University of Bath, UK, 1986) This exploration had presented an assessment of vitality execution of structures inside hot dry atmosphere of Egypt. Part of the examination concentrated on normal ventilation through a hypothetical procedure for ventilation standards and logical study for the impact of opening proportions on indoor ecological conditions.

The solarium is a fenced in area connected to a house with glass dividers and rooftop. This south-bound space can be introduced in both new and retrofit structures to furnish an agreeable space with positive engineering qualities that can lessen the temperature swings and warming requests of the house, and hence can prompt huge investment funds in the working expenses of the building (Mihalakakou, 2000). Despite the fact that this vitality sparing methodology is fairly basic and reasonable, an ill-advised plan may bring about overheating and result in an expansion in the vitality utilization of the building (Bryn and Schiefloe, 1996).

Since numerous studies have demonstrated that the wind impact is significantly more prevailing than temperature lightness (stack impact) in initiating wind stream [17], the use of characteristic cross ventilation is dependably the favored decision by the planners and building originators to produce indoor air development and enhance their building warm environment [18]. However these days, in the states of the hotter atmosphere and denser fabricated environment, the ordinary idea of common cross ventilation does not generally effectively apply. The requirement for a compartmentation of spaces in a profound arrangement building and more reduced format of arranging where structures are laid firmly like in the porch houses have brought about constrained openings for cross-wind stream [19].

The plan of a solarium or a nursery is critical with respect to warm productivity. As indicated by Bastien and Athienitis (2010), the usefulness of a solarium or a nursery straightforwardly relies on upon the shape and tilt edge. They discovered prominent contrasts regarding sun based radiation retention between various setups of a sunspace. The states of four unique nurseries have been considered by Gupta and Tiwari (2003). They found that relying upon the date, time, shape and size of a nursery, those factors have a significant part in warming a solarium, particularly in the winter. They watched that an even shape is the best alternative at a lower scope because of the way that the weighted sunlight based portion is higher for this shape.

Bastien and Athienitis (2010) contemplated the solarium rooftop tilt point scope of 25° up to 65° and absorptance of

0.5 to 0.9 for inside divider surfaces of the sunspace, and broke down the sunlight based radiation dissemination and the warm reaction. The outcomes exhibited that the ideal slant plot for a solarium in Montreal and for the winter day and age is 65° . As indicated by their study, the most dire outcome imaginable is a solarium inclined by 25° .

In the nineteenth century, the improvement of stack ventilation technique has been appeared by the framework worked in House of Commons, England where open fires were utilized to produce a warm draft. In the meantime, depleted openings in the upper part of the building actuated a stack impact to extricate hot air and some circulation into through the building [14, 15].

Tiwari et al. (2002) in their examination on the assessment of sun based division (Fn) for the north mass of a controlled situation nursery affirmed that the dissemination of sun powered vitality on various dividers and entryways of a solarium is an essential calculation for foreseeing the execution of the sunroom. Gupta and Tiwari (2003) demonstrated that the floor is as vital as the north divider in the weighted sun powered portion. Weighted sun oriented division has an immediate association with accessible radiation for warming the living space. Divider (1997) thought about four distinctive reenactment programs utilized for figuring the sunlight based radiation dissemination in a solarium. The creator clarified that point by point programs, in light of the geometrical arrangement of an exceedingly coated space, for example, a sunroom, are more precise. The examination likewise underlined the transmission through the coating reflection and assimilation into record.

Rodrigues et al. (2000) played out an investigation of sun powered smokestack wind current and its move from laminar to turbulent stream. They utilized a limited volume strategy for their study and they presumed that a proper harmony between warm solace and ventilation ought to be considered in planning the smokestack. They contended that as hole width expands, ventilation rate enhances however the development proportions diminishes.

In such manner, Spencer et al. (2000) and Chen and Li (2001) investigated an ideal depression width (or ideal width/tallness proportion) that amplifies the ventilation rate. Be that as it may, a more extensive crevice causes the turn around stream that brought about a diminishing in mean stream rate in the sun based fireplace. Gan (2006) utilized a CFD program to look at the part of various parameters, for example, channel width and floor region on the stream rate. Supplanting external skin with a photovoltaic board was researched in this study.

3. PHYSICAL MODEL

3.1 WORKING PRINCIPLE OF SOLAR CHIMNEY:

The sunlight based smokestack is one of the innovation which dealing with the lightness standard. Where's the air is warmed through nursery impact which created by sun

based radiation (warm vitality). The use included is not all that high. Such a large number of methods can be utilized as a part of cooling or warming of structures. The sunlight based stack can be utilized as a part of rooftop level or inside divider too. The sunlight based smokestacks are sun powered uninvolved ventilation frameworks it implies they are non mechanical. The warmth is brought out through convective cooling standard. The sunlight based stack is composed taking into account the way that hot air rises upward; they diminish undesirable warmth amid the day and trade inside (warm) air for outside (cool) air. The sun oriented fireplace for the most part made of a dark empty warm mass with opening at the highest point of stack for leave the hot air. The air went through the room and exit from the highest point of smokestack. The two objects are fathomed one is the better ventilation and furthermore it diminishes the temperature inside the room. It can be functioned as switch for warming the room moreover. The Trombe divider is functioning as sun based smokestack appeared in Fig. 3.1. what's more, benefits of sun oriented stack are: Merits: There is no mechanical part, Low support, No electrical Consumption, No an Earth wide temperature boost, No Pollution and It can be utilized for both warming and cooling and fault just is to expands the cost of building.

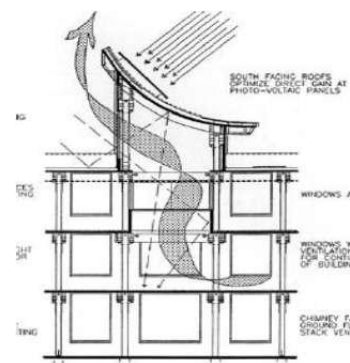


Fig. 3.1. Natural stack ventilation strategies in modern building

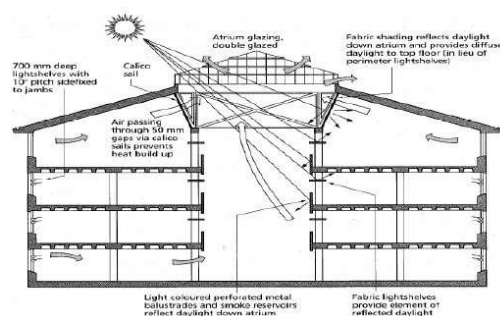


Fig. 3.2. Double Glazed Atrium

3.2 PHYSICAL MODEL

A straightforward two-story private building has been mimicked with different solariums and the sun based fireplace setups. Parametric studies were done to look at the impact of every plan parameter on the warm conditions in the building. The mimicked solarium is thought to be

legitimately gave. The solarium solid floor has the same determination as the back divider and goes about as a catching surface. The back dividers in both the solarium and the sunlight based stack and the solarium solid floor have a protection layer as their last layer to be less influenced with the adjoining room, encompassing and the ground temperature separately.

The air inside a SCAS is warmed in two phases, first in the solarium and after that in the stack, to achieve a higher temperature than it has in the solarium. It is accepted in this study the air inside the solarium is supplanted totally by the contiguous room air and the grinding is overlooked inside the SCAS amongst air and inside surfaces. Afosono and Oliveira (2000) discovered that contrasted with misfortunes from development, constriction and bowing grating misfortunes between liquid, air inside for this situation, and divider surfaces is unimportant when divider surfaces are smooth.

The physical warmth trade handle in this model. Since the warmth move in profoundly coated spaces, for example, a solarium is an exceptionally muddled process, the accompanying presumptions have been made to rearrange the definition stage. The air inside the solarium and the sun based fireplace are thought to be all around blended and have just estimations of T_{fs} and T_{fsc} at each time n individually.

Vitality protection and uninvolved cooling/warming are the most proficient and shoddy contrasting options to customary vitality sources. Most studies in hot atmospheres have uncovered that the most vitality effective spaces are those which utilize inactive procedures for cooling⁴. The expression "uninvolved" infers that vitality expending mechanical parts like pumps and fans are NOT utilized. Latent cooling building plan endeavors to incorporate standards of material science into the building envelope to moderate warmth move into a building and expel undesirable warmth from a building. Latent cooling systems can be ordered in three fundamental classifications as takes after.

Ventilation can be viewed as one of the fundamental necessities for the warm solace by controlling temperature, mugginess, air movement, and nature of air with respect to contaminants. The fundamental elements of ventilation are connected straightforwardly to both solace and wellbeing. As ventilation is imperative to present appropriate warm conditions by accomplishing great air development, and expelling additional warmth produced inside spaces, Ventilation can likewise be viewed as a fundamental variable to bring clean air into working by evacuating air

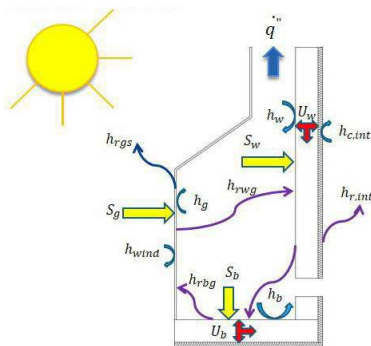


Fig. 3.3. Schematic side section of the SCAS

As it can be found in Fig. 3.3, the solarium in this SCAS has a south confronted glass divider to adequately retain sun powered radiation. The glass rooftop is slanted toward the south to enhance the warmth pick up in the solarium. The back divider in both fireplace and solarium, warm mass, is made of cement. Warm dormancy of the back divider changes over the divider to a warmth hotspot for the air inside the SCAS when sun powered radiation is not

tainted by tenants and their activities. Normal ventilation is accomplished by utilizing the accessible characteristic assets of wind power and sunlight based and warm vitality. Despite the fact that these regular assets are free; they are hard to control, subsequently, the test gets to be to give and build up the appropriate control systems to achieve the required indoor air quality.

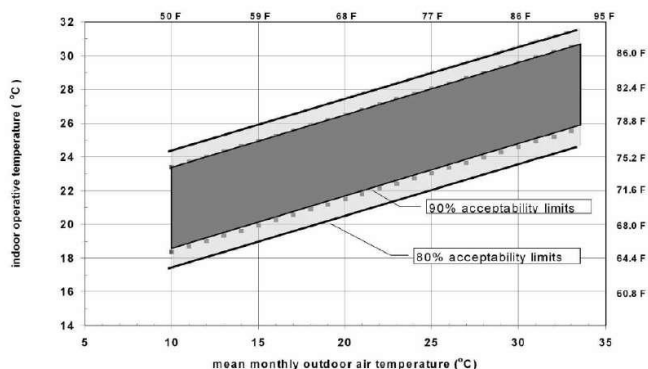


Figure 3.5 - Acceptable operative temperature ranges for naturally ventilated spaces

4. RESULTS AND DISCUSSION

4.1 The computer simulation code

As the following stride, a warm reenactment was performed amid the basic summer days utilizing a PC helped procedure executed in SIMULINK toolbar of the programming. The program ascertains the nursery air temperature and its ventilation rate for various geometrical designs. This recreation study will likewise be utilized to foresee the warm execution of the nursery and the sun oriented fireplace as indicated by the genuine climat information for Toronto and comparing sun powered force and surrounding temperature.

4.2 Validation of the SIMULINK model:

The recreation show that was made in this study to anticipate the execution of the SCAS has been approved by examination between the numerical expectations acquired from the reenactment code of this study and the hypothetical and exploratory results of Afriyie et al. (2011).

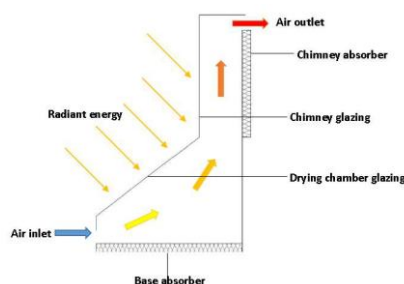


Fig. 4.1 Schematic side section of the chimney-dependent solar crop dryer

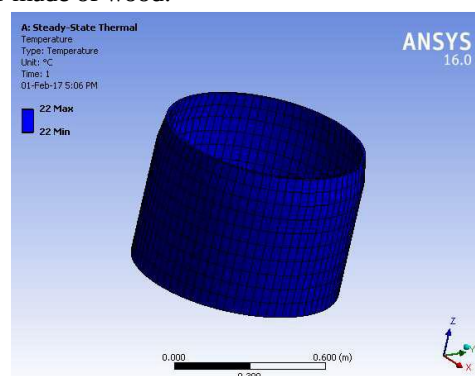
As Fig. 4.1. shows the physical model of the chimney-dependent solar crop dryer designed by the Afriyie et al. (2011) is similar to the physical model of this study. The harvest dryer comprises of a drying chamber that has glass dividers and slanted glass rooftop confronting south. A

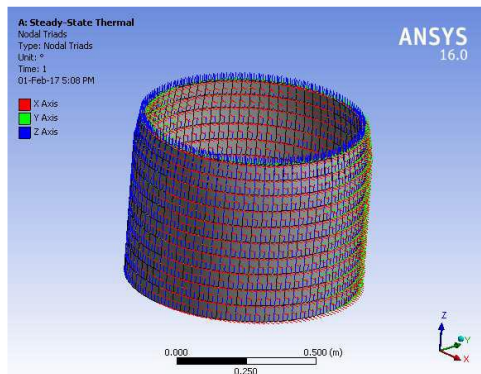
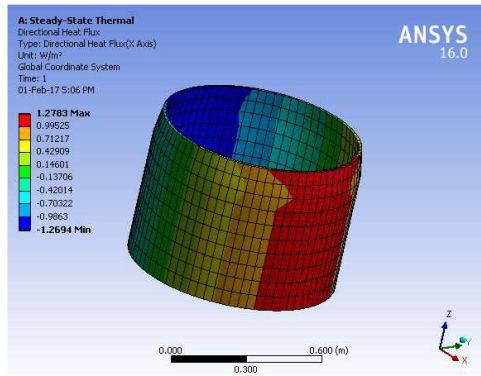
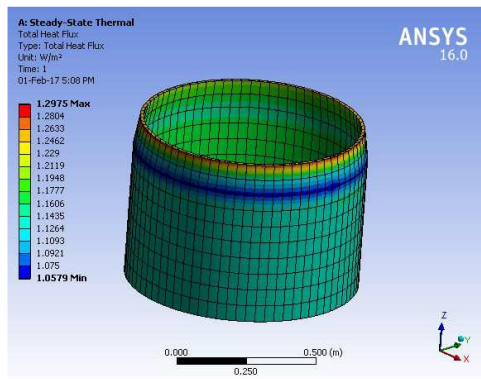
sunlight based smokestack is fused with a drying chamber slanted rooftop to upgrade the ventilation in the dryer.

Table 4.1. Assigned parameters in the validation process all of which have been chosen from experimental study has performed by Afriyie et al. (2011)

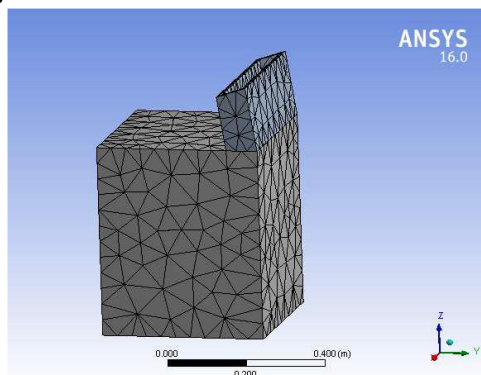
Parameter	Input value
Solarium base width	0.44 m
Solarium base Length	0.42 m
Solar chimney width	0.08 m
Solarium height	0.6 m
Chimney height	0.49 m
Solarium concrete floor thickness	0.04 m
Chimney concrete wall thickness	0.0121 m
outlet area	0.01076 m ²
Glass absorbtivity	0.66136
Glass transmissivity	0.33864
Glass emissivity	0.66136
Back wall emissivity	0.98
Base absorbtivity	0.98
Solarium roof tilt angle	64 o
Back wall conductivity	0.1716 W/mK
Base conductivity	0.18 W/mK
Irradiation to chimney glass cover	390.78 W/m ²
Irradiation to solarium glass cover	186.6 W/m ²

The exploratory model of a relating study was a research center model that comprised of three replaceable rooftop with various edges 81°, 64° and 51°. The drying chamber width and length were 440mm and 420mm individually. The analysts utilized dark painted wood with 40mm thickness as safeguard chamber floor. The examination was performed for various delta widths of 0.03m, 0.05m and 0.07m. The sun based fireplace in this model had a rectangular cross segment of 440mm length, a 80mm width and a 625mm stature. The outlet had a hole of 30mm and a width of 335mm. This stack had a dark painted back divider made of wood.

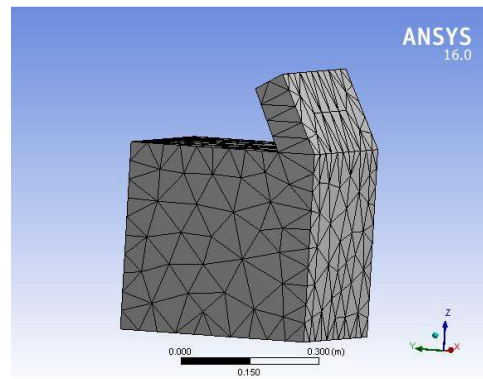




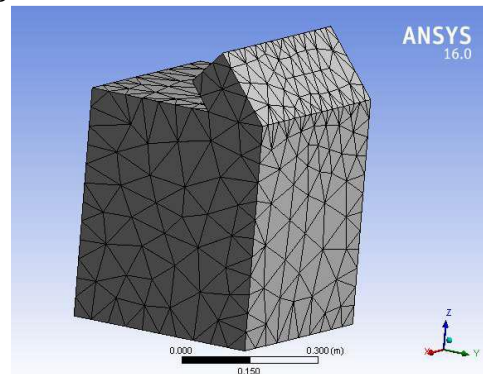
At angle 81°



At angle 64°



At angle 51°

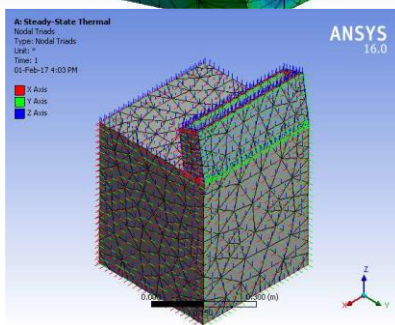
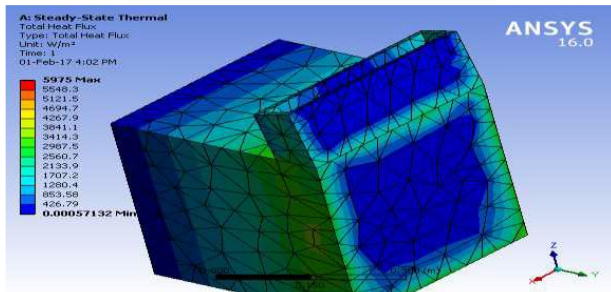
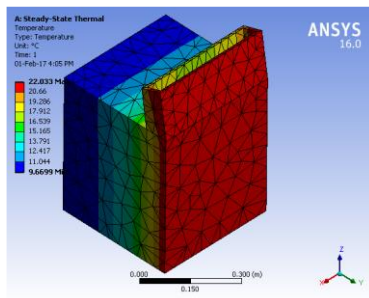


The same measurements and related natural conditions in the Afriyie et al. (2011) trial study were utilized as info information for the reenactment code. Relating input reenactment information are recorded in the Table 4.1. An examination between the present study recreation comes about (Sim) and the hypothetical (Afriyie) and exploratory results (Exp) of Afriyie et al. (2011) is shown in Table 4.2. Table 4.2. Comparison results of simulation outcome of present study (Sim), Simulation results (Afriyie) and results of the experimental trial (Exp) of published study and their relative difference (RD).

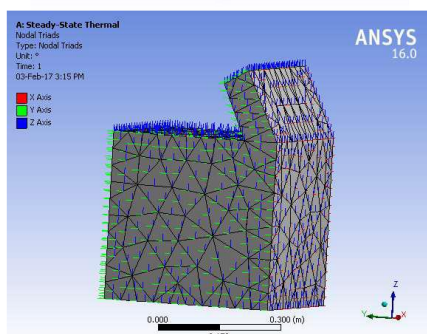
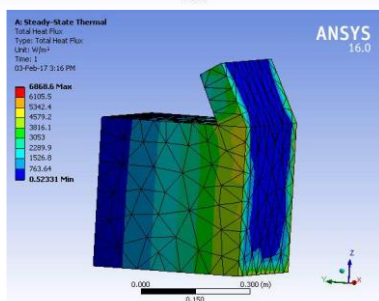
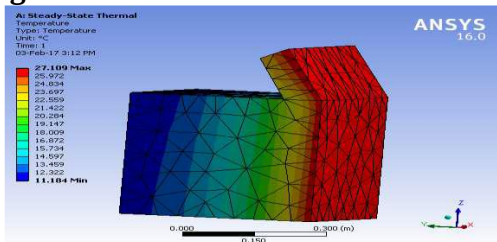
	Inlet gap 0.03m			Inlet gap 0.05m			Inlet gap 0.07m		
	Sim	Afriyie	Exp	Sim	Afriyie	Exp	Sim	Afriyie	Exp
Tfs (K)	296.2	296.40	299.7	300.00	298.4	299.57	300.00	296.64	296.86
RD (%)	1.17	1.11		0.33	0.39		1.06	0.08	
Tfsc (K)	307.6	300.32	304.3	307.2	301.91	303.63	307.00	300.00	301.37
RD (%)	1.08	1.23		1.18	0.57		1.87	0.46	
Tb (K)	302.56	303.28	307.00	303.00	305.40	306.83	302.65	303.66	305.33
RD (%)	1.45	1.23		1.25	0.47		0.88	0.55	
Tw (K)	316.50	314.30	315.54	316.15	316.24	314.58	316.10	314.47	313.17
RD (%)	0.30	0.39		0.49	0.52		0.94	0.42	
Tg (K)	314.88	312.47	313.48	314.9	314.5	313.10	314.9	312.74	311.08
RD (%)	0.45	0.32		0.57	0.44		1.23	0.53	

As it can be obviously found in Table 4.2., the relative distinction, RD, of the reproduction consequences of the present study with those of the experimentation trial of the study by Afriyie et al. (2011) is up to 1.87%, where $RD = |Sim - Exp| / Exp \times 100$, Tfs is the temperature of air inside the solarium, Tfsc is the air temperature of the sun powered smokestack, Tb is the solarium floor temperature, Tw is divider temperature and Tg is the glass temperature. This examination demonstrates that the reproduction after effects of the present study are in a decent concurrence with the hypothetical and trial consequences of past distributed results inside their working conditions.

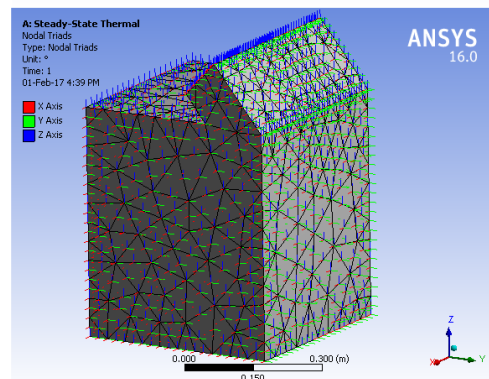
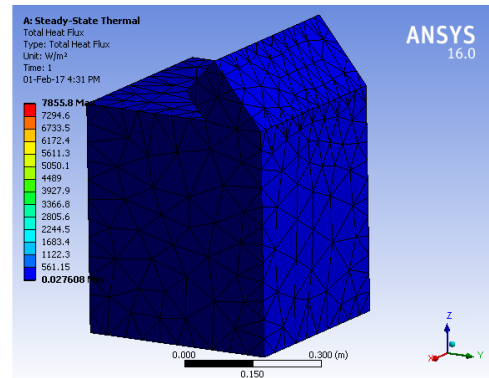
At angle 81°



At angle 64°



At angle 51°



4.3 CHARACTERISTICS OF DIFFERENT ELEMENTS OF THE SCAS

The physical qualities of the SCAS ought to be characterized for the assessment procedure. Toronto's climate information for the month of July, being the hottest with the slightest twist drive on the SCAS, have been utilized as a part of this procedure (Fig. 4.2-4.5). Physical properties of various segments of the SCAS all of which were chosen in view of ASHRAE (2008) and are introduced in Table 4.3. are as per the following:

Glass:

The coating in this application is thought to be a twofold coating with no low E covering both of which have 6mm thickness. As per ASHRAE (2009) this glass cover has the absorptance, α , of 0.11; transmittance, τ , of 0.70 and emissivity, ϵ , of 0.87.

- Air (liquid inside the SCAS):

As said before, Ong (2003) presented an observational relationship by which the physical properties of the air inside the SCAS are resolved. These connections depend straightforwardly broadcasting live temperature and are fitted for 300-350 K.

- Heat retaining back dividers and solid floor:

The back divider in both the solarium and the sunlight based fireplace furthermore the floor in the solarium are made of strengthened cement. These components are all thought to be 24cm thick. The inward surface of each of these components is painted dark to increment sun powered radiation assimilation. To improve the issue, they all have

the same physical properties and are protected from outside condition with the same protection material with the same thickness. Dividers and the floor have the absorptance, α , of 0.82; conductivity, k , of 1.63 W/m K; emissivity, ϵ , of 0.95; thickness, ρ , of 2400 kg/m³ and warmth limit, Cw, b , of 1090 J/kg K.

5. CONCLUSIONS & FUTURE WORK

5.1 CONCLUSION:

As indicated by principle objective, the present research planned to characterize normal ventilation uninvolved procedures that are reasonable and suitable to be connected into the nearby atmosphere of Cairo. The examination procedure was to assess the proficiency of applying the regular ventilation detached systems inside a private space on the indoor ventilation rates and warm solace inside neighborhood hot summer atmosphere.

The examination uncovered that the strategies that rely on upon warm lightness impact, as a working standard, could accomplish critical high ventilation rates inside nearby hot atmosphere of high temperatures and sunlight based radiation. The concentrate likewise uncovered that to accomplish better warm indoor conditions with these methods, they ought to be joined with another latent cooling system, as evaporative or radiative procedures. Double divider procedure, with factors of air crevice, development material, opening measurements, and opening position, was explored inside neighborhood summer conditions utilizing Energy Plus as a CFD reproduction motor to examine the framework productivity on stream rate and warm solace utilizing just aloof convective system inside both day and night conditions and all introductions of sun oriented presentation (east, south, and west introductions).

5.2 FUTURE WORK

Despite the fact that this thesis is the principal inquire about assessing the plausibility of the SCAS in a residence particularly in the climate condition, for example, Toronto territory, it has a few restrictions all of which are presented and clarified in this segment as takes after:

- The see figure and the sun oriented gathering property for a profoundly coated space have not been tended to in this work.

While building up a non specific computational framework for recreation investigation of the sunlight based helped, ventilation in a joined solarium in a private working in the climate state of Toronto locale is an incredible begin to survey the possibility of such an application, noteworthy advance can absolutely be made by seeking after the key issues in a more sun based radiation centered way. As said in book reference, Wall (1997) pushed on the importance of a nitty gritty computation of the sun powered radiation circulation in a very coated space, for example, a solarium. Unquestionably there are numerous conceivable ways to

deal with look at the sun based radiation in a SCAS with various arrangement, for example, beam following and radiosity strategies to gauge the measure of the radiation either retained or transmitted inside the SCAS. A few parameters, for example, see calculate and sunlight based accumulation property must be considered for this particular space.

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