

Lessons from the Past to Enhance the Environmental Performance of Primary School Classrooms in Egypt

Mady Mohamed

Dep. of Architecture, Faculty of Engineering, Zagazig University
*Corresponding Author: madyhmd@yahoo.com

Copyright © 2014 Horizon Research Publishing All rights reserved.

Abstract The achievement of adequate internal environment quality (IEQ) – as one of the most important aspects of quality of life - lies at the core of every debate about built environment of school buildings. Many attempts have been made in the past to examine different aspects of the internal environment quality of primary classrooms. Unhealthy classrooms with poor environmental quality were found to lead to absenteeism among staff and pupils, and negatively affect the performance of children, schoolwork as well as the education process. Children are more susceptible than adults to the effect of poor internal environment quality, which can be “subtle and do not always produce easily recognizable impacts on health and wellbeing”. Egyptian schools are no exception. The author of the current research believes that the environmental performance of these schools could be better by adopting passive strategies and measures. The current paper presents and analysis three examples of the contemporary schools thought to be climatically and environmentally responsive. Their environmental performances are analyzed in order to adopt useful ideas and measures to deal with the hot dry climate in Egypt. The precedents are chosen from the hot dry region and the semi-arid zones according to the Koppen Climatic Classification. Hourly climatic data of their locations are synthesized Using Meteonorm 1 software and analyzed using Weather Tool2 to investigate the response of the school design to the climate context. Results suggest a number of useful passive measures that could be applied on the Egyptian schools in order to enhance their environmental performance.

Keywords Precedent Analysis, (IEQ) Internal Environment Quality, Primary School Classrooms, Quality of Life

1. Introduction and Background

¹ Meteonorm is a comprehensive meteorological reference. It gives you access to meteorological data for solar applications, system design and a wide range of other applications for any location in the world.

² Weather Tool is a software for analyzing and visualizing climatic data and for passive design analysis

The provision of primary schools in Egypt is one of the demanding issues facing the Egyptian government since the earthquake of 1992. In the aftermath of the quake the government has designed a substantial number of primary schools around the country in an attempt to replace schools lost in the disaster [13]. One problem is that schools of typical design have been built in varying climatic regions of the country without taking into consideration the varying effects of climate on the environmental behavior of such schools. Mohamed and Gado confirmed in previous researches [11, 13] that the majority of pupils and teachers in the Egyptian government primary schools are not thermally comfortable during much of the academic year inside the classrooms. This is very important since the majority of children up to the age of twelve in Egypt spend from 15% to 22% of their time in mainstream schooling. The author of the present paper believes that the environmental performance of these classrooms could be better addressed than at present. Mohamed [11] proved that thermal comfort of school occupants in Egypt could be significantly enhanced through applying passive strategies and measures on school building design. Other researches [11, 16] suggested a number of traditional ways of dealing with climate in Egypt. In the current research, the author is trying to devise a number of traditional/contemporary passive measures through precedent analysis. Three primary schools from the hot dry region are selected. These schools are:

- Elementary school in Agadir, Morocco;
- Sidi el-Aloui school in Tunis, Tunisia;
- Eureka School: AID India.

2. Research Aim and Objectives

The current research mainly aims to set out a number of proposed passive measures aiming to enhance the environmental performance of the Egyptian schools. This is achieved through the followings objectives:

- Analyze the architectural design of the precedents;
- Analyze the climate of their locations and set out the recommended passive strategies for their buildings;
- Highlight the environmental responsive design

- features/measures;
● Set out the most useful lessons from each school that could be applied on the Egyptian schools.

3. Research Methodology

The precedents have been chosen from the hot dry region and the semi-arid zones according to the Koppen Climatic Classification. Hourly climatic data of their locations are synthesized Using Meteonorm software based on the nearest available climatic stations. Using this climatic file, the best recommended passive strategies for their buildings are proposed by Weather Tool software. The percentages of the expected effectiveness of applying six passive strategies; thermal mass effect, exposed mass + night-purge ventilation, passive solar heating, natural ventilation, direct evaporative cooling, and indirect evaporative cooling are quantified. The design of the school buildings are compared to the recommended strategies. A comparison matrix is presented in order to conclude the most used strategies and measures in the three case studies.

4. Results and Discussions

In this section, the case studies are presented in terms of location and climate, recommendations for the design of the

school building, school description, advantages of the environmental design of the school, and finally the lessons from the case study.

4.1. Elementary School in Agadir, Morocco

Location	Agadir, Morocco
Architect/Planner	Jean-Francois Zevaco
Client	Morocco Ministry of Education
Date	1966

4.1.1. Location and Climate

Agadir, situated on the southern part of the Morocco's Atlantic coastline near to the Western Sahara. Agadir climate is arid to semiarid; mild, wet winters with hot dry summers along coast with a hot, dust/sand-laden wind especially common in summer [5]. On analyzing the hourly climatic data of Agadir, the data showed that the average monthly outdoor air temperatures range from 15.3 °C in January to 22.3 °C in August. While the maximum monthly temperature ranges from 26.3°C in December to 32.6 in October, reaching its peak in 21st July of 39.0°C. The average daily direct solar radiation ranges from 6355 wh/m² in January to 9247 wh/m² in March. Based on the average daily incident radiation on a vertical surface using Weather Tool, the optimum orientation in Agadir is the south west (207.5°) (Figure 1). The prevailing wind is mostly blowing from the northeast and the southwest (Figure 2).

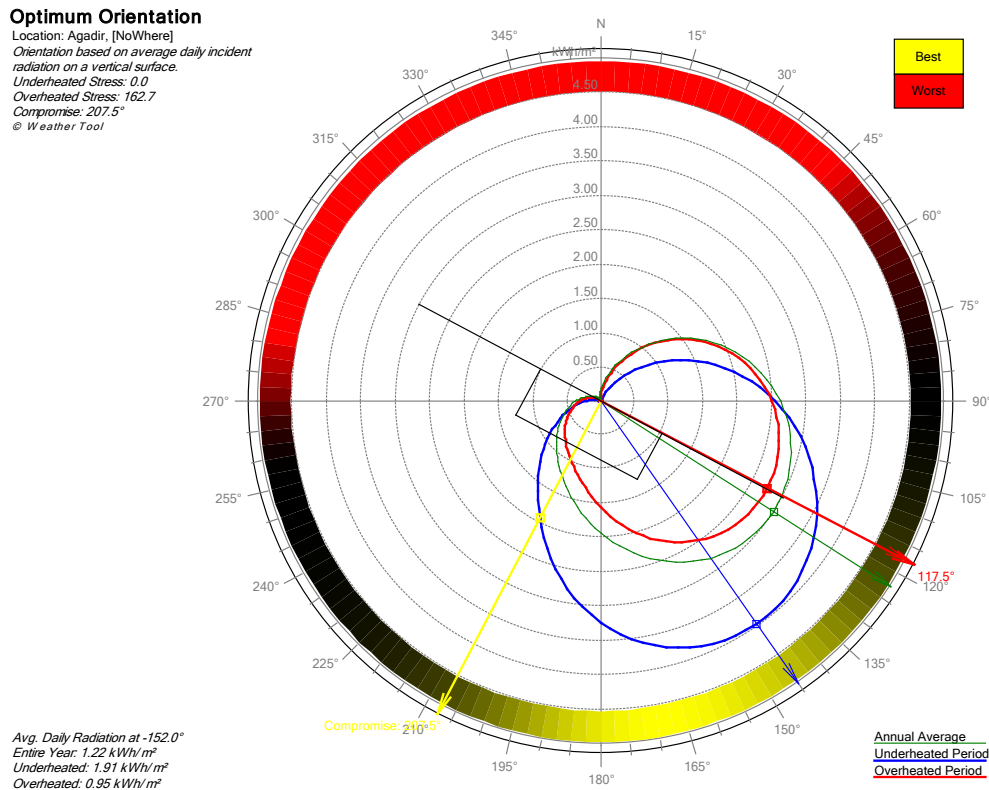


Figure 1. Optimum orientation for the school location, by the author using Weather Tool

Prevailing Winds

Wind Frequency (Hrs)

Location: Agadir, [NoWhere] (30.5°, -40.7°)
 Date: 1st January - 31st December
 Time: 00:00 - 24:00
 © Weather Tool

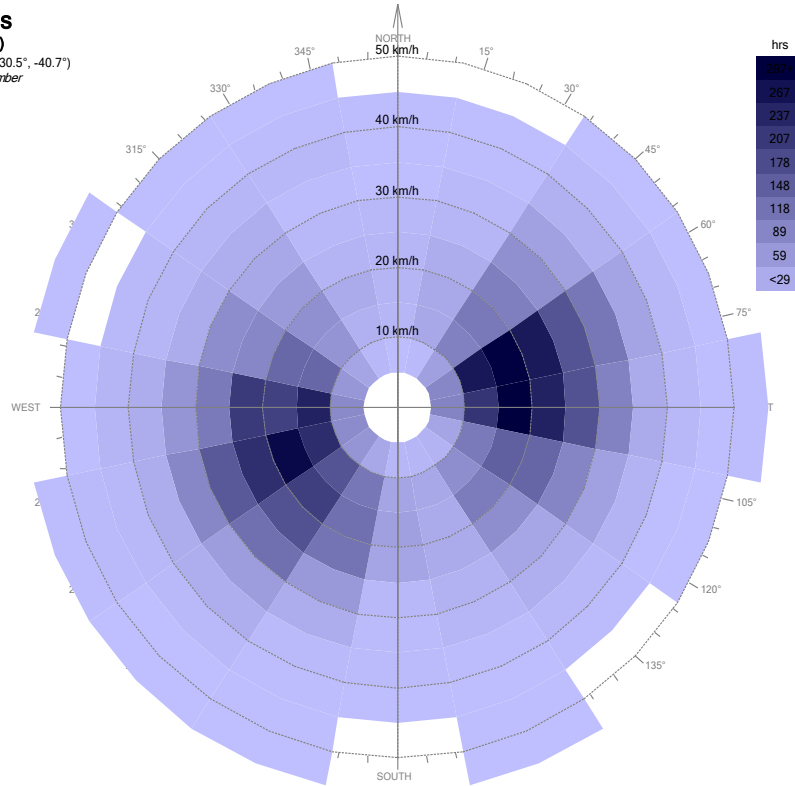


Figure 2. Prevailing winds for Agadir city, by the author using Weather Tool

Comfort Percentages

NAME: **Agadir**
 LOCATION: [NoWhere]
 WEEKDAYS: 00:00 - 24:00 Hrs
 WEEKENDS: 00:00 - 24:00 Hrs
 POSITION: 30.5°, -40.7°
 © Weather Tool

CLIMATE: Cfa

Moist mid-latitude climate with mild winters.
 Humid subtropical with hot muggy summers and thunderstorms.
 Winters are mild with precipitation from mid-latitude cyclones.
 Warmest month above or equal to 22°C.

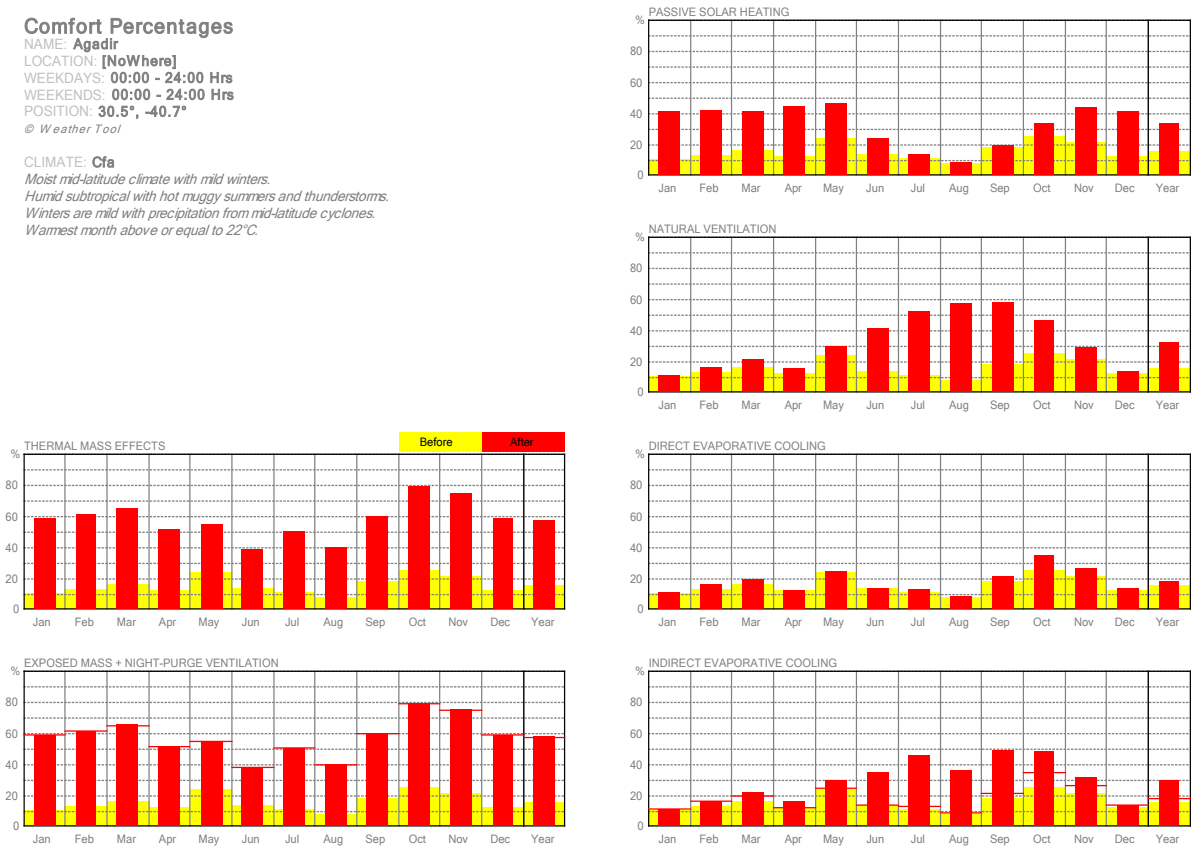


Figure 3. Recommended passive strategies for Agadir city, by the author using Weather Tool

The expected effectiveness of applying the different passive strategies on the thermal performance of the school building is showed in the above figure (Figure 3). It is clear that thermal mass effect, natural ventilation, and indirect evaporative cooling have the best effect on enhancing the thermal performance of the buildings in Agadir city.

4.1.2. School Description

This school is located in an urban residential community within walking distance of the Agadir town square in Morocco. It includes sixteen classrooms, administrative offices and service facilities. The school consists of two classroom buildings lie at a 30 degree angle to one another. A wedge-shaped concrete canopy provides circulation between the two-storey buildings to avoid the traditional long narrow corridors in school buildings (figure5). The administration offices are attached to the canopy's eastern angle in a diamond-shaped. The classrooms are arranged back-to-back so that each pair shares a common wall. This arrangement is reversed on the second floor so that convex angles overhang concave ones on the facades. Each classroom building contains four trapezoidal rooms [1].

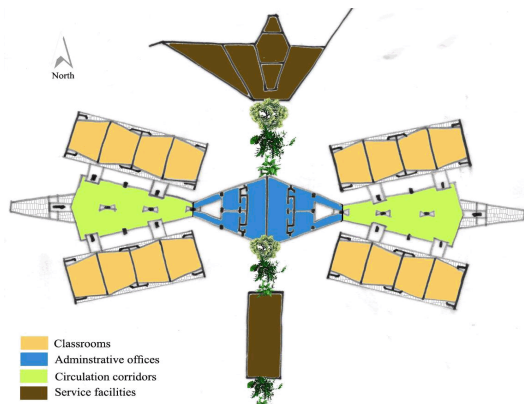


Figure 4. Floor plan of the school, by the author after (Aga Khan Trust for Culture 1979)



Figure 5. Elevation of the classrooms building (Aga Khan Trust for Culture 1979)

The school building integrates many good design features. The two level heights with the horizontal extension are suitable for a primary school. The architect eschewed the traditional long narrow corridors in school buildings by providing the triangle canopy for the circulation between classrooms. This also is working as courtyard between the

classroom buildings that helps to provide the potential of the cross ventilation phenomenon and achieve the recommended passive strategy of natural ventilation (Figure 6). Reversing the arrangement of the trapezoidal rooms arranged on the second floor is a good idea to shade the facades (Figure 7) and achieve by such the thermal mass strategy. More importantly that the 30 degree angle between the buildings gave the designer the ability to build the four buildings mostly in the same direction that to a certain extent cope with the best orientation suggested by Weather Tool. Integrating the wood in the building's materials in addition to provide the façade with an attractive view is suitable for the hot dry climate. The vertical and horizontal shading devices (Figure 8), prevent the direct penetration of the solar radiation inside the classrooms and by turn reduce the discomfort might cause from the solar radiation.



Figure 6. The triangle canopy works as a courtyard between the classrooms (Aga Khan Trust for Culture 1979)



Figure 7. The trapezoidal rooms arranged back-to-back with reversing the arrangement on the second floor (Aga Khan Trust for Culture 1979)



Figure 8. Rear façade and the vertical lovers (Aga Khan Trust for Culture 1979)

The playground with the grassy ground cover and vegetation, beside its aesthetic and beauty, trees provide shade for exterior facades of the buildings. It also helps to enhance the internal air quality (IAQ) of the school since it

prevents the presence of air pollutants such as volatile organic compounds and dust and achieve the indirect evaporative cooling strategy. The horizontal design of the school with the wide areas of playground protects the classrooms buildings from the noise that can affect negatively the educational process.

4.1.3. Lessons from the School

Some passive design lessons from the school building could be concluded:

1. The horizontal extension is much better than the vertical extension for primary schools building;
2. The non-traditional circulation, beside enhancing the design, could help achieving cross ventilation inside the spaces as it works as a courtyard;
3. The reversing in the floors with using horizontal and vertical louvers provided the classrooms with a good combination of shading devices.

4.2. Sidi El-Aloui School in Tunis, Tunisia

School details:	
Location	Tunis, Tunisia
Architect/Planner	Samir Hamaici, Association de Sauvegarde de la Médina de Tunis
Client	Ministry of Higher Education and Scientific Research and Ministry of Housing
Date	1986

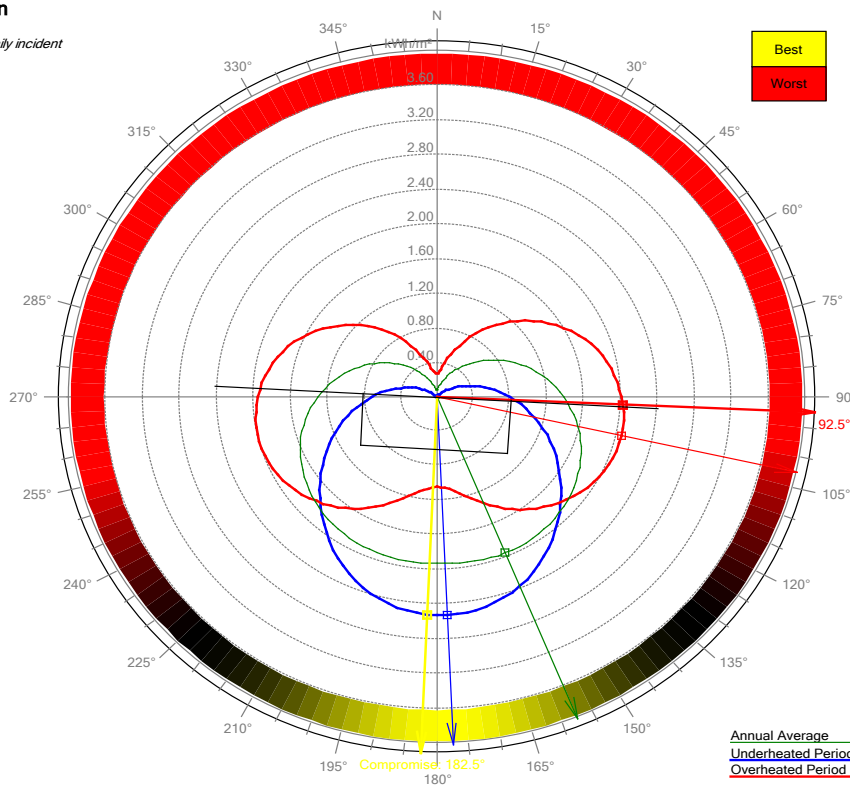
4.2.1. Location and Climate

Tunis is the capital city of Tunisia and is located Situated on a large Mediterranean gulf, (the Gulf of Tunis), behind the Lake of Tunis and the port of La Goulette (Halq al Wadi), the city extends along the coastal plain and the hills that surround it. At the centre of more modern development (colonial era and post) lies the old medina where the school is located. The climate of Tunisia is typically Mediterranean; hot dry in the summer and cold and rainy in the winter [2]. On analyzing the hourly climatic data of Tunis, the data showed that the average monthly outdoor air temperatures range from 10.1 °C in January to 26.6 °C in August. While the maximum monthly temperature ranges from 18.3°C in January to 34.9 °C in July, reaching its peak in 21st July of 40.0°C. The average daily direct solar radiation ranges from 4409 wh/m² in January to 9653 wh/m² in July. Based on the average daily incident radiation on a vertical surface using Weather tool, the optimum orientation in Tunis is nearly the south (182.5°) (Figure 9). The prevailing wind is mostly blowing from the north, northwest and the west (Figure 10).

Applying Weather Tool to suggest the proposed passive strategies revealed that thermal mass effect, natural ventilation, passive solar heating and indirect evaporative cooling have the best effect on enhancing the thermal performance of the buildings in Agadir city (Figure 11).

Optimum Orientation

Location: TUNIS, [NoWhere]
 Orientation based on average daily incident radiation on a vertical surface.
 Underheated Stress: 447.5
 Overheated Stress: 360.2
 Compromise: 182.5°
 © Weather Tool



Avg. Daily Radiation at -177.0°
 Entire Year: 1.91 kWh/m²
 Underheated: 2.50 kWh/m²
 Overheated: 1.04 kWh/m²

Figure 9. Optimum orientation for the school location, by the author using Weather Tool

Prevailing Winds

Wind Frequency (Hrs)
 Location: TUNIS, [NoWhere] (36.8°, 0.2°)
 Date: 1st January - 31st December
 Time: 00:00 - 24:00
 © Weather Tool

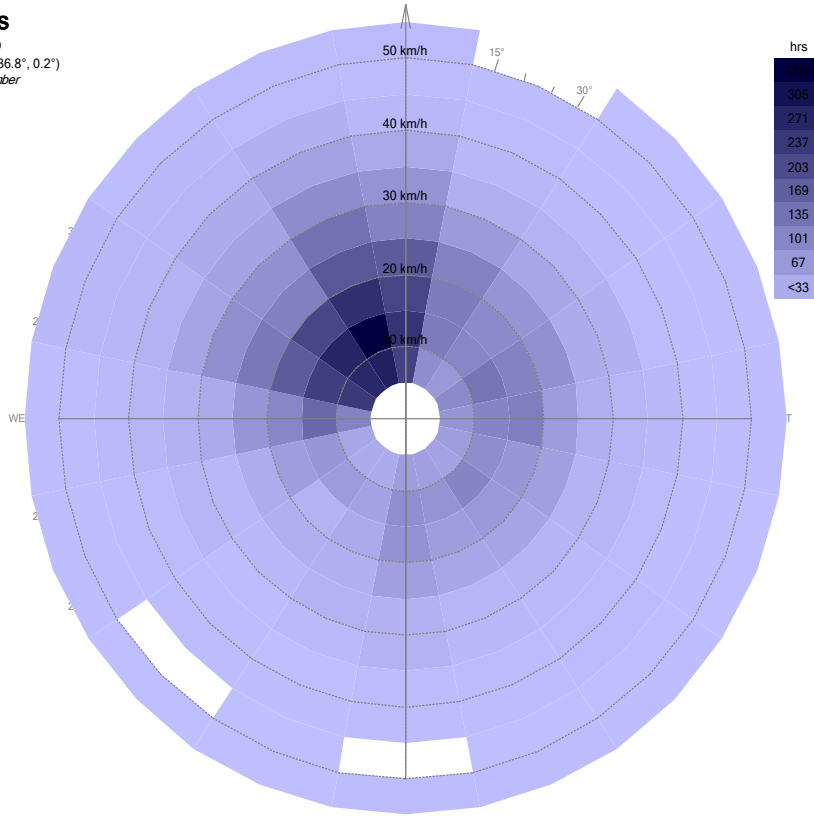


Figure 10. Prevailing wind of Tunis city, by the author using Weather Tool

Comfort Percentages

NAME: TUNIS
 LOCATION: [NoWhere]
 WEEKDAYS: 00:00 - 24:00 Hrs
 WEEKENDS: 00:00 - 24:00 Hrs
 POSITION: 36.8°, 0.2°
 © Weather Tool

CLIMATE: Cfa
 Moist mid-latitude climate with mild winters.
 Humid subtropical with hot muggy summers and thunderstorms.
 Winters are mild with precipitation from mid-latitude cyclones.
 Warmest month above or equal to 22°C.

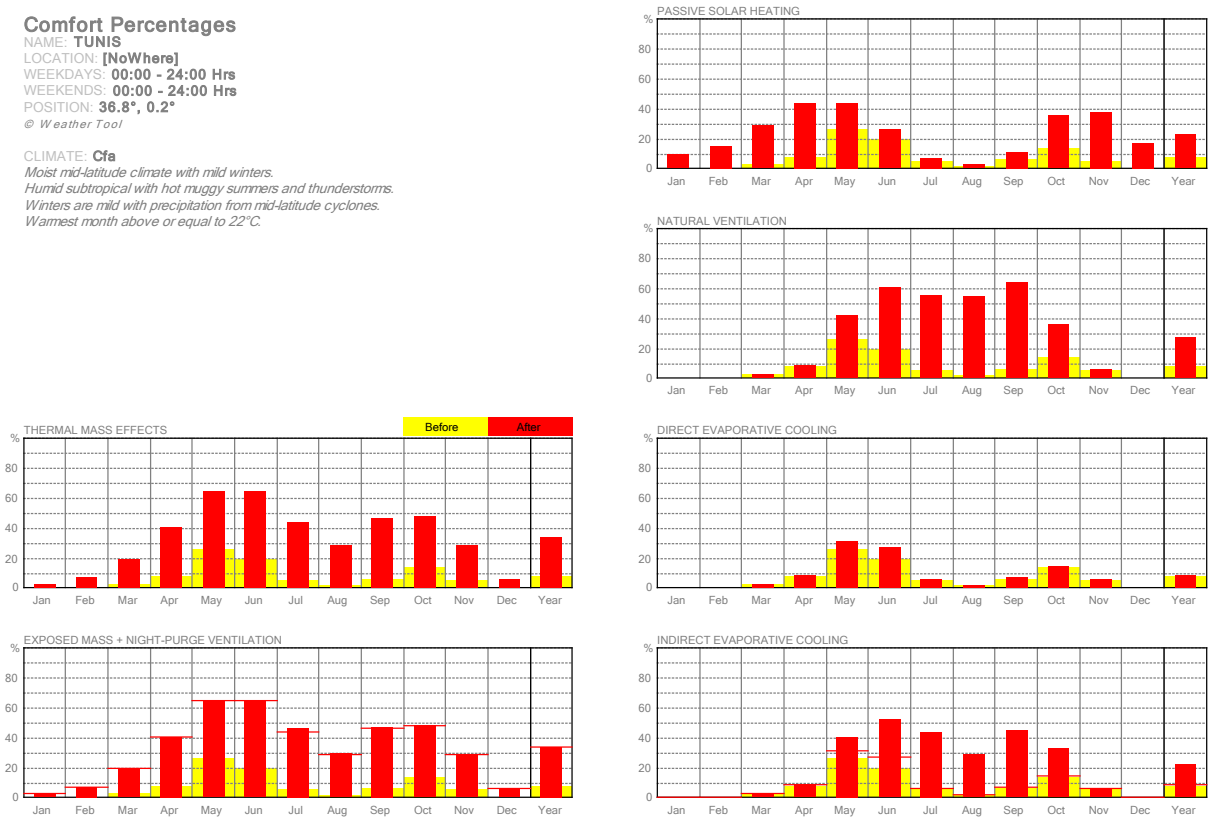


Figure 11. Recommended passive strategies for Tunis city, by the author using Weather Tool

4.2.2. School Description

The school is located in a very dense sector of the Tunis medina, surrounded by low-rise buildings and narrow streets on three sides and a park on the front elevation [3]. The entrance façade faces a public park. This façade is symmetrical about the park's principal axis (Figure 13). The main door is given importance by a two-storey assembly of Mashrabiya directly above it, the lower enclosing a balcony, the upper recessed within the window frame. The façade wing is one storey higher than the rest of the school to bring it into the scale of neighboring structures and accommodate the headmaster's suite [3]. It contains sixteen classrooms of 49.8 sq m (6*8.3 m), eight classrooms in each floor (Figure 12). It also includes a meeting room, four offices and three bedrooms flat for the headmaster on the second floor. The classrooms are distributed symmetrically around paved courtyard (Figure 14). The school is constructed from a reinforced concrete frame structure with hollow tile flooring and hollow brick infill and the facades are rendered by cement. The surfaces are finished with cement plastering and painted with white plastic paint washable with water. Windows, doors and mashrabiya are made of wood [2].

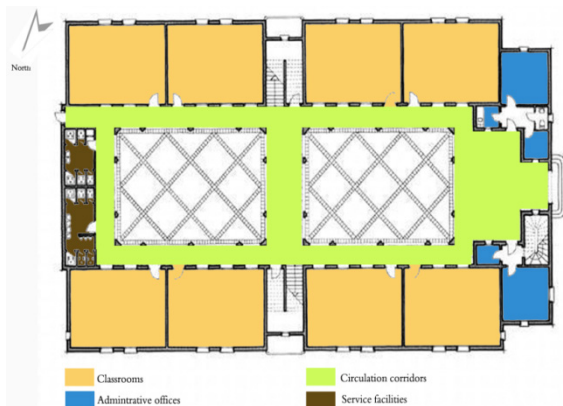


Figure 12. Floor plan of the school, by the author after (Courtesy of architect 1989)



Figure 13. The main façade of the school (Courtesy of architect 1989)

The architect has maximized the use of the small site by building two rows of classrooms separated by a courtyard. The design of the school respects the scale of the neighboring buildings. Also the school has adopted its architectural

details from the traditional environment of the area; the height of the building, the courtyard, openings, decorations and colors. In most spaces, day light is sufficient even when it is cloudy. The five windows of each classrooms (three onto the courtyard and two onto the streets) managed to provide a good level of daylight for the classrooms during the different times of the day. The opposite windows with the two levels enhanced the capability of the cross ventilation inside the classrooms (Figure 15). Also using the combination of glass and wood in the windows helps the control of the light and air inside the classrooms.



Figure 14. the paved courtyard of the school (Courtesy of architect 1989)



Figure 15. The two parts of the windows with two different materials

The relatively high height of the classrooms (3.85 m) created enough space for hot air to accumulate and to be ventilated through the upper part of the windows achieving by such the required cross ventilation [2, 10, 17]. The design of the courtyard is considered to be ideal, since it is facing the north direction by the long side, its dimensions ratio lies within the recommended ratio 1:2:1.4. By designing the courtyard, the architect succeeded in providing a good orientation for all the classrooms towards the prevailing wind direction. Also, this provides the classrooms with partly best orientation, according to the climate analysis. It worth mentioning that, Sidi el-Aloui primary school was the first school which does not follow the typical floor plan designed by the government after the independence [10].

4.2.3. Lessons from the School

- Employing the courtyard in such climate helps too much to enhance the daylight and the cross ventilation of the spaces;

- Designing the windows from two different materials and from more than one level ease the control of the sun penetration and the air movement inside the classrooms;
- The relatively high height of the ceiling causes the occurring of the stack effect phenomena.

4.3. Eureka School: AID India (Design Share: Designing for the Future of Learning 2011)

School details:

Location	Walodai Village, Tamil Nadu , AID India
Architect/Planner	Arche Studio Chennai Private Limited.
Client	Private
Date	2006

continent. Lying entirely in the northern hemisphere. While India has great variation of climate, with striking contrasts of meteorological conditions, the climate is mainly hot and tropical. Although the location of the school does not represent a typical Hot dry zone, instead it is considered a hot humid zone of the world. On analyzing the hourly climatic file of Tamil Nadu, it shows that April-June is the hottest summer period with the temperature rising up to the 40°C, November-February is the coolest winter period with temperature hovering around 20°C. However, Tamil Nadu presents extremes of dampness and dryness Surprisingly, Tamil Nadu gets all its rains from the North-east Monsoons between October and December, when the rest of Tamil Nadu remains dry.

Quantifying the expected effectiveness of the passive strategies (figure18) revealed that thermal mass effect, natural ventilation, and indirect evaporative cooling have the best effect on enhancing the thermal performance of the buildings in Agadir city.

4.3.1. Location and Climate

India is located in the southern peninsula of the Asian

Optimum Orientation

Location: Sholapur, IND
 Orientation based on average daily incident radiation on a vertical surface.
 Underheated Stress: 0.0
 Overheated Stress: 1845.3
 Compromise: 190.0°
 © Weather Tool

Avg. Daily Radiation at -169.0°
 Entire Year: 1.18 kWh/m²
 Underheated: 2.34 kWh/m²
 Overheated: 0.75 kWh/m²

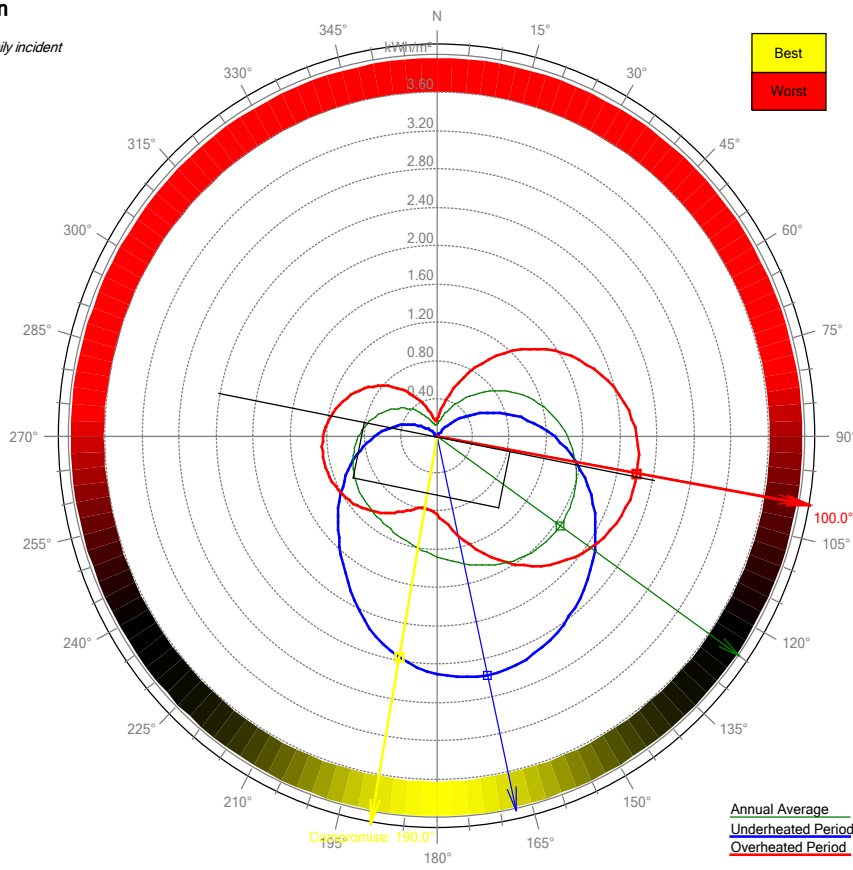


Figure 16. Optimum orientation for the school location, by the author using Weather Tool

Prevailing Winds

Wind Frequency (Hrs)
 Location: Sholapur, IND (17.7°, 75.9°)
 Date: 1st January - 31st December
 Time: 00:00 - 24:00
 © Weather Tool

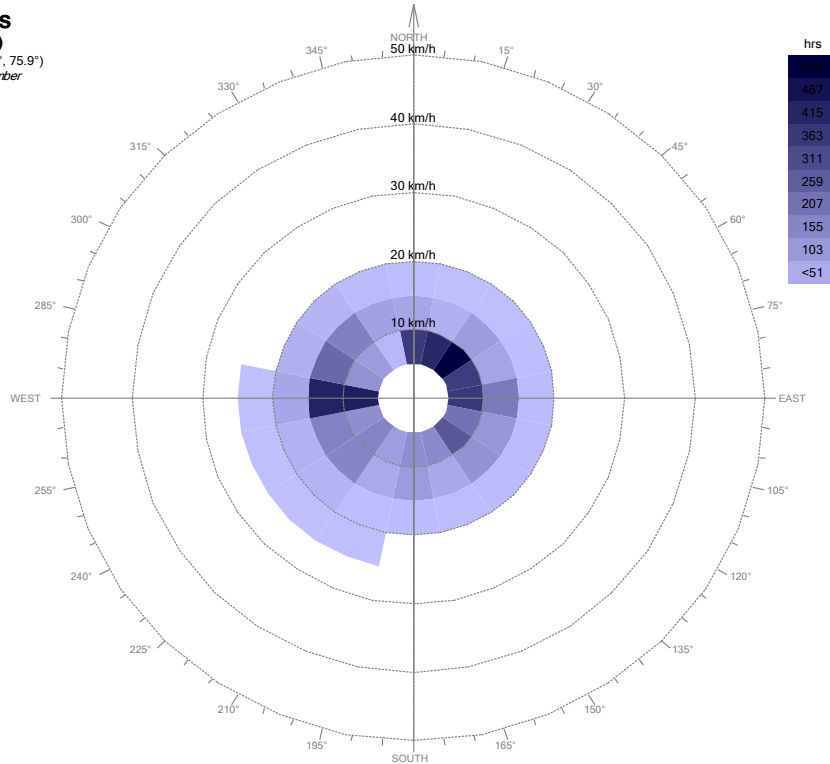


Figure 17. Prevailing wind of Tamil Nadu city, by the author using Weather Tool

Comfort Percentages

NAME: Sholapur
 LOCATION: IND
 WEEKDAYS: 00:00 - 24:00 Hrs
 WEEKENDS: 00:00 - 24:00 Hrs
 POSITION: 17.7°, 75.9°
 © Weather Tool

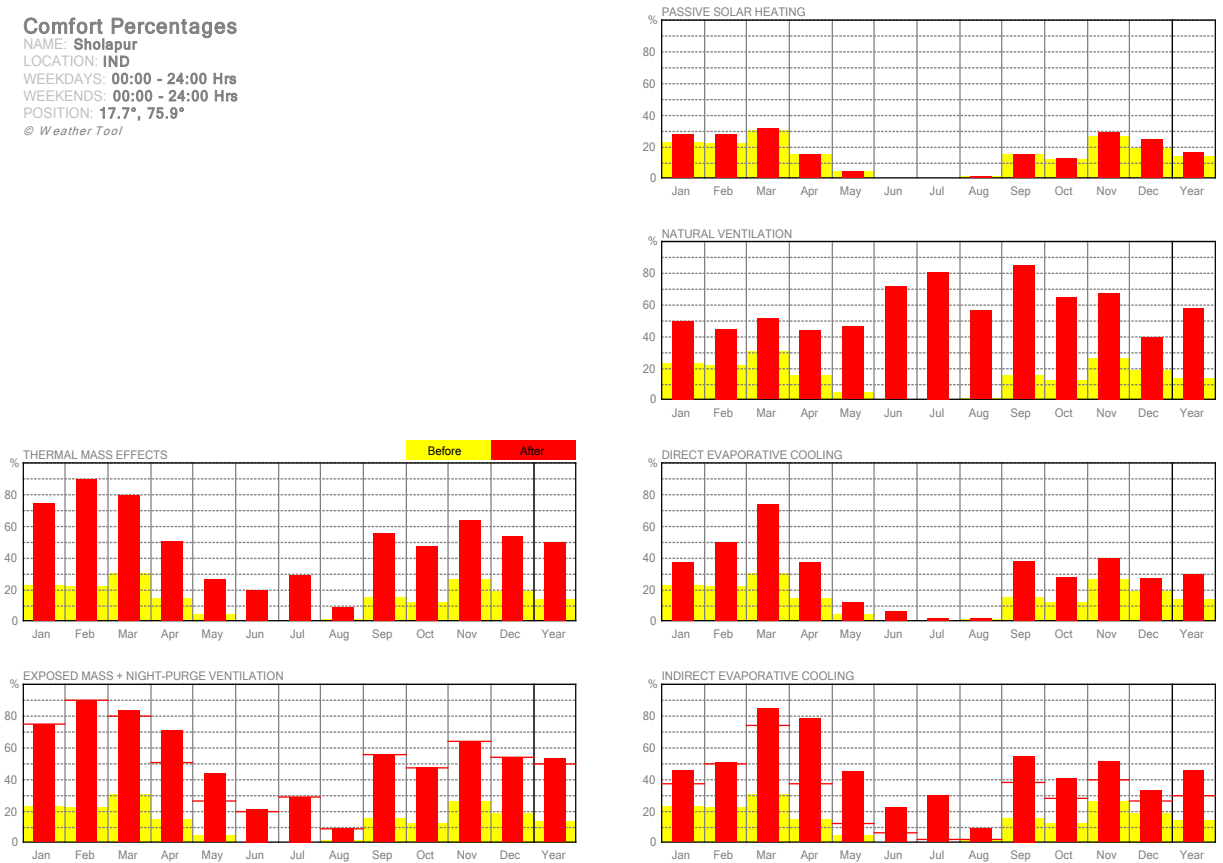


Figure 18. Recommended passive strategies for Tamil Nadu city, by the author using Weather Tool

4.3.2. School Description

The school is located inside a development campus for a village cluster at Walodai Village, Tamil Nadu State, India. The school is formatted in a linear form with the classrooms directed to the North (Figure 19- Figure 20). The school takes advantage of other campus resources - a library, multipurpose hall, and computer and science labs. The school has seven classrooms each of about 18.95 square meter area. Students sit on reed floor mats for collaborative group learning activities. Minimal classroom furniture for storage and display is supplied by an on campus carpentry unit. The school office is taken out from the classroom building to create an open pavilion leading to a stage and rear playground and a tree shaded West courtyard (Figure 20).



Figure 19. Front view of the school (DesignShare: Designing for the future of learning 2008)

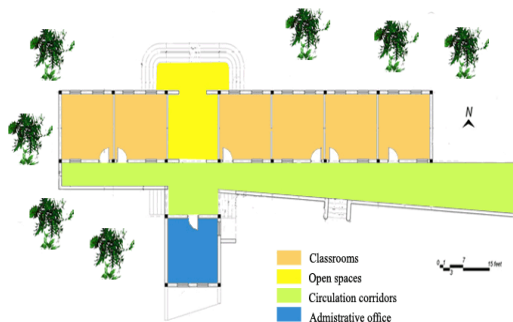


Figure 20. Ground floor plan of the school, by the author after (DesignShare: Designing for the future of learning 2008)

The school design tried to deal with hot climate through applying the recommended passive strategies. According to the recommended orientation, the school is directed to the north/south by the two long sides. The Innovative double roof construction and insulating wall surfaces laid with rat trap brick bond respond to the thermal passive strategy and reduce heat gain and enhance the thermal comfort of occupants (Figure 22). With the Rat Rap Bond technique there is reduction in cost of the wall by 25% as with conventional English bond (25 cm thickness wall) 350 bricks are required per cu. m, whereas in Rat-trap bond only 280 bricks are required and also the reduced number of joints reduces the mortar consumption (Figure 24). The air gaps created within the wall help make the house thermally comfortable. Designing the windows and "jallis " (brick lattice) on two sides enable the classrooms to achieve good

day lighting with air convection aided by cross ventilation and stack effect (Figure 22).

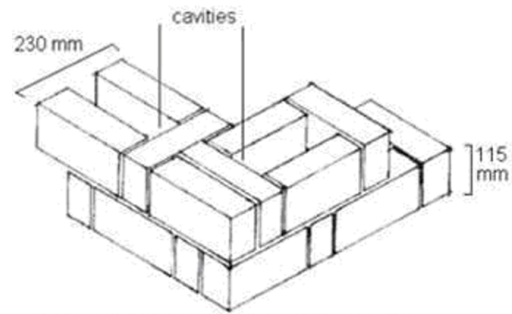


Figure 21. Rat Trap Bond Bricks (Batra 2011)



Figure 22. Classroom interior shows the brick lattice's window (DesignShare: Designing for the future of learning 2013)



Figure 23. The ferro-cement jack arch shells roofs for classrooms (DesignShare: Designing for the future of learning 2013)

The roof is constructed from double roof with ferro-cement jack arch shells and corrugated tin roof. The double roof also reduces the heat gain by reflecting the incident solar radiation (Figure 24). The ferro-cement technology for roofing developed by Development Alternatives uses state uses the design principles of manufacture reinforced shells, commonly called channels. They are produced on specially designed vibrating tables and profiled modules. It has a uniform segmental profile; they are 2.5 cm thick and 83 cm wide, The max length is 6.0 m. System of construction Ferro-cement channels are manufactured using a fixed proportion of cement, sand and water to give high strength mortar that is reinforced with a layer of galvanized iron chicken wire mesh of 22 guage and

tor steel bars of an 8-12 mm diameter provided in the bottom ribs of the channel [9]. The opening from two sides between the two layers of the roof lay to dissipate the heat by the incoming breeze and achieving by such the night purge ventilation strategy (Figure 23). The school design in with simplicity has a variety of transition spaces that lead to different learning activities. The choosing of local materials save the project more than 35% of the expected cost [8].

4.3.3. Lessons from the School

- Double roofs and walls is a good solution for hot climate to reduce the heat gain and increase the thermal comfort of occupants;
- Opening windows on both sides of the classrooms (upwind and downwind) provide the interior with cross ventilation;
- Using suitable opening such as the brick lattice's window provides the classroom's interior with the required day light without glare, provide the classroom with an adequate cross ventilation, and prevent the penetration of the direct solar radiation;
- Appropriate orientation and shading devices are fundamental requirements for hot climate;
- Attached opening and shaded spaces to the classrooms is a very good space to be used instead of

the classrooms in the hottest days.

5. Conclusions and General Outcomes

The current paper was concerned by analyzing three precedents from a similar climate condition to Egypt. this aims to set out useful passive measures that could be applied on our school to enhance the environmental performance of their spaces. Analyzing the three school designs set out several recommendations that could be illustrated in (Table 1). In general, the school design should incorporate green building parameters. Traditional techniques could be replaced or developed by appropriate contemporary technology such as RTB bricks and Ferro-cement roofing. Using the appropriate construction technology such as, rat trap brick bond and ferro-cement jack arch shells, recycled packing wood, mild steel tubes and corrugated metal roofing and local sourcing of construction material reduced embodied energy content and eco foot print. In respecting to the site constrains and being inspired by traditional architecture aspects in hot climate zone with the using of contemporary aspects, Schools become a landmark for the possibility of using the past concepts without stands against the progress.

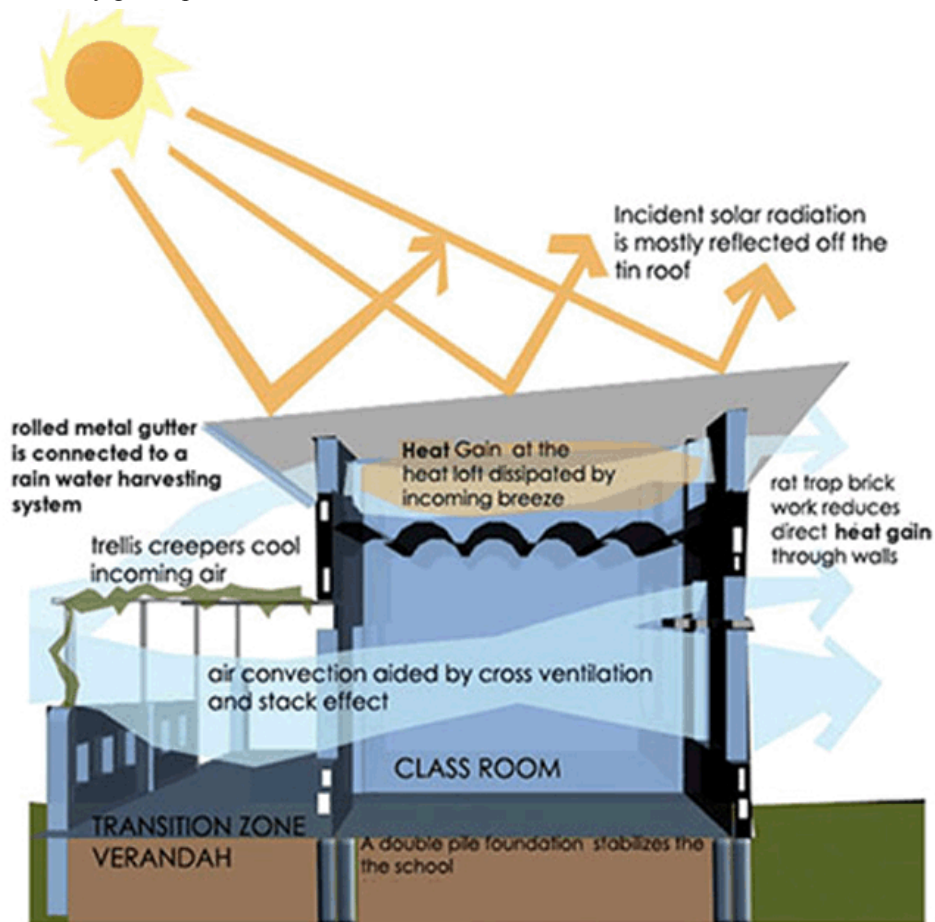


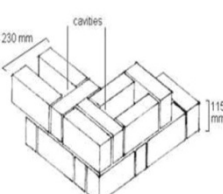







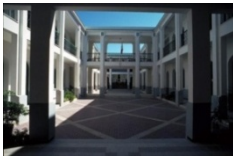
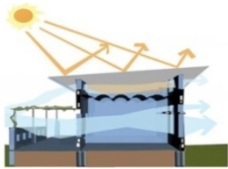




Figure 24. The environmental performance of the classroom construction (DesignShare: Designing for the future of learning 2013)

Table 1. The responsive design of the precedent to achieve the recommended passive strategies for the hot climatic zone, by the author

Recommended passive strategies	Precedents		
Thermal mass effect,	Elementary school in Morocco	Sidi el-Aloui school in Tunisia	Eureka School: AID India
			
<p>The trapezoidal rooms arranged back-to-back with reversing the arrangement on the second floor to over shading the classrooms</p>	<p>Using thick walls with shading devices around the openings</p>	<p>rat trap brick bond respond to the thermal passive strategy and reduce heat gain</p>	
Exposed mass + night-purge ventilation,			
	<p>The upper opening of the classrooms that could be left opened during night to enhance the night purge ventilation</p>	<p>The opposite windows with the two levels enhances the capability of the cross ventilation inside the classrooms during the day / night</p>	<p>The ferro-cement jack arch shells roofs for classrooms to enhance the night purge ventilation</p>
Passive solar heating,			
	<p>Using the glazing windows in the south facade to achieve the passive solar heating during the winter</p>	<p>The two parts of the windows with two different materials helps control the solar penetration in summer/winter</p>	<p>the brick lattice's window enable the classrooms to achieve good day lighting with air convection aided by cross ventilation</p>
Natural ventilation,			
	<p>The non-traditional circulation, helps achieving cross ventilation inside the spaces as it works as a courtyard</p>	<p>Using the recommended ratio 1:2:1.4 in the design of the courtyard enhancing the natural ventilation</p>	<p>The outside opened and shaded space works as a buffer zone and enhances the cross ventilation of the classrooms</p>
Indirect evaporative cooling.			
	<p>Rear façade and the vegetation around the classrooms to provide indirect evaporative cooling</p>	<p>the vegetation around the classrooms enhancing the IAQ of the spaces</p>	<p>the vegetation around the classrooms to provide indirect evaporative cooling</p>

6. Future Work

Specific design measures and features will be developed and taken further to be applied on the Egyptian schools. These passive design measures could be tested through scale models and simulation programs.

REFERENCES

- [1] Aga Khan Trust for Culture (1979). Elementary School ArchNet.
- [2] Akbar, J. (1989). Text report of Sidi el-Aloui primary school, The Aga Khan Award for Architecture.
- [3] Architecture, T. A. K. A. f. (1989). Text report of Sidi el-Aloui primary school.
- [4] Batra, A. (2013, 2013). "RatTrap Bond." Retrieved 31/10/2013, 2013, from <http://www.gharexpert.com/a/ashishbatra/1658/Ratrap-Bond-0.aspx>.
- [5] Central Intelligence Agency. (2013, 10/01/2012). "Field Listing - Climate." Retrieved 24/03/2014, 2012, from <https://www.cia.gov/library/publications/the-world-factbook/fields/2059.html>.
- [6] Courtesy of architect (1989). line drawings and photograph of Sidi el-Aloui primary school.
- [7] DesignShare: Designing for the future of learning (2008). Eureka School: AID India, DesignShare.com
- [8] DesignShare: Designing for the future of learning (2013). Eureka School: AID India, DesignShare.com
- [9] Energy and Resources Institute (2004). Sustainable building design manual, TERI Press.
- [10] Ibrahim, A., N. Al-Shenawi, et al. (1989). Sidi El Aloui Primary School. Alam Al Bena, Center for planning and architectural studies, CPAS, Prints and publication section.
- [11] Mohamed, M. (2009). Investigating the environmental performance of Government primary schools in Egypt: with particular concern to thermal comfort. Dundee School of Architecture. Dundee, Dundee University. PhD 442.
- [12] Mohamed, M. (2010). Traditional ways of dealing with climate in Egypt. The Seventh International Conference of Sustainable Architecture and Urban Development (SAUD 2010). S. Lehmann, H. A. Waer and J. Al-Qawasm. Amman, Jordan, The Center for the Study of Architecture in Arab Region (CSAAR Press). 1: 247-266.
- [13] Mohamed, M. and T. Gado (2009). Assessment of thermal comfort inside primary governmental classrooms in hot dry climates Part I: A case study from Egypt SUE-MoT 2009 Second International Conference on Whole Life Urban Sustainability and its Assessment. M. Horner, A. Price, J. bebbington and R. Emmanuel. Loughborough, UK, Loughborough University: 979 - 990.
- [14] Mohamed, M. and T. Gado (2009). Assessment of thermal comfort inside primary governmental classrooms in hot dry climates Part II: A case study from Egypt SUE-MoT 2009 Second International Conference on Whole Life Urban Sustainability and its Assessment. M. Horner, A. Price, J. bebbington and R. Emmanuel. Loughborough, UK, Loughborough University: 991 - 1001.
- [15] Mohamed, M., T. Gado, et al. (2005). The environmental performance of classrooms in Egypt: a case study from El-Minya governorate. The Second Scottish Conference for Postgraduate Researchers of the Built & Natural Environment (PRoBE 2005). P. C. O. Egbu and M. K. L. Tong. Glasgow Glasgow Caledonian University: 643-651.
- [16] Mohamed, M., M. Osman, et al. (2010). "Investigating the intelligence of the low-tech earth architecture of the Sahara: A feasibility study from the western desert of Egypt." Intelligent Buildings International (IBI) 2(2): 179-197.
- [17] Selma, A.-R. and J. Steele (1994). Sidi el-Aloui primary school. Architecture for Islamic Societies Today. London, Adademy Editions: 150 pages.