Lowland Technology International 2018; 19 (4): 65-76
International Association of Lowland Technology (IALT): ISSN 1344-9656

Research Paper

Green nursing-home model: The Thammapakon Pho Klang nursing home, Thailand

W. Kulariyasup [1], J. Horpibulsuk [2] and S. Horpibulsuk [3]

ARTICLE INFORMATION

Article history:

Received: 20 July, 2017
Received in revised form: 02 November, 2017
Accepted: 05 November, 2017

Publish on: 01 June, 2018

Keywords:

Green building
Nursing home
Human-factors engineering
OTTV
RTTV

ABSTRACT

This paper presents the design of the new Thammapakon Pho Klang Nursing Home, Nakhon Ratchasima, as a modern model for Thai nursing homes. The nursing home is based on green-building, energy-saving and human-factors engineering principles and covers an area of 102,000 m^2 (2,520 acres). The model includes the site design and the buildings of the nursing home, which conforms with green-building and energy-saving principles. The novel nursing home represents a practical approach to the optimization of building use and building resources in the areas of building utilization, water management, waste management, environmentally friendly materials selection, the effect of buildings on the health of building users and the environment, construction, operations, maintenance, and final demolition. The designed buildings include an office building, a hospital, a dormitory for the elderly, a canteen and a multipurpose building. The elderly's facility design is based on universal design and human-factors engineering. Google's SketchUp 8 program was used to design the layout of the buildings, the style and size of the openings around the buildings, the building envelope materials, and the position and types of vegetation around the building according to sun direction. It was determined that the overall thermal transmission values (OTTV) and the roof thermal transmission values (RTTV) of the designed buildings are within the prescribed energy-efficient building standard (OTTV < 30 Watt/m^2 and RTTV < 10 Watt/m^2).

1. Introduction

The number of the elderly people in Thailand has been increasing at a sharp rate since 2001. As in most other developed countries, the Thai population pyramid faces similar issues with regards to a rapidly aging population (College of Population Studies, 2012). Based on Thailand'elderly population data for 2009, it was predicted that by 2015 the elderly population will increase to 14.9 million, which is equivalent to twice the elderly population of 2009. In 2030, this number will increase to approximately 17.8 million, or 25% (approximately 1/4) of the total Thai population (Department of the Interior,Ministry of Interior, 2012). In 2009, the population

[1] PhD scholar, Graduate Program in Construction and Infrastructure Management, Suranaree University of Technology, Nakhon Ratchasiam, 30000, THAILAND, wisit_kul@hotmail.com
[2] Lecturer, Institute of Medicine, Suranaree University of Technology, Nakhon Ratchasiam, 30000, THAILAND, jitwadee@sut.ac.th
[3] Professor , School of Civil Engineering, Institute of Engineering, Suranaree University of Technology, Nakhon Ratchasiam, 30000, THAILAND, suksun@g.sut.ac.th
Note: Discussion on this paper is open until December 2018.

of Nakhon Ratchasima province was second to that of Bangkok and had the largest elderly population, followed by Khon Kaen and Chiang Mai (Foundation of Thai Gerontology Research and Development Institute, 2009). Such changes exert long-term effects on the social, economic and employment situation as well as resource allocation in the area of health and welfare in Thailand. To minimize the negative impact of these changes on the entire society and the elderly population, a paradigm shift in public thinking and social infrastructure improvements are required. The elderly are faced not only with the decline of physical fitness, chronic illness and disability but also the loss of their economic and social roles, which may affect their mental health (Suwanrada et. al., 2010). Therefore, the establishment of standards for service and support networks represent key measures to ensure the stable social protection of the elderly.

The provision of safe shelter for the elderly is an important issue with respect to improving their quality of life and to solving the social and economic problems of the country. The Elderly Act, B.E. 2546 (2003), established social welfare and social work programs to enable the elderly to support themselves and live happily and conventionally. A nursing home is a location that provides shelter for elderly who experience hardship, such as poverty, homelessness, the lack of a caregiver or the inability to live peacefully with one's family. In addition to accommodation, a nursing home also provides healthcare and social services.

However, most nursing homes in Thailand lack facilities for the elderly. This deficiency is most likely due to several factors, such as a lack of building-renovation funds, a lack of knowledge and expertise in such renovation and a lack of building-renovation standards. The renovation and construction of nursing homes should take into account the principle of accessibility (according to ministerial regulations B.E. 2548 and 2555) and the green-building principle to enable the elderly to live in healthy physical environment while decreasing energy use. This research was supported by the National Research Council of Thailand (NRCT), the Foundation for Thai Gerontology Research and Development Institute (TGRI), the Nakhon Ratchasima Provincial Administrative Organization and Suranaree University of Technology in fiscal year 2013. The goal of the research was to design a new provincial nursing home (known as the Thammapakon Pho Klang Nursing Home) according to green-building, energy-saving and human-factors engineering principles to replace an antiquated, sub-standard facility and to create a 3-D animation of the entire development. The nursing home will be constructed on a new 102,000 m^2 (2,520 acres) site.

Even though there are available research works on the green building certificates and accessible housing, these are mainly for developed countries and not applicable for developing countries like Thailand. The standard facility design specified by developed countries are moreover not applicable for Thailand's elderly population because of different anthropometry. The design concept for Thailand context that most of elderly in the nursing home are poorer and weaker than those in developed countries is novel and is thus the focus of this paper. Thailand is tropical and therefore required a special roof to control indoor temperature and prevent rain during rainy season. The temperature characteristics for roof and pavement materials available in Thailand will be included in this paper. These data and the sunlight analysis are used for building design to have maximum shade and shadow and suitable building envelope materials for Thailand tropical context. The comparison of the present simulation with other tradition simulation is not the scope of this study because all the traditional Thai nursing homes have not been designed using green-building, energy-saving and human-factors engineering principles. The simulation and design presented in this research are the Thailand first.

The primary steps taken to achieve the research objectives were 1) the preparation of an incident report, 2) the prioritization of facility improvement, 3) the design of the Thammapakon Pho Klang Nursing Home buildings and 4) the preparation of the animation and a research description (for publication).

The construction drawings for the new Thammapakon Pho Klang Nursing Home (to be constructed after funding is provided) and the animation offer significant benefits to the Department of Public Works and Town & Country Planning by providing advice to the authorities that will construct and renovate nursing homes. Additionally, the nursing home and site will serve as a model for visitors from various agencies and provide guidelines for nursing-home improvement. These outcomes will increase the well-being of the elderly and contribute to the resolution of social and economic problems.

The main agencies that will use the results of this study are the Department of Social Development and Welfare, the Ministry of Social Development and Human Security, the Local Administrative Organization and the Department of Public Works and Town & Country Planning. These agencies govern and enforce laws on construction and building control.

2. Materials and methods

The project-implementation guidelines were based on conclusions reached at several stakeholder meetings.

These stakeholders included members of the engineering, architecture, medicine and nursing faculties of Suranaree University of Technology, representatives of the Nakhon Ratchasima Provincial Administrative Organization and nursing home representatives. A total of four meetings were held. To plan and design the new nursing home, site information, user information, the requirements of the activities areas, building styles and the connections among architectural spaces as well as construction site survey data were analyzed.

The procedure's first phase was to collect anthropometry data on the elderly in the existing nursing home to determine facility dimensions using human-factors engineering. In the second phase, the researchers attended training courses and visited various buildings certified under the energy-efficient building standard of the Energy Ministry and according to the green-building standards of the Thai Green Building Institute. Then, the nursing home was designed by combining our research outcomes based on three main principles: green building (Thai Green Building Institute, 2014), universal design (Associate of Siamese Architects under Royal Patronage, 2008) and human-factors engineering (G. Salvendy, 2012). The third phase was the 3-D modeling of the nursing home using the SketchUp software. To determine the overall thermal transfer values (OTTV) and the roof thermal transfer values (RTTV), the effect of sunlight on the building model was assessed. The two values were compared with the criteria of energy-efficient buildings.

Universal Design and Human-Factors Engineering.

Universal design enables individuals to access or use facilities equally, particularly the elderly and the disabled. To achieve this goal, anthropometric examination of the elderly is required (using human-factors engineering).

Green Building and Energy-Saving Design.

The design master plan of the buildings and landscape in the nursing-home project followed green-building and energy-saving principles. These principles take into account the environment inside and outside buildings to reduce energy consumption, increase energy conservation (Department of Alternative Energy Development and Efficiency, 1993 and Fund for the promotion of energy conservation, 2004), increase fresh air, decrease pollution, and enhance resident quality of life. The focus was on sustainable building management based on reasonably priced technology whose use is consistent with the climate of Thailand. This climate is tropical wet and dry or savanna climate. In addition, Thailand has a moist climate and high rainfall averages for approximately 6 consecutive months. The winter is cold and dry during a brief period of 3 months, and the remaining 3 months are hot and dry (Thai Meteorological Department, 2015).

Thailand is located in a tropical climate zone, so the building envelope is significant for the design of energy efficient buildings. The building envelope prevents the heat transfer to the building and hence the reduction in the cooling load of air conditioning systems and energy consumption. The performance of the building envelopes is determined by OTTV and RTTV in Thailand (Department of Alternative Energy Development and Efficiency, 1993).

In Thailand the OTTV and RTTV values of public buildings must meet the legal requirements to ensure that building envelope has a capacity sufficient to prevent heat entering the building. The OTTV and RTTV have been applied in practice since B.E.2538 (1995) and calculation method has been improved in B.E.2552 (2009) to be more precise and appropriate for Thailand.

The OTTV is the average value per square meter of heat transfer through walls and windows from the outside into a building. The general form of the OTTV equation for an external wall is as follows:

$$OTTVi = (Uw)(1-WWR)(TDeq) + (Uf)(WWR)(\Delta T) + (WWR)(SHGC)(SC)(SF) \quad [1]$$

The OTTV of the whole exterior wall is given by the weighted average of the OTTVs of individual walls at different orientations, like this:

$$OTTVwall = \frac{\sum (OTTVi \times Ai)}{\sum Ai} \quad [2]$$

The RTTV is the average value per square meter of heat transfer through the roof from the outside into a building. The general form of the RTTV equation for a roof is as follows:

$$OTTVi = (Ur)(1-SKR)(TDeq) + (Us)(SKR)(\Delta T) + (SKR)(SHGC)(SC)(SR) \quad [3]$$

The RTTV of the whole roof is given by the weighted average of the RTTVs of individual roofs at different orientations, like this:

$$RTTVroof = \frac{\sum (RTTVi \times Ai)}{\sum Ai} \quad [4]$$

In this case, the OTTV and RTTV were calculated using OTTVEE Version 1.0a, a program developed by the Faculty of Architecture, Chulalongkorn University.

3. Results

3.1 Layout of master plan

The master plan was prepared based on the suitability of the project site and the linkage between activity buildings. Planning must take into account the hygienic needs, comfort, and safety of residents. In addition, accessibility and space utilization by the elderly, particularly those suffering from Alzheimer's disease and those who are disabled, and other users must be considered. The infrastructure and environmental management is based on the green-building concept. The results are as follows (Figure 1).

To control accessibility by various parties and provide for the safety of the elderly, the nursing home consists of 3 zones: public, semi-public and private. The project has 2 ways of entry: the main entrance on the east side and a sub-entrance on the west side. To respond to the needs of the elderly, the nursing home has several activity buildings. The garden is used as a walkway to connect the buildings and an activity field. There are roofed walkways in the park and between buildings to prevent heat accumulation. The existing trees are maintained with minimal cutting to provide shade on the buildings and site. The area of the nursing home's hardscape is decreased using low thermal reflective materials or paving blocks with water permeability and by plantings to provide shade.

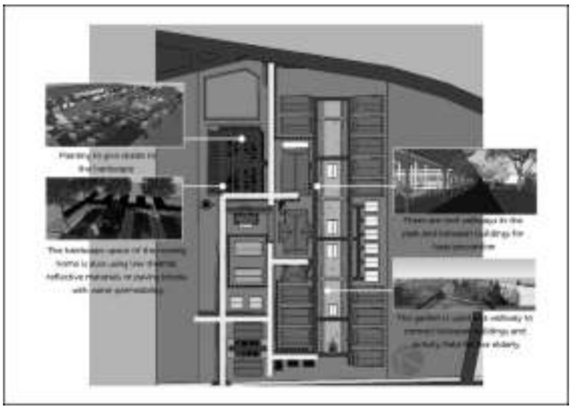


Fig. 1. Project site plan.

The main road for traffic within the project is 6m wide and concrete, with a 2m wide walkway on both sides. The parking area is covered with concrete slabs alternating with grass blocks. There is a drainage system for direct rainfall to the project's pond. To avoid danger, cars are not allowed in the elderly residence area. However, in case of emergency, ambulance access is provided.

For water management, a drainage area is provided at the site's lower end. To partially recycle wastewater, a treatment system is adopted. Rainwater collection is practiced to decrease the use of tap water and to create a reserve for emergencies. A sub-meter is installed to monitor water use and leakage in the main building and surrounding structures. Sanitation equipment uses a water-saving system.

To manage illumination and the lighting appliances in the nursing home, the buildings are designed to allow natural light and reflections (indirect sun) into the buildings as appropriate. Lamps with a high light-utilization coefficient and solar garden lamps are chosen.

Waste from various sources is sorted prior to disposal. Rubbish bins are provided at various points, both indoors and outdoors. Waste is collected according to schedule at collection points prior to delivery to the Kokkruat Subdistrict Administrative Organization for disposal.

3.2 Design guidelines for project buildings

The building design considers the habits and characteristics of the residents (i.e., users), including the elderly and the nursing home's staff. The functional areas in the projects are suggested as follows: 1 office building, 1 multi-purpose building, 1 canteen, 7 dormitories for male elderly (25 beds per dormitory), 7 dormitories for female elderly (25 beds per dormitory), 1 dormitory for male patients (25 beds per dormitory), 1 dormitory for female patients (25 beds per dormitory), 10 activity buildings, 1 hospital (first aid), 2 system buildings and 2 staff dormitories. These functional areas were planned to construct in various phrases due to the budget limitation. The first priority was set for office building, multi-purpose building, canteen, hospital and elderly dormitory. The observed lifestyle of the elderly and staff at the Thampakorn Pho Klang and Thampakorn Wat Muang nursing homes was used to design 5 buildings in the new nursing-home complex: an office building, a hospital, a dormitory for the elderly, a canteen and a multipurpose building.

All of the designed buildings possess facilities sufficient to the needs of the elderly and the disabled in accordance with the ministerial regulations entitled The Establishment of Facilities in Buildings for Disabled or Handicapped Persons and the Elderly, B.E. 2548, and human-factors engineering (example data in Table 1). All stairs employ a 0.13-0.15 m riser and a 0.30 m tread (Figure 2). The stair railings are round and smooth and 40 mm in diameter. In front of the staircases, a 0.30 m wide contrast-texture floor surface across the width of the stairs is provided. Anti-slip aluminum stair nosings with obvious colors are used. A general ramp with a 1:12 slope is designed to connect the different levels (Figure 3). Grab bars with a diameter of 30-40 mm and a height of 0.80 meters are used. The ramp elements follow the ministerial regulations referred to as The Establishment of Facilities in Buildings for Disabled or Handicapped

Persons and the Elderly, B.E. 2548. All of the doors are sliding doors with a width of not less than 1.20 m except for bathroom toilet entries, which can be swing doors. Sliding windows are employed in locations likely to be used by the elderly.

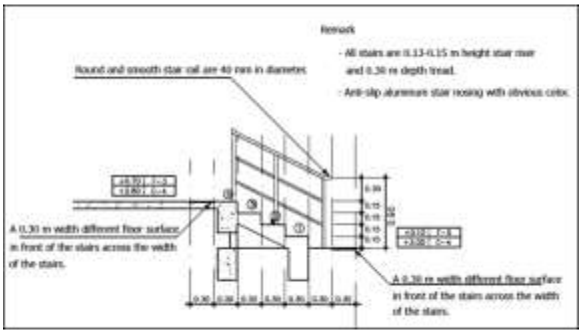


Fig. 2. Stair specifications.

Table 1. Body dimension in stand position (male)

No.	Specification	Avg.	S.D.	Max	Min
1	Head circumference	53.35	2.37	58.60	48.00
2	Upper neck circumference	37.89	4.10	45.60	28.50
3	Neck circumference	37.86	4.21	46.20	29.00
4	Upper chest circumference	90.75	7.28	107.20	75.00
5	Chest circumference	89.69	7.70	105.40	74.10
6	Under chest circumference	85.56	9.09	106.10	67.00
7	Waist circumference	86.33	10.94	108.60	68.20
8	Abdomen circumference	89.21	10.83	111.20	67.40
9	Hip circumference	94.07	6.98	114.60	79.00
10	Thigh circumference	44.33	7.76	65.60	28.00
11	Calf circumference	32.90	4.06	42.30	24.10
12	Arm circumference	39.29	5.33	53.10	29.00
13	Upper circumference	27.83	3.76	36.60	19.30
14	Elbow circumference	28.91	2.84	35.00	22.50
15	The largest lower arm circumference	23.52	3.06	32.10	17.50

Fig. 3. General ramp with 1:12 slope.

The indoor temperature for various roof slopes, roof materials and building envelope materials were previously researched (P. Onbhuddha, 2006) as shown in Figure 4 and Table 2 and are used for the building design in this study. The energy saving with various roof slopes, roof materials and building envelope materials is evident. The higher slope results in lower indoor temperature and hence the saver energy for air-condition system (Table 3). The 30 degrees of roof slope was found to be the effective construction cost in Thailand. Green pavement materials (outdoor) have more efficiency to reduce heat temperature that transfers to building wall (Macnolia Quality Development Corperation limited, 2014) (Table 4).

Table 2. Heat inside the building for various materials (at 12.00 p.m., 21 March) (P. Onbhuddha, 2006).

Material	Avg. temperature inside the building (° C)	
	Below the roof	Inside the building
Roof materials		
- Monier (Concrete)	54.05	52.15
- Tin roof	55.32	53.59
Wall materials		
- Masonry	54.05	52.15
- Concrete block	55.26	53.24
- Aerated concrete	51.60	49.58
Insulation materials		
- Gypsum board	54.05	52.15
- Fiberglass 3”	48.24	42.55
- Fiberglass 6”	46.63	41.30

All of the building roofs are designed in the Manila (Figure 5) or hip roof (Figure 6) styles. The isosceles triangular shape of the Manila roof effectively ventilates heat out of the attic (S. Punyakeaw, 2003). To effectively withstand the sun and rain, the roofs have a 30° slope, and the eaves of the building are not less than 1.50 m deep (Figure 7). The thickness of the light-colored roofing is 5 mm. A roof insulator is installed beneath the roof tile, and 75 mm thick fiberglass insulation with reinforcing aluminum foil is installed on the ceiling. Each roof is sprayed with a ceramic coating.

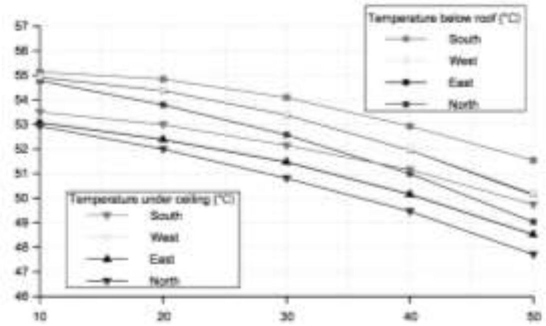


Fig. 4. Effect of roof slope on the room temperature at 12.00 p.m., 21 March after (P. Onbhuddha, 2006).

Table 3. Effect of roof slope on heat inside the building (P. Onbhuddha, 2006).

Roof slope (°)	Energy cost in Air-Condition system (Baht/year)
10	28,614
20	24,907
30	24,318
40	23,582
50	22,633

Table 4. Surface temperature of pavement materials (at 2.00 p.m., 21 March) (Macnolia Quality Development Corperation limited, 2014).

Pavement material	Green area	Surface temperature	Heat reduction	% of heat changed
Concrete	0%	42 oC	0 oC	0%
Turf blocks	40%	36 oC	6 oC	14.29%
Grass cells	80%	30 oC	12 oC	28.57%
Grass	100%	27 oC	15 oC	35.71%

The walls are constructed of aerated concrete full pole face (i.e., a double wall with a gap in the middle). Because this aerated concrete has a lower heat transmission capacity than brick, it furnishes better heat protection (the thermal conductivities of aerated concrete and brick are 0.13 and 1.15 watts/m.Kelvin, respectively). The overall heat transfer OTTV of aerated concrete and brick are normally 32 - 42 and 58 - 70 watts/m^2, respectively) (Fund for the promotion of energy conservation, 2004). Aerated concrete requires less construction time because of its greater strength. It is also recommended for use as an alternative green material, such as geopolymer masonry units, which are manufactured without Portland cement (P. Sukmak et al, 2013). The bathroom walls are constructed of brick because of the material's high moisture resistance. All of the walls are painted with light colors. All of the mirrors possess high solar heat gain coefficients (SHGC) with highly visible transmittance. Therefore, green glass with a solar heat gain coefficient of 0.54 (Department of Alternative Energy Development and Efficiency, 1993 and Fund for the promotion of energy conservation, 2004) is used. To decrease energy consumption in cooling or ventilation, the natural ventilation in the main area is more than 70% with 2 opposite side vents. The long cantilever roof is designed to provide shade for the walls and openings.

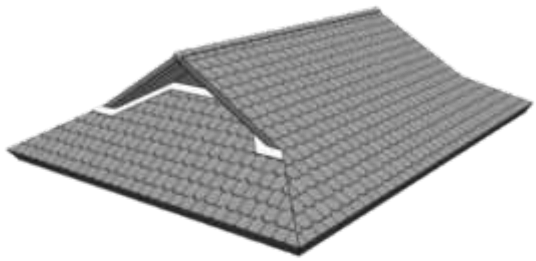


Fig. 5. Manila-style roof.

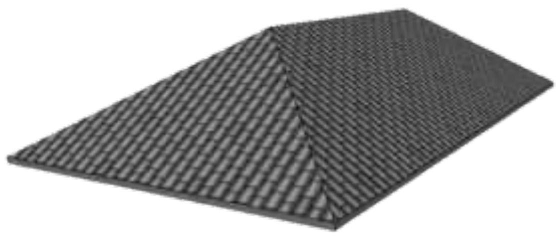


Fig. 6. Hip roof.

There are restrictions on the layout of the buildings. For example, the dormitory for the elderly and the office building extend east-west. Thus, the buildings are significantly affected by sunlight. In the case of the dormitories, each building is 8 meters long. Therefore, the shadow of each building provides shade to the neighboring building. Planting trees between the buildings can decrease heat transfer to the buildings and increase the quantity of fresh air inside them. Planting shrubs around and between buildings and planting small perennial canopy plants at the east side of the building with a spacing of 4.50 meters facilitates improved air flow and natural lighting in the building, resulting in good ventilation and minimal moisture. Standing trees with relatively sparse canopies are planted to prevent sunlight on the south side. On the west side, standing trees with dense canopies are planted to block the sun from afternoon to evening.

The floor plans are designed to receive the breeze and natural light during daytime. The surrounding terrace prevents sunlight from striking the building wall during the day (Figure 8). Thus, the users can rest comfortably during the day. The landscaping is designed to promote energy efficiency, for example by planting trees in positions to provide shade on the building. In addition to creating a pleasant atmosphere for the building, such plantings promote resident quality of life. The distance between each building is not less than 8.00 m. Therefore, the elderly have sufficient space outside the building for their activities.

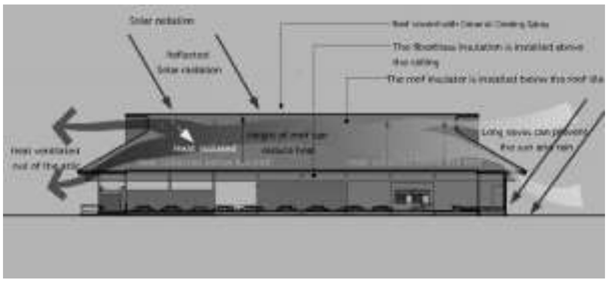


Fig. 7. Below-roof heat venting and sunlight/rain protection.

Fig. 8. Concept of Building design.

To produce hot water, renewable energy, such as solar energy and solar thermal energy, is used. A fan is used to increase wind speed inside the building to achieve a comfortable condition for the residents and to increase the ventilation rate when the wind speed is low. Electrical devices are chosen or designed to effectively bring natural light and indirect sun into the area. Solar lamps are used as exterior lighting at night to decrease power consumption. Embedded ceiling lamps with acrylic covers, 60 x 120 centimeters reflector sheets and T5 - 2x 28 watt fluorescent lamps (daylight) are used to save energy (Ministry of Energy, 2014).

Each building stores rainwater on the roof using the rain gutter at the eaves to transfer the rainwater to a storage tank. The turbidity of the rainwater is decreased by a sediment filter. The treated rainwater is subsequently used for watering plants or building sanitation. Effluent from showers and sinks is treated in sedimentation ponds and reused, primarily to water plants. Toilet wastewater is treated in a treatment tank (one per building) and subsequently delivered to the drainage. In the bathrooms, water-saving sanitary products are used. Effluent from the kitchen must pass through a grease trap prior to release into the drainpipe. Materials are selected that do not emit harmful substances, such as volatile organic compounds (VOC) and formaldehyde. Fans are used to provide adequate ventilation in the buildings and to increase the air circulation rate.

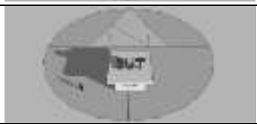
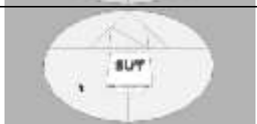
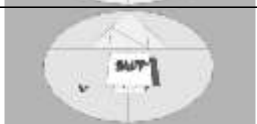
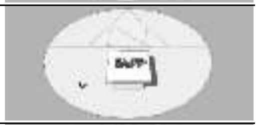
The anthropometry of the elderly was used to design equipment according to human-factors engineering. This equipment includes furniture with few sharp angles and no wheels, lever-type door handles, a chair/bench height of 0.45 m, a bed height of 0.45 m, a table height of 0.75 m (with the space beneath the table at a height of not less than 0.60 m), and wardrobes with 2 hanging levels: normally high (1.80 – 1.90 m) and 1.20 m for wheelchair-bound elderly.

3.3 Analysis of the sunlight direction that affects the buildings

To understand the angle of the sunlight that strikes the building envelopes, a model simulation using Google SketchUp 8 was performed in which the location of the building model was set to match the actual construction site. The sunlight on the 1st of every month from January to December between 06.00 a.m. - 06.00 p.m. was studied. The Baan Thampakorn Pho Klang Nursing Home is located at latitude 14.54'57.6"N and longitude 101.58'36.0"E. Examples of sunlight striking the building envelopes are shown in Table 5.

In October, the sun rises in the east (actually, slightly southeast), starts to move further toward the south during the following month and moves to its most southerly point in January. The sun returns toward the east until April, when it rises at its most easterly point. Then, the sun moves north until June, when it rises at its most northerly point. In July, the sun rises slightly more to the east, reverses toward the east in September and then moves toward the south again in October. The sun travels slightly toward the south throughout the year except April and September, when the sun travels in a straight line from east to west. The building envelopes on the east and west are exposed to the sun during the morning and evening throughout the year. The north side of the buildings is exposed to the sun during the morning and evening from May to August but does not receive direct sunlight during other months. The south side of the buildings is exposed to the sun during morning and evening in October and receives direct sunlight nearly daily from November to March. The south side of buildings does not receive direct sunlight all day from April to September.

Table 5. Sunlight hit on the building envelopes.

Month / Time	January	February
06.00		
08.00		
10.00		
12.00		
14.00		
16.00		
18.00		

3.4 Building analysis

The simulation analysis of the 5 buildings using Google SketchUp 8 for various sunlight values and various periods is shown in Figure 9. The set value for the analysis is the path of the sun on 23 March 2014, 22 June 2014 and 22 December 2014 because the analysis results are compared with the requirements specified in the guideline solutions. The layout of the buildings, the style and size of the openings around the building, the building envelope materials, and the position and type of vegetation around the building were improved by trial and error method to minimize the sunlight stroked to the buildings using the analysis data of the sunlight direction presented in section 3.3 until the OTTV and RTTV are in compliance with the Thai energy efficient building standard. It is noted from that OTTV and RTTV values are significantly dependent upon the area and materials of walls and roofs. The value presented in Table 2 were used as input parameters for OTTV and RTTV calculations.

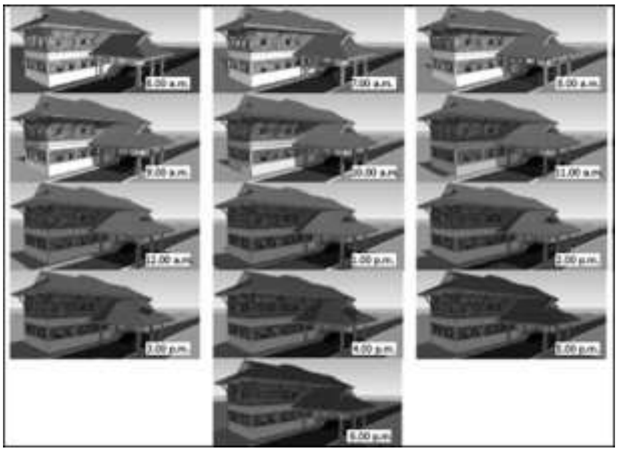


Fig. 9. Example of the simulation of sunlight striking the office building envelope on 22 June 2014 (6.00 am – 6.00 pm).

3.5 Calculation results for OTTV and RTTV

In this study, the OTTV and RTTV were calculated using OTTVEE Version 1.0a. The OTTV and RTTV of all of the buildings are within the prescribed Thai energy-efficient building standard (OTTV < 30 Watt/m^2 and RTTV < 10 Watt/m^2) (Ministry of Energy, 2014). The hospital building has an OTTV of 29.21 Watt/m^2, the office building has an OTTV of 25.01 Watt/ m2 and both buildings have the same RTTV of 9.60 Watt/m^2. The multipurpose building has an OTTV of 28.51 Watt/m^2 and an RTTV of 9.34 Watt/m^2. The dormitory for the elderly has an OTTV of 26.60 Watt/m^2 and an RTTV of 9.20 Watt/m^2. Finally, the canteen building has an OTTV of 23.23 Watt/m^2 and an RTTV of 8.81 Watt/m^2.

To conclude, a comparison of building details between the existing and new nursing home is summarized in Table 6. Facilities of elderly, green building, energy saving are compared and presented. The existing nursing home has unsuitable facilities for the elderly. It is very old and located in inappropriate area and has no plan for sustainable management. The new nursing home has however been designed to have a suitable project location, lay out planning, and facilities based on environmentally friendly, energy saving and high efficiency principles.

4. Conclusions

This paper presents the design for the new Thammapakon Pho Klang Nursing Home. The nursing home aims to provide appropriate facilities for the elderly in Thailand and to optimize resource utilization related to energy consumption, water management, waste management and environmentally friendly materials. The project also seeks to decrease the impact of the building on the health of the residents and the environment and promotes the health of the building users throughout the building's lifetime: design, construction, operation, maintenance and final demolition. The design is based on the evaluation criteria of Thailand's Rating of Energy and Environmental Sustainability (TREES), which were established by the Thai Green Building Institute (TGBI).

Table 6. Comparison of existing nursing home and new nursing home.

Topic/ Factors	Items	Existing Buildings		New Buildings	
		Meet the requirement	Remark	Meet the requirement	Remark
Facilities of elderly (Human Factors Engineering)	Sign	x	A few direction signs but not cover all areas	/	Direction signs covered all area
	Ramp	x	Only one ramp at first aid room. No ramp at any stepped areas.	/	Ramps at all stepped areas.
	Stair	x	Unsuitable dimension observed for all stairs.	/	Suitable dimension for elderly.
	handrail	x	Unsuitable dimension for some handrail.	/	Suitable dimension for elderly.
	Elevator	x	The elderly dormitories were two stories building without elevator	x	No elevator because all buildings are 1 story building
	Parking	/		/	
	Pathway	/		/	
	Toilet	x	Unsuitable for elderly. Neither handrail in toilet nor toilet for disable person	/	Full facilities for elderly in toilet and toilet for disable persons provided
Green building	Building manage-ment	x	Very old buildings and with no plan for building management	/	New building with building management

Table 6. Comparison of existing nursing home and new nursing home. (cont.)

Topic/ Factors	Items	Existing Buildings		New Buildings	
		Meet the requirement	Remark	Meet the requirement	Remark
Green building	Site and Lands-cape	x	In downtown and poor pollution	/	Located in a good environment
	Water conser-vation	x	No plan for water conservation	/	Available plan for water conservation
	Materials and resources	/	Wood and concrete	/	Efficiency materials
	Indoor environmental quality	x	Solid window with no natural light	/	With natural light, and good ventilation
	Environmental protection	/	Buildings with septic tanks	/	Buildings with septic tanks
Energy saving	Using energy saving and cost	/	All buildings had staff to control energy used	/	Designed with energy saving concept
	Renewable energy using energy efficiently	x		/	Solar cells used in this project
	The use of tools and equipment with high performance.	x		/	Available high performance tools and equipment.
	Reduce Reuse Recycle	x		/	Available 3R.

The Thammapakon Pho Klang Nursing Home is divided into 3 zones: public, semi-public and private to control accessibility by various parties and to provide for the safety of the elderly. The original environment is retained as much as possible, and the unnecessary removal of trees is avoided. If necessary, trees are removed and planted in other areas by specialists. More than 40% of the project area is green space. The hardscape area of the designed buildings is decreased using low thermal-reflective materials, paving blocks with water permeability and planting trees to provide shade.

The design considers the management of the water that flows through the project. For example, sufficient drainage areas are provided, and at least 50% of the surface of the entire project facilitates water seeping into the ground (Thai Green Building Institute, 2014). A water collection system for reuse and solar lamps for outdoor lighting are included in this design.

Due to restrictions on the layout of the buildings, certain buildings (such as the dormitory for the elderly and the office building) face east-west and are strongly affected by sunlight. The dormitories are spaced 8 meters apart so the shadow of one building shades the neighboring building. Planting trees in the space between the buildings can also decrease the amount of heat that enters the building and enables the breeze to blow throughout the structure.

The roofs of all of the designed buildings are Manila or hip style with 30-degree slopes, long eaves and a ventilation opening on the roof. Thermal protection for roofs is provided by a reflective heat sheet beneath the roof tile, insulation on the ceiling and a vented soffit. The heat that enters the building is decreased by the balcony on the side and the front of the building, and the heat reflection is decreased by carefully organizing the elements of the landscaping and layout around the building.

A building envelope constructed from aerated concrete (a double wall with a gap in the middle) and smooth plaster is used in all of the designed buildings, which decreases and slows heat flow into the buildings. Painting the walls with light colors decreases the absorption of thermal radiation and the amount of heat that enters the buildings. For doors and windows, aluminum frames and door frames with natural color and amber glass are used.

In the dormitory, sliding doors and windows are used for safety and convenience. The bedroom windows are cross-sliding. The buildings are open on at least two sides for better air flow, and trees should be planted to shade the opening. Standard doors are the sliding type with an opening width of not less than 1.20 meters. The living rooms and bedrooms of the dormitory for the elderly use sliding glass doors and windows. Openings are placed deep into the building, and natural light is allowed to pass through these openings. In addition, louvers attached to the walls between the stacked roofs facilitate natural lighting and better airflow into the building.

Planting shrubs around and between the buildings and planting a small-canopied perennials at the east side of the building with an interval of 4.50 meters can improve air flow and let natural light into the building at certain times to provide good ventilation and decrease moisture. Planting standing trees with relatively sparse canopies prevents sunlight from falling on the south side. Planting standing trees with dense canopies on the west side blocks the afternoon and evening sun.

Each building stores rainwater on the roof using the rain gutter at the eaves to transfer the rainwater to a storage tank. The turbidity of the rainwater is decreased by a sediment filter. The treated rainwater is subsequently used for watering plants or building sanitation. Effluent from showers and sinks is treated in sedimentation ponds and reused, primarily to water plants. Wastewater from toilets is treated in a treatment tank (one per building) and subsequently delivered to the drainage. Water-saving sanitary equipment is used in the bathrooms. Effluent from the kitchen must pass through a grease trap prior to release into the drainpipe. Materials were selected that do not emit harmful substances, such as volatile organic compounds (VOC) and formaldehyde. A fan is used to provide adequate ventilation in the building and to increase the air circulation rate.

The building facilities are designed according to universal design and human-factors engineering. Human-factors engineering data were used to design the interior components of the nursing home. For example, the handrail diameter is 30 – 40 mm, the handrail height is 0.80 m, the stair riser is 0.13 – 0.15 m and the tread is 0.30 m. In addition, the furniture has few sharp angles and no wheels, lever-style door handles are used, the chair/bench and bed heights are 0.45 m to facilitate standing/sitting of the elderly, the table height is 0.75 m and the space beneath the table has a height of not less than 0.60 m.

Computer-aided design was used to create an efficient, suitable design. In this study, 2 programs were used: Google SketchUp 8 and OTTVEE version 1.0a. Google SketchUp 8 was used to investigate the sun direction for designing the layout of the buildings, the style and size of the openings around the buildings, the building envelope materials and the position and type of vegetation around the buildings. OTTVEE version 1.0a was used to calculate the overall thermal transmission value (OTTV) and the roof thermal transmission value (RTTV). The OTTV and RTTV of all of the designed buildings are within the prescribed energy-efficient building standard (OTTV < 30 Watt/m^2 and RTTV < 10 Watt/m^2). Although the building materials are the same for all of the buildings, the OTTVs and RTTVs vary because the area of the roofs and window sizes as well as the exposure of each building differ.

The result of this study improves quality of life for the elderly. Good physical and mental health in the elderly decreases the economic and social problems of the country. The energy-saving ideas used in this design reflect the sustainable use of construction resources and an environmentally friendly perspective.

Acknowledgements

The authors would like to thank the Foundation of Thai Gerontology Research and Development Institute, Suranaree University of Technology and the Higher Education Research Promotion and National Research University Project of Thailand, Office of Higher Education Commission, for funding the research. Thanks are extended to the Nakhon Ratchasima Provincial Administrative Organization (KORAT PAO) and the elderly nursing home staff and instructors from the Institute of Nursing, SUT, for their assistance in data collection and recommendations.

References

Associate of Siamese Architects under Royal Patronage, Universal Design Code of Practice issue B.C.2551, Bangkok, 2008.

College of Population Studies, Chulalongkorn University, Database of elderly population. [Internet]. [cited 2012 Aug 14]. Available from: http://www.cps.chula.ac.th/research_division/article_ageing/ageing_001.html.

Department of the Interior,Ministry of Interior, Statistics and data. [Internet]. [cited 2012 Aug 14]. Available from: http://www.oppo.opp.go.th/pages/statistics/stat_2553/Stat53_001.pdf.

Department of Alternative Energy Development and Efficiency, Ministry of Energy, Guide to Energy Conservation in Buildings, Bangkok, 1993.

Department of Alternative Energy Development and Efficiency, Ministry of Energy, Design guideline for energy conservation building "Glass", Bangkok, 1993.

Department of Alternative Energy Development and Efficiency, Ministry of Energy, Design guideline for energy conservation building "insulation", Bangkok, 1993.

Department of Alternative Energy Development and Efficiency, Ministry of Energy, Design guideline for energy conservation building “Material and Equipment for Energy Conservation”, Bangkok, 1993.

Department of Alternative Energy Development and Efficiency, Ministry of Energy, Insulation saves energy, Bangkok, 1993.

Department of Alternative Energy Development and Efficiency, Ministry of Energy, Electricity savings in air conditioning system for office buildings, Bangkok, 1993.

Foundation of Thai Gerontology Research and Development Institute, Elderly situation in Thailand B.C.2009, Bangkok, 2010.

Fund for the promotion of energy conservation, Building design to suit the environment, Bangkok, 2004.

Fund for the promotion of energy conservation, Installing awnings to block the sunlight, Bangkok, 2004.

Fund for the promotion of energy conservation, Installing insulation under the roof, Bangkok, 2004.

Fund for the promotion of energy conservation, Taking advantage of the natural light and air, Bangkok, 2004.

Fund for the promotion of energy conservation, The cooling of buildings, Bangkok, 2004.

Fund for the promotion of energy conservation, Windows and awnings, Bangkok, 2004.

Salvendy, G., 2012. Handbook of Human Factors and Ergonomics 4th ed., New Jersy: John Wiley & sons, inch: pp 1752.

Ministry of Energy, The program encourages the use of T5. [Internet]. [cited 2014 Oct 8]. Available from: http://t5.egat.co.th/detal1.htm.

Ministry of Energy, The ministerial regulation of The Types, Sizes, Standard, Guideline and Method to design the building conservation, [Internet]. [cited 2014 Oct 8]. Available from: http://www.scribd.com/doc/19251353/Energy-2552#about.

Onbhuddha, P., 2006. An optimun roof design for reducing indoor thermal Environment of house by computational fluid dynamics, Master’s thesis, Department of Energy Management Technology, School of Energy, Environment and Materials, King's Mongkut University of Technology, Thonburi, 2006.

Macnolia Quality Development Corperation limited,How to create thermal comfort. [Internet]. [cited 2014 Nov 15]. Available from: http://www.magnolia.co.th/th/project/story.php

Sukmak, P., Horpibulsuk, S., Shen, S. L., 2013. Strength development in clay–fly ash geopolymer, Construction and Building Materials, **40**: pp 566-574.

Punyakeaw, S., 2003. The improvement of residential roof using low cost material in order to reduce heat transfer, Bangkok: Master’s thesis, Department of Architecture, Faculty of Architecture, Silapakorn University.

Thai Green Building Institute, Thai's Rating of Energy and Environmental Sustainability for New Construction and Major Renovation. [Internet]. [cited 2014 Feb 13]. Available from: http://www.tgbi.or.th/trees.php.

Thai Meteorological Department, Knowledge of Meteorology, [Internet]. [cited 2015 Feb 3]. Available from:http://www.tmd.go.th/info/info.php?FileID=22.

Suwanrada. W., Chalermwong. D., Kamjuti W., Kamruangrit S. and Boonma J., 2010. Long Term Care System for Old-age Security research project, Saksopa Printing, Bangkok, 2010.

Symbols and abbreviations

A_i	overall area of the external wall or roof (m^2)
$OTTV_i$	overall thermal transmission value of the external wall (W/m^2)
$OTTV_{wall}$	overall thermal transmission value of whole external walls (W/m^2)
$RTTV_i$	roof thermal transfer value (W/m^2)
$RTTV_{roof}$	overall thermal transmission value of whole roofs (W/m^2)
SC	shading coefficient of fenestration of wall or roof (0< SC <1)
SF	solar factor for wall (W/m^2)
SHGC	solar heat gain coefficient
SKR	skylight ratio of roof (skylight area/gross area of roof)
SR	solar factor for roof (W/m^2)
TD_{eq}	equivalent temperature difference (K)
U_f	overall thermal transmission coefficient of fenestration ($W/m^2.K$)
U_r	thermal transmittance of opaque roof ($W/m^2.K$)
U_s	thermal transmittance of skylight area ($W/m^2.K$)
U_w	U-value of opaque wall ($W/m^2.K$)
WWR	window-to-wall ratio for wall (0 < WWR < 1)
ΔT	temperature difference between interior and exterior (K)