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BUILDING ORIENTATION SELECTION FOR THERMAL COMFORT FIELDWORK MEASUREMENT: A SYSTEMATIC LITERATURE REVIEW

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Abstract

Building orientation is a significant design consideration, mainly with regard to solar radiation and wind. The orientation of buildings has an important influence on the side of thermal comfort. In predominantly hot humid regions like Malaysia which receives sunlight all year around, buildings should be oriented to minimize solar gain and maximize the comfort. Therefore, it is crucial for residential buildings to be oriented in the best orientation to get more comfort for its occupants since most of the people spend their time inside the house. The overall aim of the study is to determine the effects of orientation towards thermal comfort condition and occupants' satisfaction in low cost detached housing while the purpose of this paper is to review the research method of determining the orientation that will be carried out during the fieldwork measurement of thermal comfort. There are various orientations used by previous researchers. Hence, this paper will examine them to get the best solution in deciding the orientation for the thermal comfort fieldwork experiment, using a Systematic Literature Review (SLR).

Keywords: *building orientation; method of orientation; residential building; low cost house; systematic literature review (slr)*

1.0 INTRODUCTION

Orientation of building is important to its overall comfort and occupant's satisfaction in the building. A properly oriented building may reduce heating and cooling while maintaining comfort to its occupant (EcoWho, 2017). Building orientation has strong correlation with wind direction and sun radiation (Prianto et al., 2000). Every region in the world has a specific climatic behaviour; some places might be too hot or too cold and some other in between. Prior to every construction, there is an important decision to be taken in determining the building location; the orientation. Malaysia is a tropical country described as warm and humid within the Capricorn and Cancer Tropics. The latitude of 1° - 7°N and longitude 100° - 119°E. Malaysia is considered a tropical rainforest climate, where it is mainly characterized by low-pressure systems because it is dominated by doldrums and therefore receives rainfall throughout the year. It is a hot and humid country, particularly in the major cities and towns. Throughout the year, the climate elements are categorized as high temperature and uniform diurnal pattern. This will turn the building to its most important side so that occupants (users) will have the best living conditions even when the weather outside is not too conducive (Anumah & Anumah,

2017). In the tropics, buildings should maximally avoid direct sun and try to make a barrier between it and living space.

A building's orientation is the direction that is faced by its external facades. Building orientation can affect a building's indoor climate in two respects, i.e. by solar radiation and the heating effect on walls through windows facing different directions; and ventilation problems associated with the relationship between the direction of prevailing winds and the orientation of the building (Givoni, 1994). Building orientation is an important parameter that affects the degree of solar radiation obtained on a building façade and solar radiation is a primary factor that influences the cooling load in buildings (Mingfang, 2002). In most climate zones, the optimal orientation would be a north-south orientation with the long façade facing the equator minimizing the façade areas facing east and west (Haase & Amato, 2009).

2.0 LITERATURE REVIEW

2.1 Building Orientation

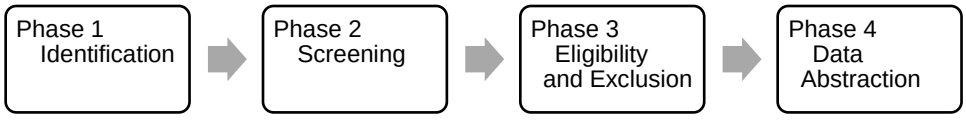
In Malaysia, the east and west facades expostulate each morning and evening to direct sunlight, while the north façade faces sunlight during May, June, July and August, and the south façade faces it during November, December, January and Feb. Building orientation should therefore be taken seriously, especially in the tropical region, in terms of its interaction with solar radiation and wind direction (Al-Tamimi, Syed Fadzil & Wan Harun, 2011). Givoni (1994) stated that the provision of efficient cross ventilation under local wind direction in hot humid regions is the major factor that could affect the orientation of the building.

The amount of solar radiation which the building envelope receives depends on its orientation. Knowledge of the propagation of solar radiation due to its orientation is an important clue in the creation of energy efficient facades. Buildings must be scheduled in such a way that they benefit from shaded indoor and outdoor living areas when the weather is hot. The sun's high angle makes it easy to shade the house through a generous overhang to the roof. This is because the sun is much lower in the sky and favours the vertical surface during the day (Al-Obaidi & Woods, 2016).

3.0 METHOD OF USING SYSTEMATIC LITERATURE REVIEW

A Systematic Literature Review was utilised to obtain related literature on the effect of orientation towards occupant satisfaction. The reviewers used SLR methodology to produce a suggested best orientation in order to decide for field measurement. There are four phases in the SLR method.

Figure 1: Phases involved in SLR



3.1 Phase 1: Identification of Literature

First, related topics or terms related to building orientation and occupants satisfaction were identified through a rigorous search. The identification was conducted by query searching that allows for a systematic search via established publication databases. The literature search conducted was finalized in August 2020. The literature search focused on studies conducted in the last ten years (2010 to 2020). For the systematic literature search the two databases scopus as well as Web of science were chosen. These two databases covered more than 11,000 journals.

In this phase, related published papers were sought from the two databases search engines. The articles published in English that include in their title or abstract the keywords:

(“orientation” OR “direction” OR “side” OR “position”) AND (“occupant” OR “resident” AND “satisfaction” OR “comfort”) AND (“residential building” OR “urban” OR “housing” OR “house”) were searched.

Table 1: SLR search string

Database	Keywords
Scopus	TITLE-ABS-KEY ((((“orientation” OR “direction” OR “side” OR “position”) AND (“residential building” OR “urban” OR “housing” OR “house*))) AND (LIMIT-
WoS	TS = (“orientation” OR “direction” OR “side” OR “position”) AND (“residential building” OR “urban” OR “housing* OR “house*).

3.2 Phase 2: Screening of the Identified Literature

The identified literature was screened to suit the building orientation and occupant’s satisfaction. However, there were no records found for the articles that included ‘occupants satisfaction’. The researcher then decided to stick with the words ‘building orientation’ as the aim of this paper is to find the best selection of building orientation for thermal comfort fieldwork measurement and the type of building which is residential building or housing.

Out of 45 published literary works, 19 were found to suit the topic of this paper, which is the building orientation selection for the thermal comfort fieldwork measurement and the residential building. The screen excluded any literature duplicates such as similar authors, similar research titles and non English publications.

3.3 Phase 3: Eligibility and Exclusion

The next phase was eligibility and exclusion. The remaining 19 literature items were reviewed thoroughly. After an extensive review, 10 items were removed because they either did not have the information on the method of determining the building orientation or the buildings referred to were not residential buildings. At this stage, 9 literature items were used for SLR. All the data in the items were analysed and abstracted. A systematic literature review was tabulated with Author(s), Year of Publication, Type of Building, Orientation Sides and Method of Determining Building Orientation.

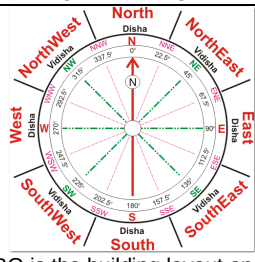
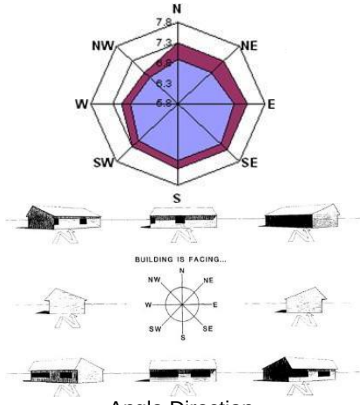
3.4 Phase 4: Items Abstraction

The last phase is abstraction. In abstraction, the building orientation was categorized into two groups. The first is with 4 sides of building orientation and the second is with 8 sides of building orientation. This abstraction later formed the suggested building orientation selection for thermal comfort fieldwork measurement. For this paper, only one group was chosen for the best selection of building orientation in order to measure the thermal comfort.

4.0 ANALYSIS AND DISCUSSION

Table 1 shows the analysis from the literature review of the orientation sides, type of building and the method of determining the building orientation.

Table 2: Analysis of orientation, type of building and the method determining building orientation

BIL	AUTHORS	ORIENTATION SIDES	TYPE OF BUILDING	METHOD DETERMINE ORIENTATION
1.	Vaca, (2015)	8 sides NE, E, SE, S, SW, W, NW, N	Residential Building	
2.	Valladares-Rendon et al., (2016)	4 sides E, W, N, S	Residential Building	BO is the building layout on a horizon plane or the sun's path pointing at an AZM angles between 0° and 360°. Typically, N is 0° or 360°, E is 90°, S is 180° and W corresponds to the 270°
3.	Prasad et al., (2017)	4 sides N, S, W, E	Residential Building	Long Façade facing with Angle N - 0° - 90° E – 90° - 180° S - 180° - 270° W - 180° - 360°
4.	Nie et al., (2015)	4 sides W, E., N, S	Residential Building	Angle Direction 90°=north, 180°=west, 270°=south, 0°=east
5.	Al-obaidi & Woods (2016)	8 Sides north, northeast, east, southeast, south, southwest, west and northwest	Residential Building	North = 0 North-East = 45 East = 90 South-East =135 South = 180 South-west = 225 West =270 North-West = 315
6.	Morrissey et al, (2011)	8 Sides north, northeast, east, southeast, south, southwest, west and northwest	Residential Building	
7.	Bekkouche et al., (2013)	4 sides S, E, W, N	Residential Building	Angle Direction

Building orientation is important in order to decide for fieldwork measurement of thermal comfort. Building orientation is also an important parameter that affects the degree of solar radiation obtained on a building façade and solar radiation (Mingfang, 2002). From the table above, there are two groups of building orientation in the 9 selected literature. First group is for 4 sides of building orientation and the second group is for 8 sides of orientation. All the building

types were similar, which is a residential building. It can be seen that the authors used the same method in order to determine the building orientation which is by using angle direction which are N - 0° - 45°, E – 90° - 135°, S - 180° - 225°, W - 180° - 315° (see Figure 2). From the analysis above, more authors used 4 sided orientation than those using 8 sides of orientation. It is suggested that 4 sides of building orientation which are North, South, East and West orientation were the best selection of orientation because these four orientations are the most used based on the analysis above.

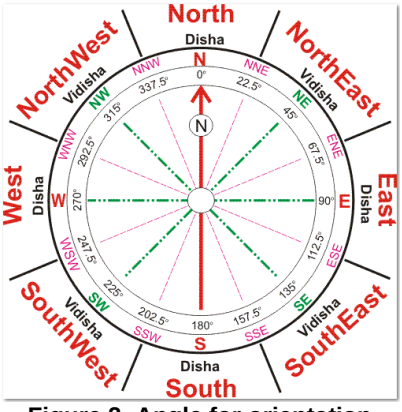


Figure 2: Angle for orientation

(Source: Vaca, (2015)

5.0 CONCLUSIONS

This systematic literature review highlights the selection of the building orientation that should be considered in order to be used for thermal comfort fieldwork measurement in residential buildings. The building orientation can be determined by using angle direction. This will help the researcher to identify the orientation of the building during the fieldwork measurement. Therefore, it can be concluded that the best selection building orientation for thermal comfort fieldwork measurement was the 4-side of orientation (North, South, West and East).

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