CHAPTER II
LITERATURE REVIEWS

2.1.Thermal Comfort

According to *ANSI/ASHRAE Standard 55*, thermal comfort is the condition of mind which expresses satisfaction towards the thermal environment; assessed by subjective evaluation (ANSI, 2017). From one perspective, human body is an engine that generate excess heat into its surroundings to continue operating. This heat transfer is proportional to temperature differences in the environment. Cold environment leads to more heat exerted, while hot environment leads to insufficient heat exerted; both scenarios lead to discomfort (Çengel & Boles, 2015). One of the most important goals of HVAC (heating, ventilation, and air conditioning) system is to maintain this standard of thermal comfort for buildings/enclosures. While most people would feel comfortable at room temperature (**20-22˚C**), this value may vary greatly between individuals and also depend on factors such as activity and clothing. Acclimatization also plays a role in determining an individual's thermal comfortability; stemming from some differences in humans living in different climate including sweat distribution, core-to-skin temperature gradient, and body fluid regulation (Tochihara, et al., 2022). Thermal comfort is influenced by 2 major ranges which determine heat gain and loss: **human thermal comfort ranges**, and **room thermal comfort ranges**.

Psychological parameters such as individual expectations – being quite uncommonly taken into account, also affect thermal comfort (de Dear & Brager, 1998). Among the most recognized thermal comfort models is the **PMV** (Predicted Mean Vote) model; developed using principles of heat balance and experimental data collected in a controlled climate chamber under steady state conditions (Fanger, 1970). On the other hand, the **adaptive model** was developed based on numerous field studies with the main idea being occupants dynamically interact with their environment – by means of clothing, operable windows, fans, personal heaters, and sun shades (de Dear & Brager, 1998). The PMV model is used to calculate on air-conditioned buildings, while the adaptive model is used to calculate on buildings where no mechanical systems have been installed (ANSI, 2017). No consensus about which model should be used for calculations on partially air-conditioned buildings both spatially or temporally.

These set of thermal comfort standards are directly taken from the Indonesian national standard for **design procedures for ventilation and air conditioning systems in buildings**: **SNI 03-6572-2001** – derived from *ASHRAE Handbook: Fundamentals, 1997*.

2.1.1. Human Thermal Comfort Ranges

Several factors contribute to human's thermal comfortability ranges. These factors include:

a) Dry air temperature

Dry air temperature has a significant impact on how much heat was lost due to evaporation and convection. Thermal comfort ranges for tropical regions are divided as follows:

1) Comfortably cool : effective temperature **20.5 – 22.8˚C**
2) Optimal comfortability : effective temperature **22.9 – 25.8˚C**
3) Comfortably warm : effective temperature **25.9 – 27.1˚C**

b) Relative air humidity

Defined as a ratio between the amount of water vapor contained within the air and the amount of water vapor contained within the air, *in a saturated state*. For tropical regions, the recommended relative air humidity range is within **40-50%**. An exception can be made for places with more population density; with the acceptable range within **55-60%**.

c) Air velocity

To maintain comfortability, the maximum air velocity allowed to fall above head **may not exceed 0.25$^{m}/_{s}$** and is recommended to be **less than 0.15$^{m}/_{s}$**. Air velocity may exceed than 0.25$^{m}/_{s}$ depending on the dry air temperature with the ratio as follows:

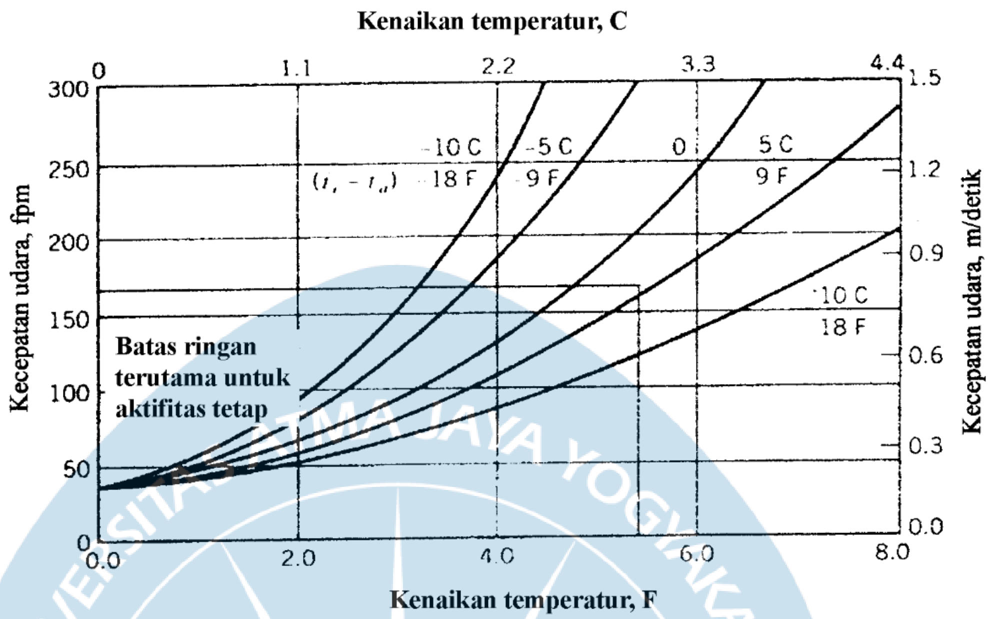
Table 2.1 Comfortability Ratio between Air Velocity and Dry Air Temperature

Air velocity (m/s)	0.1	0.2	0.25	0.3	0.35
Dry air temperature (˚C)	25	26.8	26.9	27.1	27.2

Source: (SNI 03-6572-2001, 2001)

Following the ratio presented in the table, air velocity need to be increased to compensate an increase in dry air temperature. The complete ratio can be seen in the following chart:

Chart 2.1 Air Velocity Increment to Compensate Dry Air Temperature Increase



Source: (SNI 03-6572-2001, 2001)

As pictured in the chart above, air velocity is directly proportional to dry air temperature; yet also depends on the kinds of activities in a room. For instance, if a room has a dry air temperature of 25˚C with 0.15$^{m}/_{s}$ is subjected to a temperature increase of 2.2˚C to 27˚C, the following changes apply:

- On a very low metabolic activity – presented in the chart as the lowest curve, air velocity would need to be at least 0.35$^{m}/_{s}$ to maintain comfortability.
- On a very high metabolic activty – presented in the chart as the highest curve, air velocity would need to be at least 1.2$^{m}/_{s}$ to maintain comfortability.

d) Surface radiation

Surface radiation temperature is recommended to be at the same level as dry air temperature in a room. The average temperature between mean radiation and room dry air temperature is defined as **operative temperature**. For low air velocity (v=0.1$^{m}/_{s}$), the operative temperature can be determined using the following formula:

$$t_{OP} = \frac{t_{RAD} + t_{ROOM}}{2}$$

t_{OP} : Operative temperature (˚C)

t_{RAD} : Mean radiation temperature (˚C)

t_{ROOM} : Room dry air temperature (˚C)

Source: (SNI 03-6572-2001, 2001)

e) Human activities

To calculate the requirement for air conditioning, it's recommended to use the sum of heat generated by individuals on certain activities. The following table contains a list of activities each with its usage types and heat outputs:

Table 2.2 Heat Gain Rate from Individual(s) Inside A Conditioned Room

Tingkat aktivitas	Tipe penggunaan	Kalor total Dewasa, pria		Kalor total yang disesuaikan untuk wanita. [b]		Kalor sensibel		Kalor laten	
		Btu/jam	W	Btu/jam	W	Btu/jam	W	Btu/jam	W
Duduk di gedung pertunjukan	siang hari	390	114	330	97	225	66	105	31
Duduk di gedung pertunjukan.	malam hari	390	114	350	103	245	72	105	31
Duduk, kerja amat ringan	Kantor, hotel, apartemen	450	132	400	117	245	72	155	45
Kerja kantor dengan keaktifan sedang	Kantor, hotel, apartemen.	475	139	450	132	250	73	200	59
Berdiri, kerja ringan, berjalan	Pusat belanja, pertokoan.	550	162	450	132	250	73	200	59
Berjalan; berdiri	Apotik, Bank	550	162	500	146	250	73	250	73
Pekerjaan terus menerus. [c]	Restoran	490	144	550	162	275	81	275	81
Pekerjaan bengkel ringan	Pabrik	800	235	750	220	275	81	475	139
Berdansa	Hal dansa	900	264	850	249	305	89	545	160
Berjalan 3 mph; pekerjaan mesin yang ringan	Pabrik	1000	293	1000	293	375	110	625	183
Bowling. [d]	Bowling alley.	1500	440	1450	425	580	170	870	255
Pekerjaan berat	Pabrik	1500	440	1450	425	580	170	870	255
Pekerjaan mesin yang berat, mengangkat	Pabrik	1600	469	1600	469	635	186	965	283
Atletik	Gimnasium	2000	586	1800	528	710	208	1090	320

Source: (SNI 03-6572-2001, 2001)

The table above breaks down types of activities, their usage types, and heat gains from each activities divided by three categories: total heat, sensible heat, and latent heat. Sensible heat is when heat exchanged in the body changes its temperature, while latent heat is when energy is released by the body during a constant-temperature process. The sum of these heat gains add up to total heat gain; all using Btu/h and/or Watts. Btu/h stands for British Thermal Unit; the amount of heat required to raise 1 pound (0.45kg) by 1˚F (0.556˚C) per hour.

All of the values presented above is based on dry air temperature of **23.89˚C** (75˚F). For 26.67˚C (80˚F) heat total remains the same, sensible heat must be decreased by 20%, while latent heat must be increased by the same amount. The heat gain is based on average normal man, woman, and children percentage in accordance with the usage list, with a special formula: the increment for adult female counts for 85% of an adult male, while children counts for 75% of an adult male.

f) Clothing

Heat output depends on the clothing being worn at the time – coined as **clothing thermal isolation** (**clo**). The thermal isolation from clothing materials uses the following formula:

$$1clo = 0.155^{m^2K}/_{watt}$$

Source: (SNI 03-6572-2001, 2001)

Each clothing materials differ in their values – seen in the following table:

Table 2.3 Thermal Isolation Values on Clothing Attributes

Pria	clo	Wanita	clo
Singlet tanpa lengan	0,06	Kutang dan celana dalam	0,05
Kaos berkerah	0,09	Rok dalam – setengah	0,13
Celana dalam	0,05	Rok dalam – penuh	0,19
Kemeja, ringan lengan pendek.	0,14	Blus – ringan	0,20 (a)
Kemeja, ringan lengan panjang.	0,22	Blus – berat	0,29 (a)
Waistcoat-ringan	0,15	Pakaian – ringan	0,22 (a,b)
Waistcoat-berat	0,29	Pakaian – berat	0,70 (a,b)
Celana – ringan	0,26	Rok - ringan	0,10 (b)
Celana – berat	0,32	Rok – berat	0,22 (b)
Sweater – ringan	0,20 (a)	Celana panjang wanita – ringan.	0,26
Sweater – berat	0,37 (a)	Celana panjang wanita – berat.	0,44
Jacket – ringan	0,22	Sweater – ringan	0,17 (a)
Jacket – berat	0,49	Sweater – berat	0,37 (a)
Kaos tumit	0,04	Jacket – ringan	0,17
Kaos dengkul	0,10	Jacket – berat	0,37
Sepatu	0,04	Kaos kaki panjang.	0,01
Sepatu bot	0,08	Sandal	0,02
		Sepatu	0,04
		Sepatu bot	0,08

Source: (SNI 03-6572-2001, 2001)

Each clo value is reduced by 10% if the corresponding attribute has short sleeves or no sleeves at all. If the attribute's length is above the knee, additional 5% need to be deducted from the clo value; and vice versa. To calculate the clo value of all the attributes being worn, the following formulas are used:

For male:

$$clo = 0.727\ \Sigma_{clo} + 0.113$$

For female:

$$clo = 0.77\ \Sigma_{clo} + 0.05$$

Source: (SNI 03-6572-2001, 2001)

g) Activity and clothing effects on operative temperature

Heat output generated from activities can also be coined as **met**; used in the following formula:

$$1met = 58.2^{W}/_{m^2}$$

Source: (SNI 03-6572-2001, 2001)

m^2 is a total skin area of the individual and can be determined using the following formula:

$$A_{skin} = 0.202\ m^{0425}\ h^{0725}$$

m : Body mass (kg)

h : Body height (m)

Source: (SNI 03-6572-2001, 2001)

Different activities also hold different met values can be seen in the following table:

Table 2.4 Heat Generated by Different Activities

	Btu/(jam-ft^2)	met
Istirahat		
Tidur	13	0,7
Santai	15	0,8
duduk, tenang	18	1,0
berdiri, rileks.	22	1,2
Berjalan pada jalan datar :		
0,89 m/detik.	37	2,0
1,34 m/detik.	48	2,6
1,79 m/detik.	70	3,8
Aktivitas kantor :		
Membaca, duduk.	18	1,0
Menulis	18	1,0
Mengetik	20	1,1
Mengarsip, duduk.	22	1,2
Mengarsip, berdiri.	26	1,4
Berjalan	31	1,7
Mengangkat, membungkus.	39	2,1
Menyetir atau menerbangkan :		
Mobil	18~37	1,0~2,0
Pesawat terbang, rutin.	22	1,2
Pesawat terbang, instrumen mendarat.	33	1,8
Pesawat terbang, tempur.	44	2,4
Kendaraan berat.	59	3,2
Lain-lain aktivitas penghuni :		
Memasak	29~37	1,6~2,0
Membersihkan rumah	37~63	2,0~3,4
Duduk, gerakan berat anggota badan	41	2,2
Pekerjaan mesin :		
Menggergaji (meja gergaji).	33	1,8
Ringan (industri kelistrikan)	37~44	2,0~2,4
Berat	37 ~ 44	4,0
Mengangkat tas 50 kg.	74	4,0
Mengambil dan pekerjaan mencangkul.	74 ~ 88	4,0~4,8
Lain-lain, aktivitas waktu luang :		
Berdansa, sosial.	44~81	2,4~4,4
Senam	55~74	3,0~4,0
Tenis, tunggal.	66~74	3,6~4,0
Basket bal.	190~140	5,0~7,6
Gulat, pertandingan	130~160	7,0~8,7

Source: (SNI 03-6572-2001, 2001)

2.1.2. Room Thermal Comfort Ranges

Aside from human's comfortability ranges, room thermal comfortability range also play a part in determining heat gain and loss.

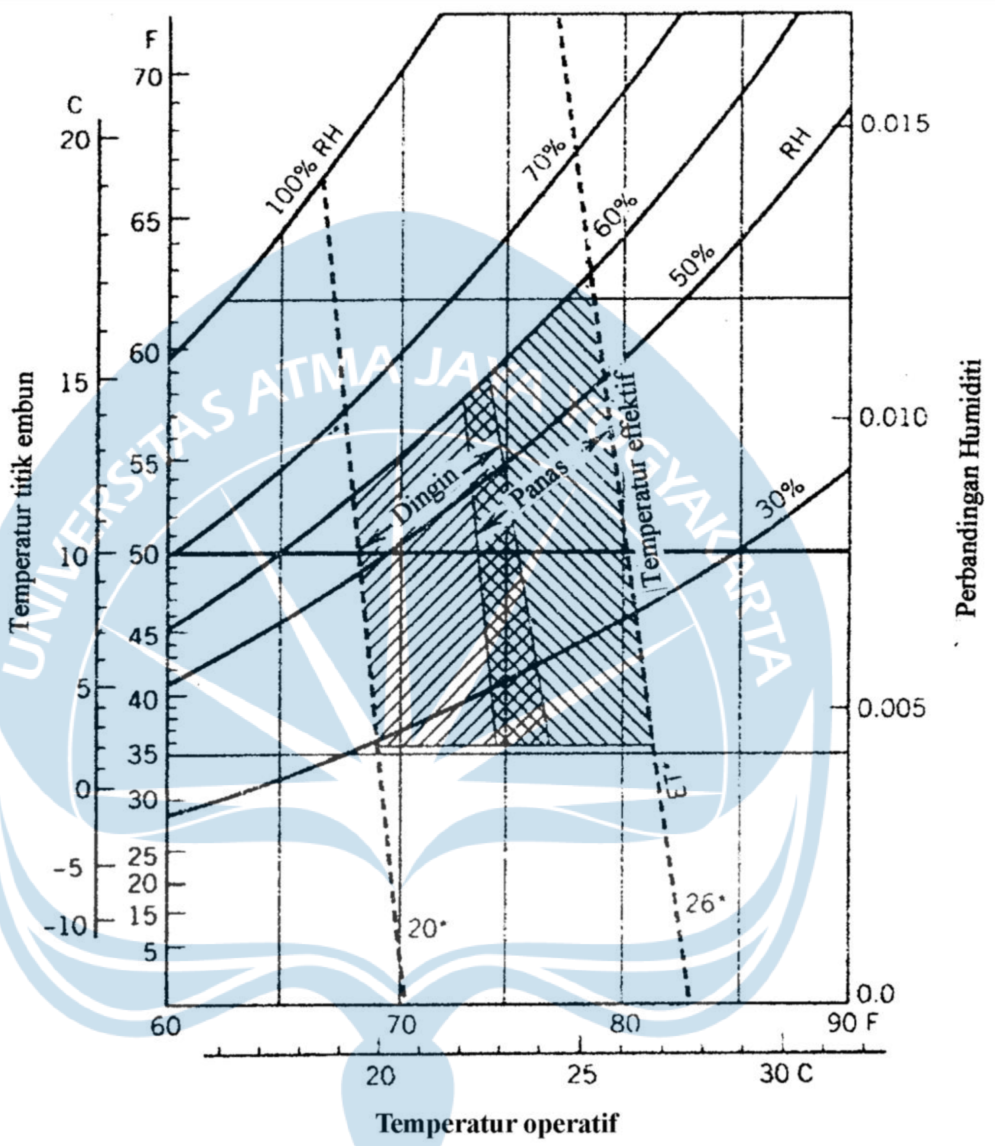
a) Effective temperature

Defined as environmental index combining air temperature and humidity into one index – an individual's response to a specific conditions remains the same even when the temperature and humidity differs; with the exception of air velocity needs to remain the same. According to *ASHRAE*, effective temperature is defined as air temperature equivalent to isothermal environment with 50% relative humidity – where individuals wear standard clothing and doing particular activities, and generates the same skin temperature and wetness.

b) Operative temperature

To achieve an acceptable zone as an operative temperature zone with relative air humidity which complies to human thermal comfort standards for light activities with less than 1.2met, and wearing clothes with values ranging from 0.5clo for summer to 0.9clo for winter, *ASHRAE* issues a comfort zone standard in the following chart:

Chart 2.2 Acceptable Zone as An Operative Temperature Zone with Relative Air Humidity which Complies to Human Thermal Comfort Standards for Light Activities with less than 1.2met



Source: (SNI 03-6572-2001, 2001)

The graph above has a predicted percentage of dissatisfied (PPD) of 10% with coordinated limits as follows:

1) For winter

   20-23.5°C on 60% relative humidity

   20.5-24.5°C on 20°C dew point, limited by effective temperature between 20-23.5°C

2) For summer

   22.5-26°C on 60% relative humidity

23.5-27°C on 20°C dew point, limited by effective temperature between 23-26°C

For Indonesia, thermal comfort zone for planning use **25°C with ±1°C margin** on **55% relative humidity with 10% margin**.

2.2.Chinese Architecture

Chinese architecture is as old as the civilization itself. Various sources of information testifies to one fact: the Chinese have always enjoyed an indigenous system of construction that retained its principal characteristics since prehistoric times. This system perpetuated itself for more than four hundred years over such a vast territory and influence; and still remain a living architecture – retaining its principal characteristics (Sicheng, 1984). There are some features that typifies Chinese architecture: bilateral symmetry, enclosed open spaces, *Feng shui* incorporated ideas such as directional hierarchies, emphasis on horizontal lines, and illusion to various cosmological, mythological, and other types of symbolism. Traditionally, Chinese architecture classifies structures acording to types – ranging from pagodas to palaces.

2.2.1. Characteristics/Features

1) Bilateral Symmetry

One of the most important features in Chinese architecture which emphasizes on articulation and bilateral symmetry – signifying balance. From royal palaces to farmhouses, this particular feature is found nearly everywhere. Even plans for renovation and/or extensions for a building will often attempt to maintain this symmetry; provided there is enough capital for the action (Knapp, 2006). The gardens however, tend to be assymetrical – contrast to the buildings. The garden composition's underlying principle is to create an enduring flow (Handler, 2005). An ideology used for a basis of the assymetrical garden design is of 'Nature and Man in One'; as opposed to the home itself, which is a symbol of the human sphere – separate yet co-existing with nature. Two essential elements of the garden are hill stones and water – representing static beauty and dynamic wonder, respectively. They depend on each other and complete the whole nature (Cui & Hu, 2015).

2) Enclosure

Buildings or building complexes in traditional Chinese architecture have been known to take an entire space of the site, yet enclose open spaces within themselves. These enclosed spaces come in two forms (Knapp, 2006):

a. Courtyard – an empty space surrounded by building connected with one another either directly or through verandas.
b. Sky well – a relatively enclosed courtyard formed from the intersections of closely spaced buildings and offer small opening to the sky through the roof space from the floor up.

These enclosures function as temperature regulator and ventilation. Sky wells are the smaller version of the open courtyard; which also function as rain water collector while restricting the amount of sunlight that enters the building.

3) Hierarchy

Strict placement of buildings in a property/complex became a basis for hierarchy and importance of its uses in traditional Chinese architecture. Buildings with front doors facing front of the property are considered more important than those facing the sides. The ones facing away from the front of property/complex are the least important. Rear buildings with more private location and higher exposure to sunlight are held in higher esteem – reserved for elder members of the family or ancestral plaques. Those facing the sides are for junior members and/or branches of the family, while the ones on the front are generally for servants and/or hired helps (Zhejiang Great Wall Documentary Culture Communication Company, 2004). In a multiple courtyard complex, central courtyard and the buildings surrounding it are considered more important than the peripheral ones – with the latter generally being used as servants' room, kitchen, or storage (Knapp, 2006).

4) Horizontal Emphasis

Traditionally, Chinese buildings are built with an emphasis on broadth and less on height; complete with an enclosed heavy platform and a large roof that floats over this base. Since buildings that were too high and large were considered unsightly, it was generally avoided (Li Y.-Y. , 1979). Chinese architecture stresses the visual impact of the building's width, using its sheer scale to inspire awe in visitors (Fu, 2017).

5) Cosmological Concepts

Since early times, Chinese architecture has been known to use concepts from their own cosmology such as *Feng shui* and *Taoism* to organize construction and layout from common residences to imperial and religious structures (Knapp, 2006). This includes the use of a number of features as follows:

a. Screen walls facing the main entrance of the house which stems from the belief that evil travel in sraight lines.
b. Talismans and imagery of good fortune.
c. Orienting the structure with the rear side elevated; ensuring water in the front.
d. Ponds, pools, wells, and other water sources built into the structure.
e. Alignment of the complex along north/south axis.

2.2.2. Types

Chinese architecture boasts various types of construction; be it for royals, religious, or commoners. These types include the following:

1) Commoners

Few examples of commoner type houses survive to this day, mainly being of wooden construction with poor maintenance. The average commoner's house did not change much – even after centuries after establishment of the universal style such as early 20^{th} century houses – were very similar to late and mid-imperial houses in layout and construction (Kohrman, 1998). These houses tend to follow a certain set pattern:

a. Center; shrine for deities and ancestors – also used for festivities.
b. Two sides; elder bedrooms.
c. Two wings of the building; junior members of the family – as well as living room, dining room, and the kitchen. Sometimes living room could be very close to the center (Cassault, 1987).

Some extended families are large enough that one or two extra pair of wings have to be built in order to accommodate them; resulting in a U-shaped building, with a courtyard suitable for farm work (Kohrman, 1998). Merchants and bureaucrats preferred to close off the front with an imposing front gate. These buildings were legally regulated – with the law that stated the number of stories, length of the building, and the colours used are dependant on the owner's class.

2) **Imperial**

Certain features were reserved solely for buildings built for the emperor. Most notable is the use of yellow roof tiles; which still adorn most of the buildings within Forbidden City. Only the Temple of Heaven uses blue roof tiles – symbolizing the sky. The roofs are always supported by brackets or *dougongs* – a feature shared only with the largest of religious buildings. Wooden columns, wall surfaces all tend to be red in color – with black often used in pagodas – derived from the believe that the gods are inspired by the black color to descend to earth. On decorations, the first Ming emperor used the 5-clawed dragon as decorations on beams, pillars, and doors on imperial architecures; yet it was never used on imperial roofs.

Only imperial family buildings were allowed to have 9 *jian* (space beteen two columns); and only gates used by the emperor could have 5 arches with the center one being reserved for the emperor himself. All of the buildings faced south due to cold winds from the north.

3) **Religious**

Buddhist architecture generally follows the imperial styles. A typical large Buddhist monastery has a set of construction rules:

a. Front hall; housing the statues of Four Heavenly Kings.
b. Great hall; housing the statues of the Buddhas.
c. Two sides/wings; accomodations for monks and nuns.

Some monasteries would also have pagodas which may house relics of the Gautama Buddha. Older ones tend to be four-sided; while later/newer pagodas would likely have eight sides.

On the other hand, Taoist architecture follows the commoner styles with a different set of construction rules:

a. Entrance is located at the sides; derived from superstitions about evil that travel in straight lines. This is strictly adherent to *Feng shui* beliefs.
b. Main deity is located in the main hall at the front; with lesser deities in the back and side halls. This is derived from the belief that souls are still alive even if the body has died.

2.2.3. Construction

1) Materials and History

Primary building material in Chinese architecture was always wood due to its very common occurrence. Chinese people also believe that life should be connected to nature, and humans should interact with animated things; which led to wood being more favored than stone – with the latter being associated with the homes of the dead (Li, et al., 2017). Brick and stones would eventually became more and more common from Tang Dynasty (AD 618-907) onward, replacing wooden edifices. Although brick and stone architecture have been used in earlier dynasties for subterranean tombs, the earliest examples of the transition can be seen as early as 523 AD in the oldest extant pagoda in China; using brick and wood for its construction.

The earliest walls and platforms in China were found using rammed earth prior to the transition to bricks and stones. The Great Wall also used similar construction materials on the earlier phases dating back to 7th century BC (Tanenhaus, 2011). The brick and stone construction we see today is a renovation by the Ming Dynasty (AD 1368-1644).

2) Structure

a. Foundations

Foundation constructions differ in their class; yet typically are some form of raised platforms. Vertical structure beams are rested on stone pedestals – which occasionally rested on piles. For lower class constructions, the platforms are of rammed earth which may/may not be paved/unpaved with bricks/ceramics. Often times, simpler construction methods are just by driving the vertical structure beams directly into the ground. Upper class constructions would typically also be from rammed earth – only this time, it's ornately carved. The vertical structure beams would rest on their pedestals solely by friction and pressure; exerted by the whole structural load of the building (Yu, Oda, Fang, & Zhao, 2008).

b. Structural beams

Primary building support uses large structural timbers. Large trimmed logs are used as load-bearing columns and lateral beams for building frame and roof support; connected directly to each other. In higher class and/or larger structures, the brackets used in co-joining the beams indirectly and the beams themself are prominently displayed in the finished structure.

c. Structural connections

Joinery, dowelling, and nothing else – these types of connections are seldomly joined with the use of glues/nails. Thanks to their semi-rigid type of joint, timber structures are capable of resisting bends and torsions under high compression. The use of heavy beams and roofs also weigh the structure down; ensuring further structural stability (Yu, Oda, Fang, & Zhao, 2008).

d. Walls

The common partition used to separate rooms or enclose a building are curtain walls and door panels; generally paired with a couple of load-bearing walls in higher class constructions. With the scarcity of trees in later dynasties, load-bearing walls became more common – typically used in non-governmental and religious buildings – using bricks and stones.

e. Roofs

There are three main types of roofs:

a) Straight inclined – has only one incline. The most commonly found roof type in lower class constructions due to being the most economical of the three.

b) Multi-inclined – has two or more inclines. Used in higher class constructions, from dwellings to palaces.

c) Sweeping – has an upward raising curvature at the roof's corner. Generally reserved for temples and palaces, yet can also be found in some of the more wealthy dwellings. Roof ridges of temples and palaces are usually highly decorated with ceramic figurines.

f. Roof apex

A large hall generally has a roof apex topped with tile ridges and statues on the center and/or each ends of the incline. This ridge serve as a weight to increase the roofing tiles' stability as well as decorations.

g. Rooftop decorations

Symbolism can be found nearly anywhere; including rooftops – ranging from the colors in eaves, roofing materials, and decorations. Gold/yellow as an auspicious color has a notable usage on imperial roofs. Another color is of green – symbolizing bamboo – which represents youth and longevity (Ministry of Culture, P.R. China, 2014).

2.2.4. The Global Spread and Arrival in Indonesia

1) The Spread over Neighboring Regions

Chinese culture started to spread after Tang Dynasty onto neighboring countries; being imported en masse. Major influence of the culture is found on Japan, Korea, Mongolia, and Vietnam with the hip and gable roof found to be the most common among them (Steinhardt, 2004). In Southeast Asian communities, Thai artisans that has connections with Yuan and Ming traders started to adopt certain techniques. Palaces and rooftops would be constructed with the same techniques, resulting in an undeniably similar facades to their Chinese counterparts. These, along with Chinese style buildings found in Ayutthaya is a nod towards the large numbers of Chinese shipbuilders, sailors, and traders who came to the country (Sthapitanonda & Mertens, 2012). One of the most recent influence being Indonesian mosques bearing Chinese style in certain parts of the country (Formichi, 2013).

2) Zheng He's Arrival in Indonesia and The Following Acculturation

Zheng He's expedition that led to his first visit to Java island was the return leg of his 2nd expedition setting sail in 1408; with Calicut (now Kozhikode) as the expedition's main destination. The visit was to establish a diplomatic relation with Majapahit Kingdom and to promote the idea of China as the Middle Kingdom (Peterson, 1994). Landed in 1413 in Sampotoalang (now Semarang) to repair his ships, some of his merchants are there to settle down. One of the reasons Zheng He's expeditions always have more-than-abundant crew members – some of which were military personnel – is to extend Chinese influence overseas; be it military powers, technological prowess, and bring new people into the tributary system (Fairbank & Twitchett, 1998). The merchants that stayed in Semarang were widely known for their shipbuilding and weapon forging skills; and ended up spreading their influence to other cities, namely Ujung Galuh (now Surabaya), and Lao Sam (now Lasem).

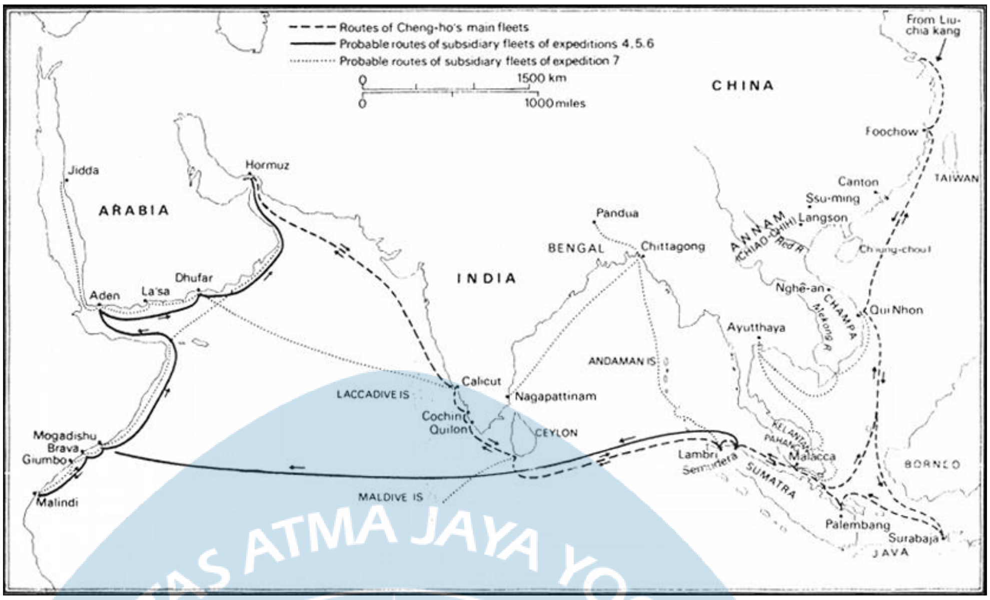


Figure 2.1 Zheng He's Maritime Expedition Routes (1405-1433)

Source: (Fairbank & Twitchett, 1998)

Nearly all of the merchants Zheng He brought in his expeditions were of the Hui Tribe from Huizhou/Hui Prefecture, Anhwei (now Anhui) Province. Houses built by them were known to be constructed from the same materials their ships use; later named 'omah gladak'/deck house, and were still adherent to the core principals of traditional Chinese architecture. The following century didn't record any particular settlements; indication that acculturation with native population is possible (Tan, 2005). Over the next couple of years, the same method used by the merchants to build their houses were adopted into the local architecture; merging more of Indonesia's own vernacular into the already established principles of traditional Chinese architecture, particularly of Hui style. Sizable parts of a town that already contains Chinese architecture complexes became known as 'Chinatown'; and has been preserved in major cities in Indonesia.

3) Hui Style Architecture

Figure 2.2 A Common Hui-Style Architecture Housing Complex with Multiple Courtyards

Source: (iNews, 2021)

The word *Hui* itself originated from Huizhou Prefecture, Anhui Province; famous for its merchants and has been dominating commodity business for ±300 years. They successfully monopolized salt-trading industry in China since Ming and Qing Dynasty – effectively making them peak famous throughout the country. Afer going back to Anhui with fortunes they brought from the trades, lands were purchased, luxurious housing complexes were built complete with educational facilities, temples, memorials, and gardens in order to glorify their family name (Ma J. , 2006).

The architecture used in these complexes are of a specific local style with rational layout and sophisticated decorations. The unique style of brick, wood, and stone decorations were born from a tradition of carving and drawing decoration among the local population (Ma J. , 2006). Like every other indigenous Chinese architectural styles, the structure contained one or more courtyards, commonly facing south, and surrounded by mountains and rivers. It's symmetrically divided by a central axis with a central hall and rooms on either sides of the complex. On the front of the central hall is a patio for lighting and ventilation (Guangyao, 2008).

a) Structure

Hui style uses wooden frame with intricate decorations on each beam. The middle part of it is always slightly arched it's commonly known as the 'Chinese watermelon beam', with both ends of the beam decorated with Ming/Qing Dynasty patterns. The vertical columns are usually spindle-shaped with Ming patterns carved on them – also commonly applied with China wood oil/tung oil.

Patio, balusters, and screen walls use bluestones, and/or red granites cut into stone bars – using natural stone material texture to combine into carving patterns (ChinaCulture, 2011).

b) Decoration

The high level decorative art in Hui style uses brick, wood, and stone carving. The carving is mostly embed on door covers, window lintels, and side walls (Zhao, 2005). The bricks would have carvings of vivid figures, fishes, flowers, birds, and abstract patterns. Wooden carvings have a lot of themes that can be used such as: traditional operas, folk stories, myths, legends, and daily life scenes like farming, fishing, travelling, etc. These carvings hold a significant role in residential houses with extensive content (Zhao, 2005).

Figure 2.3 Yin Yu Tang House Carved Window Panel

Source: Gkuriger, 2017

c) Horse-head Wall

Also called *Ma Tau* wall (translates to fire wall/firewall), the shape has a semblance to a galloping horse and is built higher than the gable wall on both sides. Horse-head wall mainly functions as its Chinese name implies: to cut off the fire from spreading further; and it worked effectively since its conception.

Figure 2.4 Horse-Head Wall on The Ends of A Cojoined Gable Roof Walls

Source: (iNews, 2021)

Typically, it was either between two-lap portrayed on the above image, or three-lap wall. As a building's scale is increased, four or five-lap may also be built on each end of the gable roof. Five-lap wall is typically symbolic of the owner's honorable status. Within its' various types such as '*Magpie Tail*', '*Print Bucket*', '*Sit Kiss*', etc. lies another of the wall's symbolism of the wisdom of ancient Huizhou people (Xing, 2010).

d) Patio

An open space enclosed by the surrounding rooms and placed on the courtyard for collecting and storing rainwater which also functions as a drainage for excess water. Huizhou people hold a geomantic belief that water is considered as a financial resource and is a taboo when one lets water run outside of the courtyard. The patio was set up to ensure that all rainwater from all sides of the complex run inside. Aside from the geomantic beliefs, its practical usage was known for bringing sunlight, convenient drainage, and sufficient ventilation (Xing, 2010).

e) White Walls and Black Tiles

These specific color combination for the walls and roof tiles inspire people with a sense of purity, simplicity, and freshness. The ingenious color arrangement done by Huizhou people can be seen as the building was composed as a beautiful piece of music with a series of jumpy notes with musical composition; manifesting it’s own features (JiaMa, 2006).