FUNGUS WOES IN JKR'S PROJECTS

CASE STUDY OF HEALTH FACILTY PROJECTS

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ROHAIMI MANSOR

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INTRO
MOULD
AKA
FUNGUS

TIMEL
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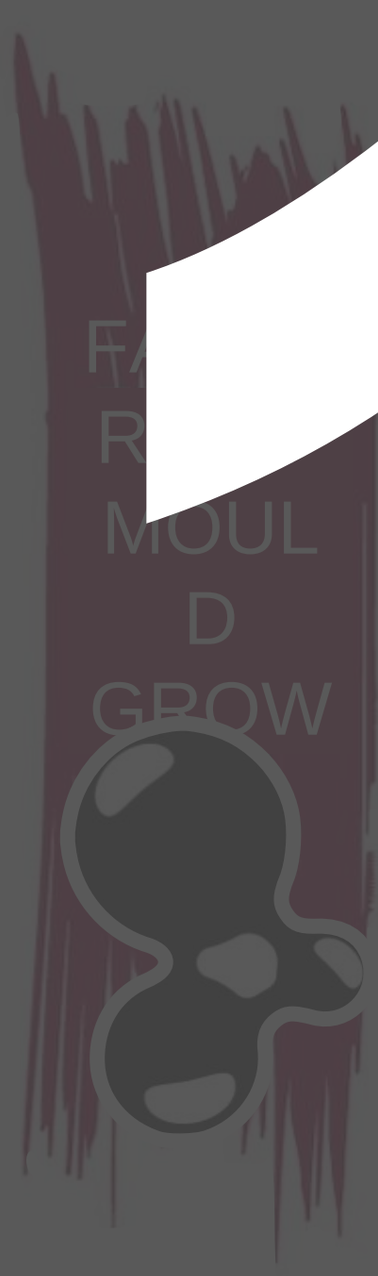
GROW



LESS
ON
LEAR
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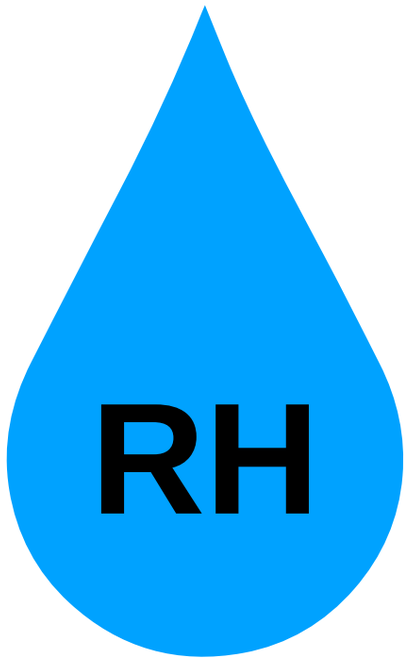
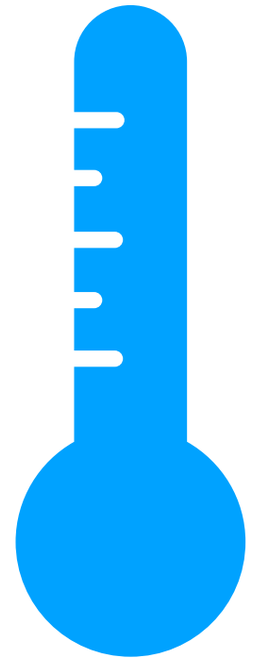
WAY
FORW

70%-90%



30°C-35°C



Malaysia where the weather is warm and humid all year-around with the average daily temperature ranging from about 30°C to 35°C and relative humidity (RH) is about 70% to 90%

Kosravi Salman et al, 2010

10,000 to 300,000

less than 500 mould species have been described as human pathogens that can cause infections

>500

GUIDELINE ON MOULD CONTROL AND REMEDIATION IN HEALTHCARE FACILITIES
Engineering Services Division Ministry Of Health 2016

Mould’s spores : 2 – 100 µm in diameter

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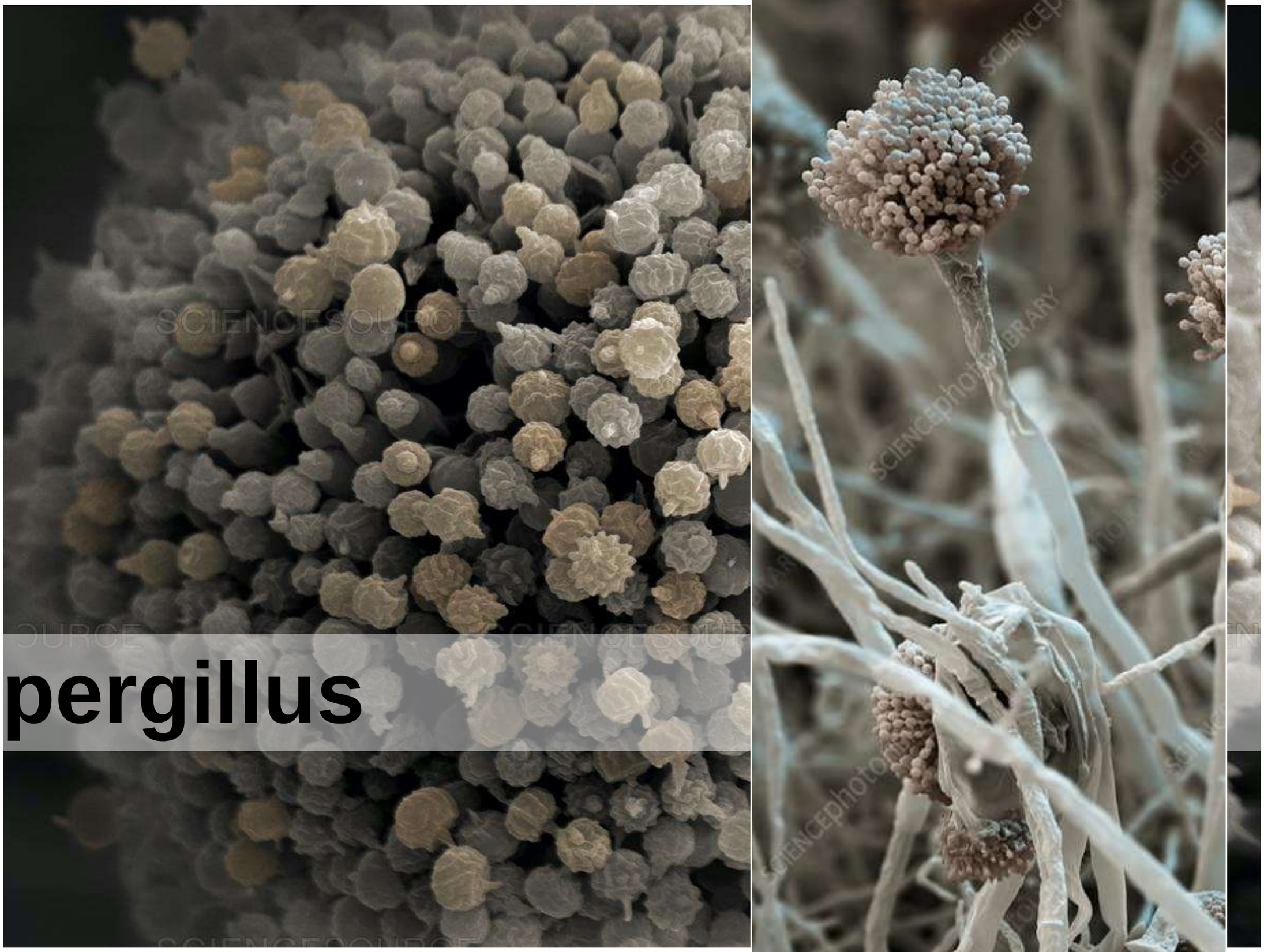
A "micron" is an abbreviated term for "micrometer", or a millionth of a meter (1/1,000,000 meters). This is about .00004 inches. For Size comparison, A human hair is about 75 microns across.

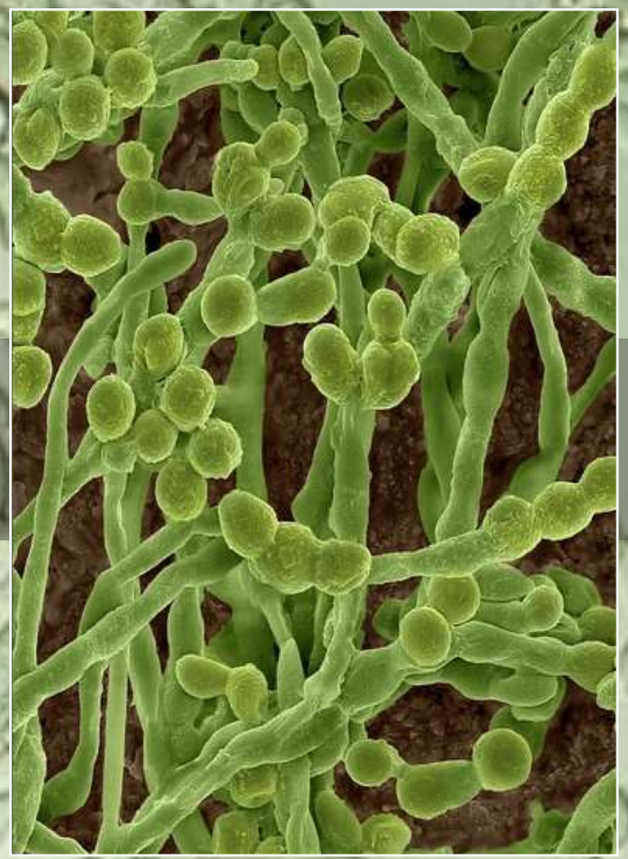


aspergillus

Kumar & Wc (2007)

Penicillium sp..

Kumar & Wc (2007)



Cladosporium sp.

Kumar & Wc (2007)

Stachybotrys chartarum

aka Black Mold

The RM550mil hospital was closed in September 2004 for 17 months due to a fungus problem.
The STAR Friday, 20 Apr 2007

Deadly fungal attack closes new Johor hospital

KUALA LUMPUR — A two-month-old government hospital in Johor has been shut down because of a deadly fungal invasion believed to have been caused by shoddy workmanship.

Faulty air-conditioning has led to the aspergillus and penicillium fungi spreading throughout the RM55S million (S$249 million) Sultan Ismail Specialist Hospital in southern Johor state.

Health Minister Chua Soi Lek on Sunday ordered the hospital closed after the authorities found it impossible to control the spread of the fungi.

The fungi, according to the minister, could cause a variety of problems for patients and staff, including fatigue, cough, shortness of breath, congestion, fever, nausea, and eye, ear and throat irritation.

"It can also lead to extremely severe, life-threatening diseases," he added.

The hospital, also known as the Pandan Specialist Hospital, has been plagued by problems since work began in 1999, with completion delayed three times.

Each time, the [illegible] Works Department has [illegible] step in as the contractor [illegible] not meet the specifications.

Also, the equipment installed in the hospital has not met minimum standards set by the ministry, thus compounding the delay.

Even now, the hospital is struggling with a faulty air-cond age system and oxygen [illegible]

Although designed [illegible] the southern region's premier specialist hospital, it has been catering only to outpatients and offering haemodialysis treatments since its partial opening in July.

Datuk Chua said the project has fallen far short of the government's pledge to provide the best health care service in the southern part of the peninsula."

The contractors have been given three to six months to rectify the problems.

Fungal invasion is common in hospitals worldwide, with entire sections sometimes closed off at times to clear the area of contamination.

New Straits Times

e medical facility, which opened in July, was supposed to be southern Malaysia's premier specialist hospital.

THE STAR

OBLEMS

[illegible] has led to the [illegible] fungi spreading [illegible] Ismail Specialist [illegible] could cause problems such as fatigue, cough, shortness of breath, congestion, fever, nausea, and eye, ear and throat irritation.

"It can also lead to extremely severe, life-threatening diseases," said Health Minister Chua Soi Lek, who on Sunday ordered the hospital closed.

Since work began in 1999, the hospital has been plagued by problems. Completion was delayed three times. It was partially opened in July, catering only to outpatients and offering haemodialysis treatments. It was designed to be the southern region's premier specialist hospital.

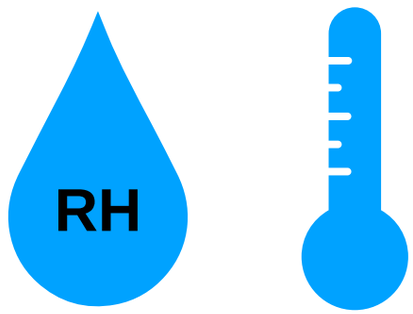
Species like Aspergillus and Penicillium dominated the hospital environment.

A detailed Study was carried out and recommendation of bio decontamination and treatment of a non leaching microbe shield (AEGIS) was proposed.
The works began in March 2005 and were completed in 4 month successfully.

2/9

PUBLIC HOSPITAL'S PROJECT DURING DLP

MINIMUM IEQ AUDIT



Maintenance Report on Major Hospital
under Defect Liability Period.
Jabatan Kerja Raya Malaysia, 2007

?

2019

2016

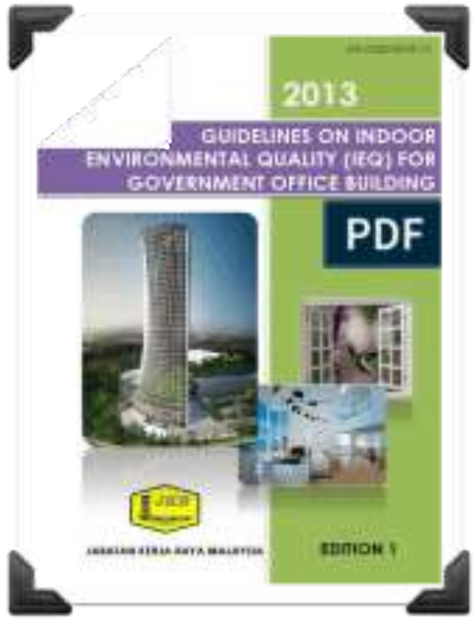
2014

2013

2009

2005

2004



INTRO MOULD AKA FUNGUS

FACTORS OF MOULD GROWTH

FACTORS OF MOULD GROW

DESIGN STRATEGIES

&

WAY FORWARD

FACTORS OF POTENTIAL MOULD GROWTH IN PUBLIC HOSPITAL BUILDING

01 PARAMETERS OF MOULD GROWTH

02 BUILDING DEFECTS

03 CONSTRUCTION QUALITY

04 MECHANICAL VENTILATION DESIGN

05 ARCHITECTURAL AND STRUCTURAL DESIGN

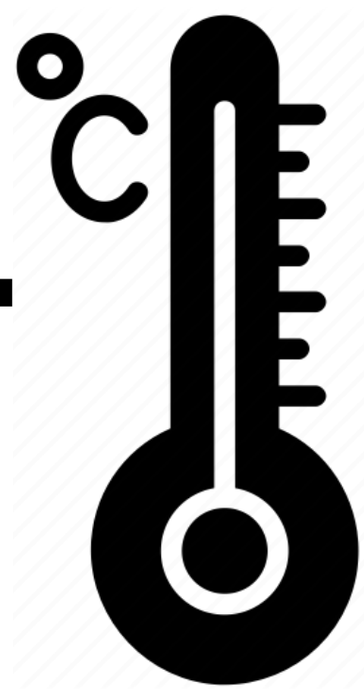
06 BULDING OPERATIONAL

01 PARAMETERS OF MOULD GROWTH

RELATIVE HUMIDITY

>70%

\+ **NUTRIENT SPORES OXYGEN** +



TEMPERATURE

5°C-50°C

Johansson et. al. (2013)

02 BUILDING DEFECTS

Recurrence of defects that relate to surface dampness due to unidentified root cause of the problem.

Unattended defects that are prone to surface dampness for certain period of time.

Prolonged water leakage either from mechanical piping system or infiltration of rainwater

Fluctuations of temperature and relative humidity due to air-conditioning system instability upon commissioning.

Wall cracks that may cause water seepage and penetration.

……300 defects up to a value as high as 20,000 defects

Maintenance Report on Major Hospital under Defect Liability Period. Jabatan Kerja Raya Malaysia, 2007

02 BUILDING DEFECTS

Excess moisture can cause some building materials to corrode and rust.

02 BUILDING DEFECTS

Prolonged water leakage either from mechanical piping system or infiltration of rainwater

02 BUILDING DEFECTS

Condensation on windows, walls and surfaces is a sign that humidity levels are too high.

02 BUILDING DEFECTS

Water stains on ceilings and walls are an obvious sign of moisture problems.

02 BUILDING DEFECTS

Condensation occurs when warm moist air meets a cold surface, which means it often occurs around windows

02 BUILDING DEFECTS

Wall cracks that may cause water seepage and penetration.

05 ARCHITECTURAL AND STRUCTURAL DESIGN

BUILDING ELEMENTS
Building elements were not fully covered (i.e. wall, roof, etc.) and water tight before commencing with final finishes works, installation of sensitive materials and equipment etc.

WOOD / MINERAL
Untreated wood / mineral-based furniture

NEW DESIGN
New design that contribute to the risk of mold growth i.e. energy efficient design, Green Building, IBS etc.

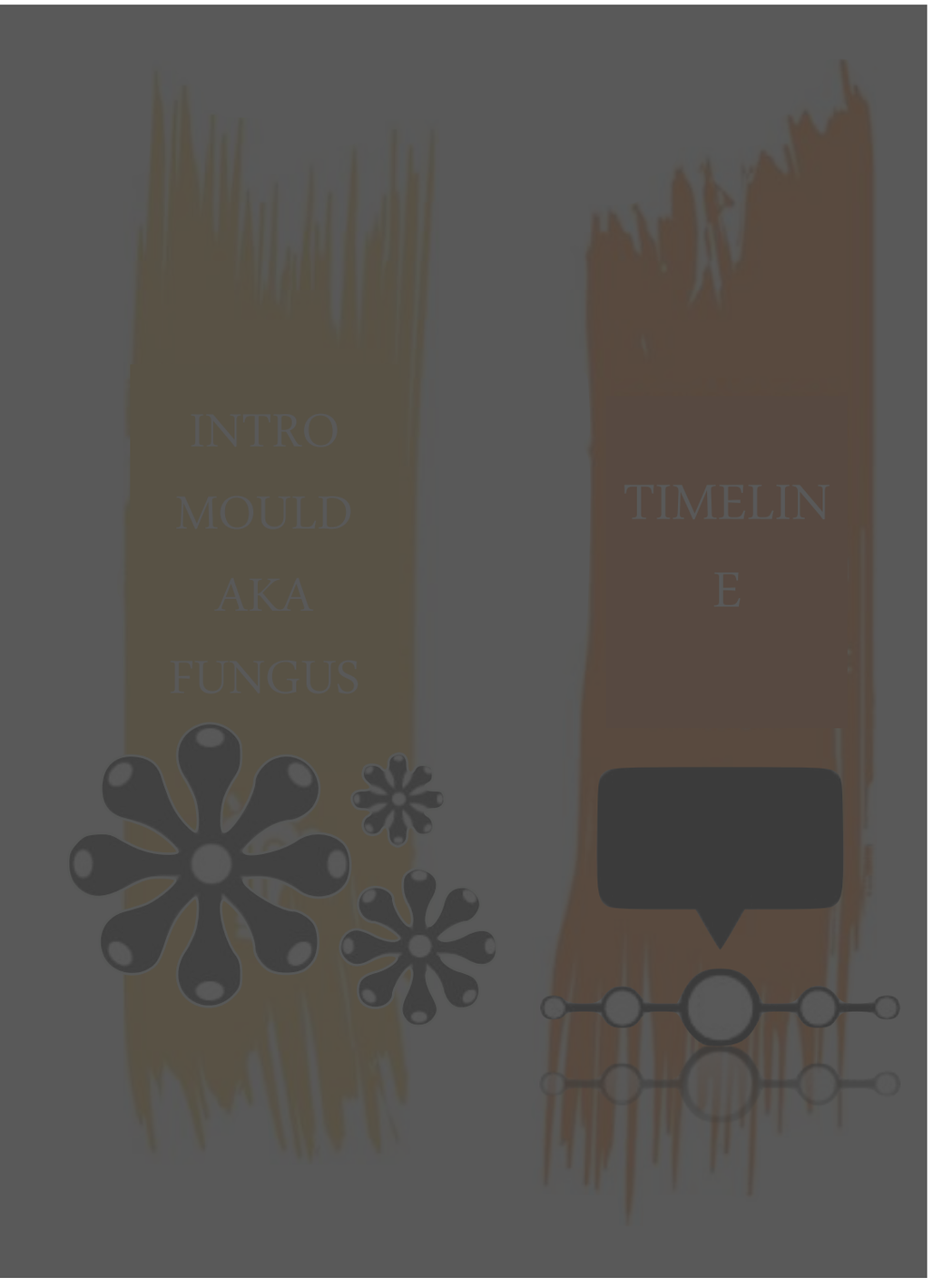
WATERPROOFING
Waterproofing on floors and walls.

WATER / MICRO
Availability of water features and landscape gardens inside/nearby the building that may introduce microbiological and particulate matter (i.e. spores, moisture, etc.) into the building.

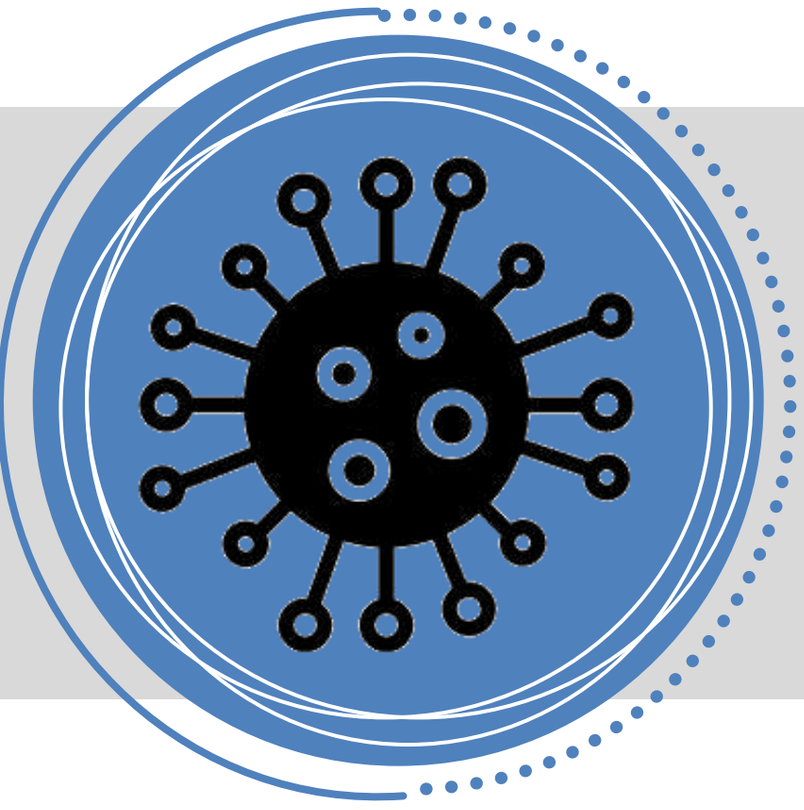
A/C ROOM DESIGN
24H / 8H air-conditioned room design

05 ARCHITECTURAL AND STRUCTURAL DESIGN

05 ARCHITECTURAL AND STRUCTURAL DESIGN



WHY MOULD GROWTH AT HEALTH FACILITY



WHY MOULD GROWTH ALWAYS OCCUR IN HEALTH FACILITY BUILDINGS?

Why MOULD growth always occur in Health Facility Buildings?

Health facility buildings like Hospital, Clinics & Labs have various type of HVAC system; these include:

1. **AC 24 hrs/7 days**
2. **AC extended hours (up to 16 hrs/day)**
3. **AC 8 hrs**
4. **Intermittent unit**
5. **Mechanical ventilation – exhaust fan**
6. **Non air-conditioned area**

Why MOULD growth always occur in Health Facility Buildings?

In Hospital Building, it is estimated around 20 – 40% Departments/rooms are 24/7 AC area, for example:

1. **Operation Theatre Dept.**
2. **Central Sterile Support Dept.**
3. **Inpatient & partly outpatient Pharmacy Dept.**
4. **Pathology Dept.**
5. **Imaging Dept (General X-ray, CT Scan, MRI etc.)**
6. **ICU, CCU, HDW, PICU, NICU etc.**

Why MOULD growth always occur in Health Facility Buildings?

In Hospital Building, it is estimated around 20 – 40% Departments/rooms are 24/7 AC area, for example:

7. **Labour Delivery Dept.**
8. **Forensic Dept (partly)**
9. **Wards (> 50% area are AC 24 hrs)**
- **Obstetric & Paediatric wards**
- **All equipment rooms, clean utility room etc.**
- **M&E rooms like Server room, TCR, UPS, Battery room etc.**

Operation Theatre, Women & Children HKL

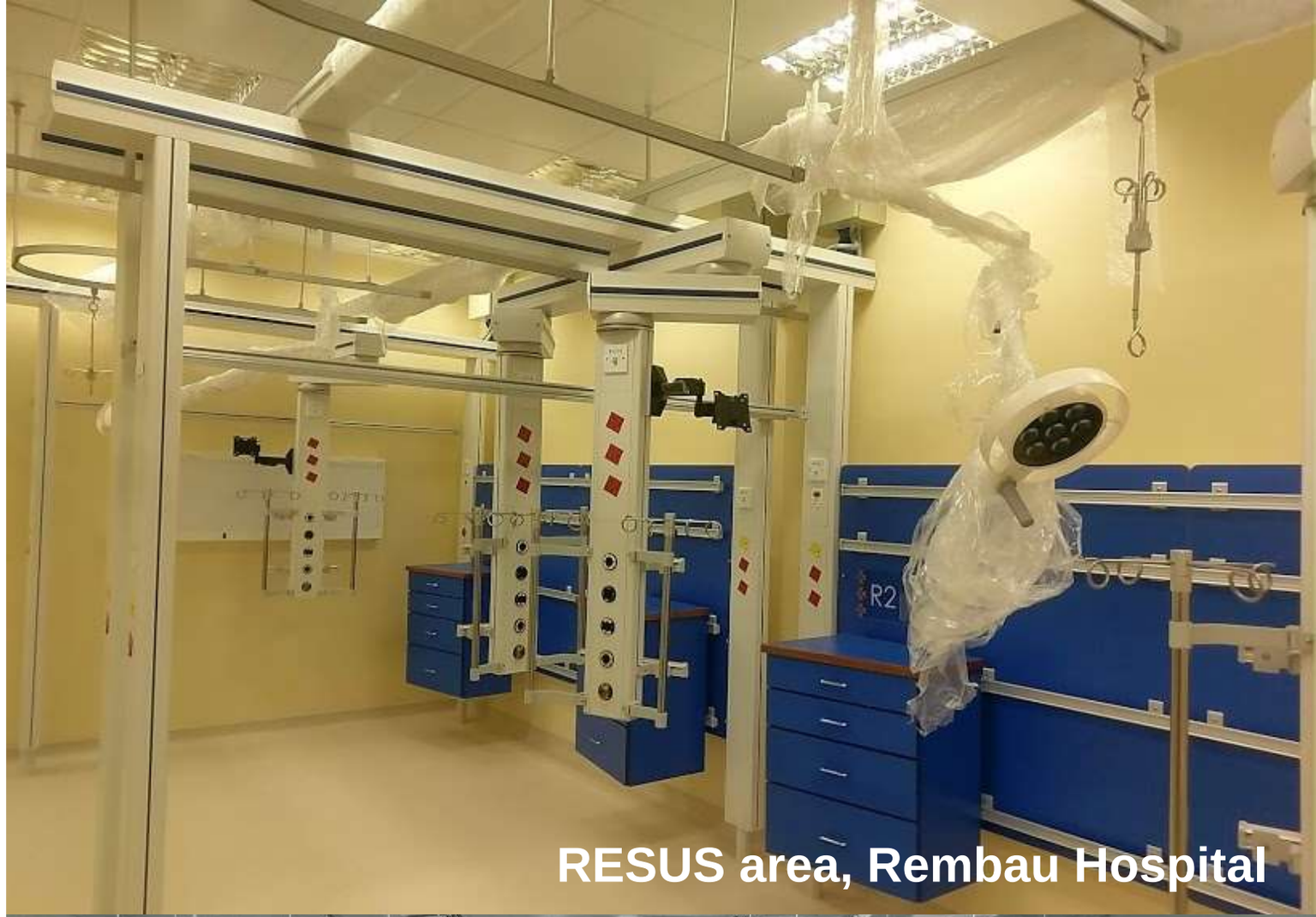

24 hrs
MRI, Women & Children HKL


Laboratories


High Dependency Unit

ICU Isolation Room, Women & Children HKL

OT Sterile Lay up, WACHKL



RESUS area, Rembau Hospital

In Patient Ward

Autopsy room & haemodialysis bays, Rembau Hospital

General ward, Rembau Hospital

Why MOULD growth always occur in Health Facility Buildings?

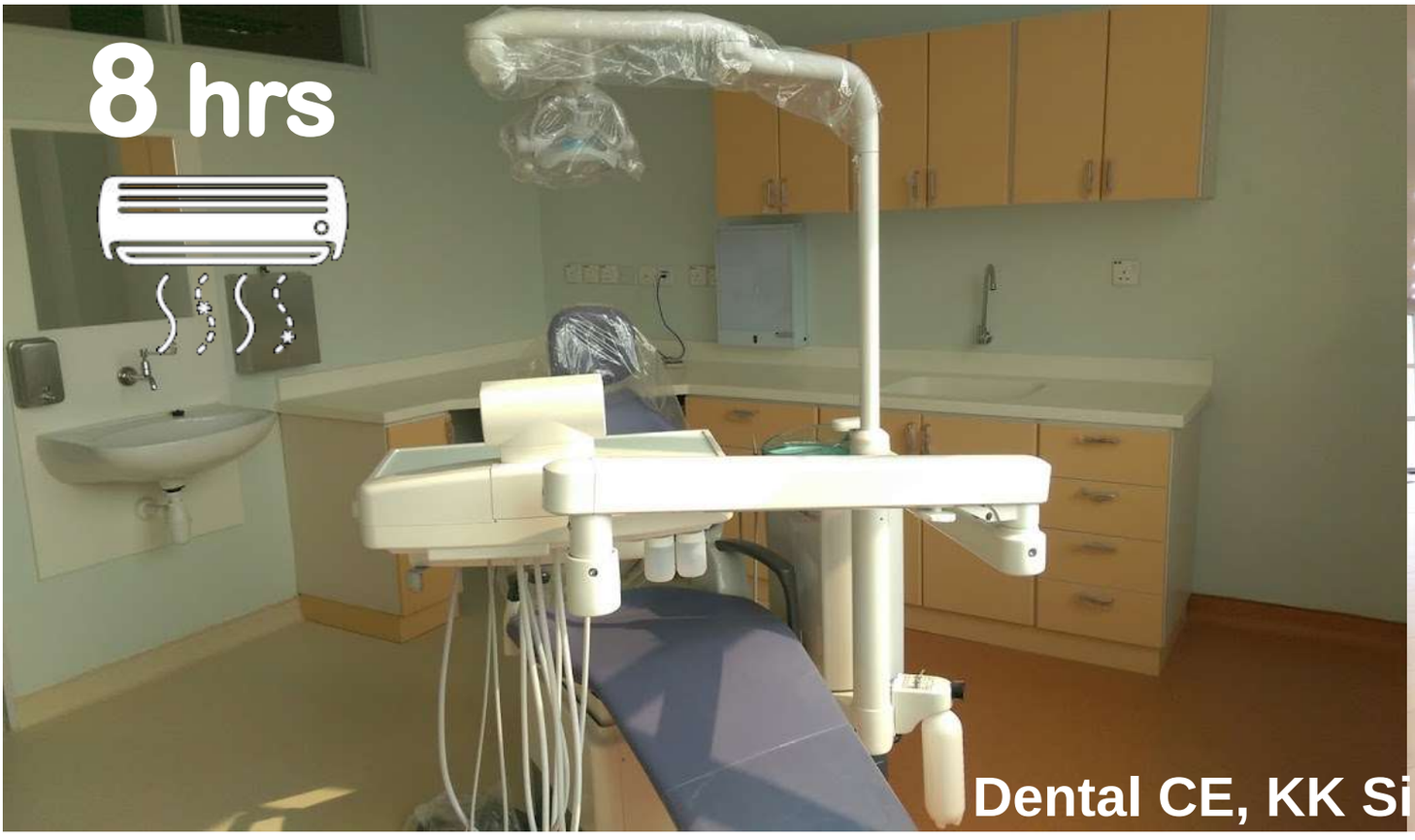
7% – 15% rooms in Health Clinics are 24 / 7 AC

- X- ray room at Imaging Dept.
- Analyser room at Pathology Dept.
- Drug store & prep area at Pharmacy Dept.
- Vaccine store at Maternal & Children Health Clinic
- Clean Utility rooms at each clinics etc.

1. Infection control
2. to control and avoid spreading/growth of bacteria/virus
3. to secure sensitive & costly equipment
4. to comply with certain standard / cost guideline

Outpatient dept, pathology lab & CE room at Gombak Setia Health Clinic

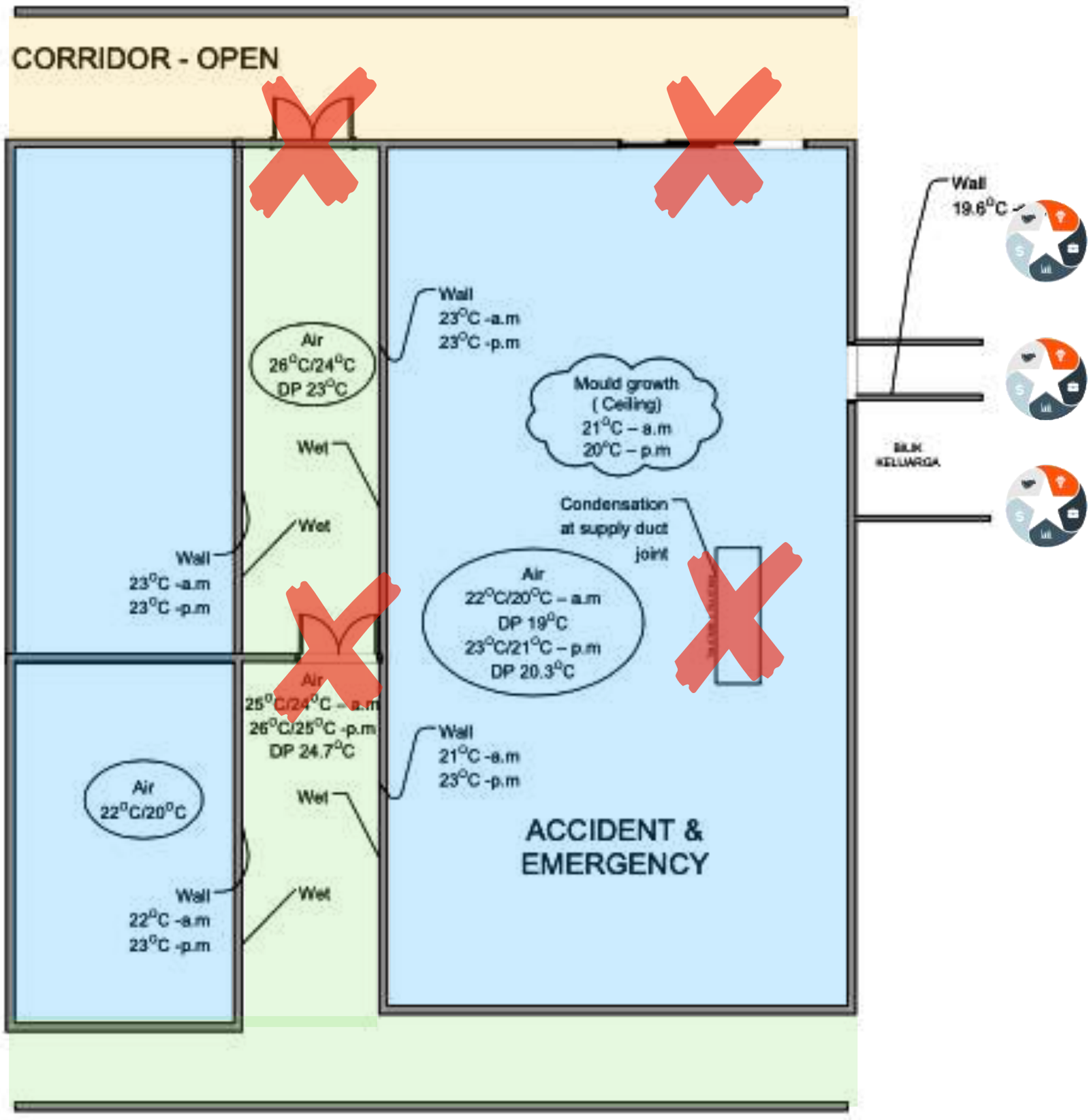
Imaging & pharmacy dept at Gombak Setia Health Clinic



Dental CE, KK Sibu Jaya & waiting area at KK Damansara

Analyser room and outpatient pharmacy at KK Kota Damansara

MOULD GROWTH IN HEALTH FACILITY BUILDINGS



Kondensasi di Accident & Emergency (A&E)

PUNCA KULAT

automatic sliding door terbuka terlalu lama sebelum ditutup kembali. Masa untuk menutup kembali melebihi 20 saat setiap kali dibuka

Suhu pada dinding luar didapati berada dibawah dew point udara sekeliling menyebabkan kondensasi pada permukaannya.

kondensasi pada supply air duct connection akibat sambungan yang tidak kemas

HSI

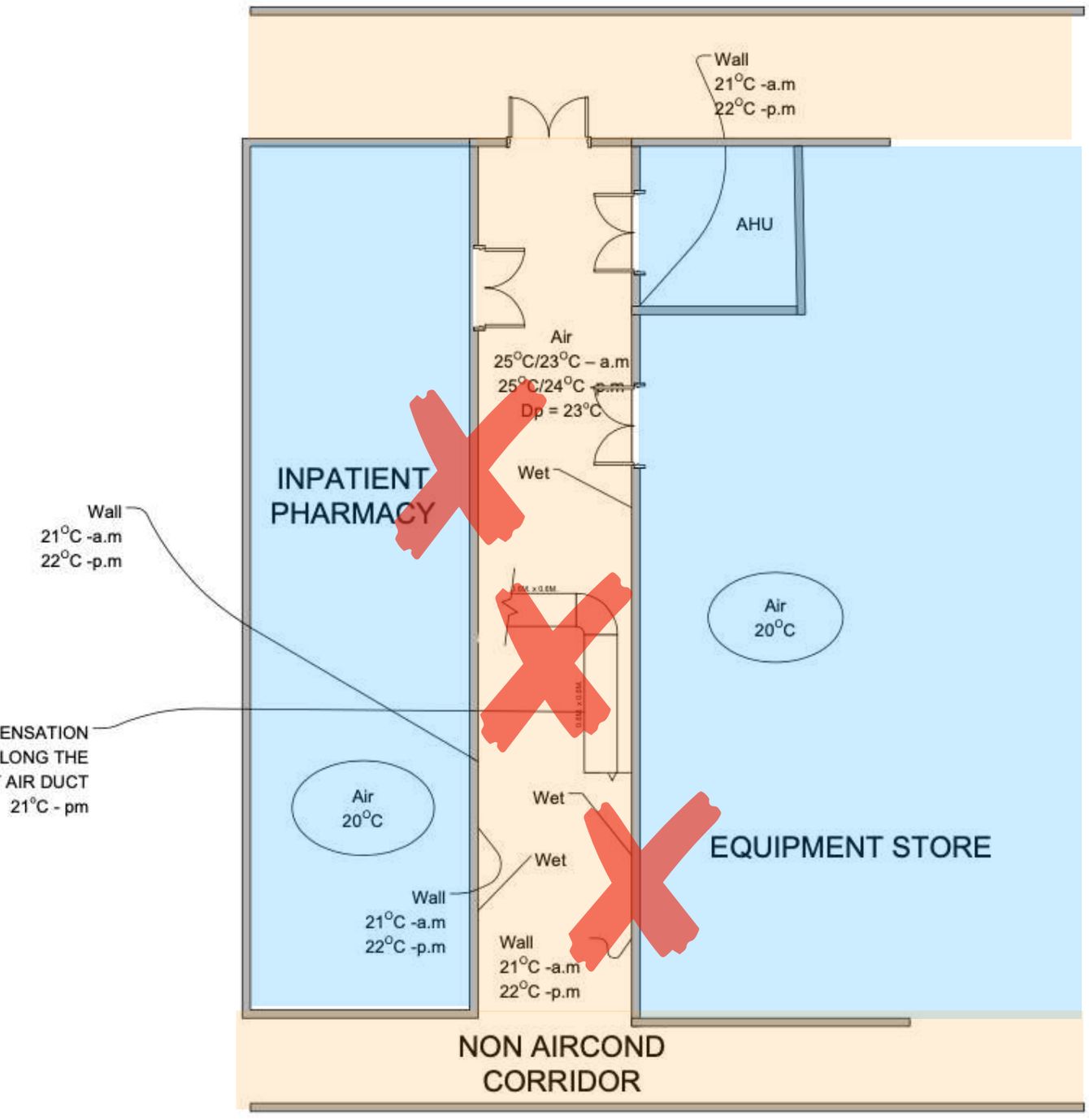
Kondensasi di Inpatient & Pharmacy

PUNCA KULAT

Suhu udara didalam ruang di kedua-dua belah bahagian lorong tersebut adalah rendah iaitu pada 20oC
Dan suhu di dinding tersebut juga adalah dibawah dew point udara sekeliling.

kelembapan relatif yang tinggi kerana ianya terbuka kepada udara luar

kondendasi pada sesalur udara yang membawa exhaust air yang tidak ditebat. Condensate water daripada kondensasi ini menitik keatas siling.



HSI

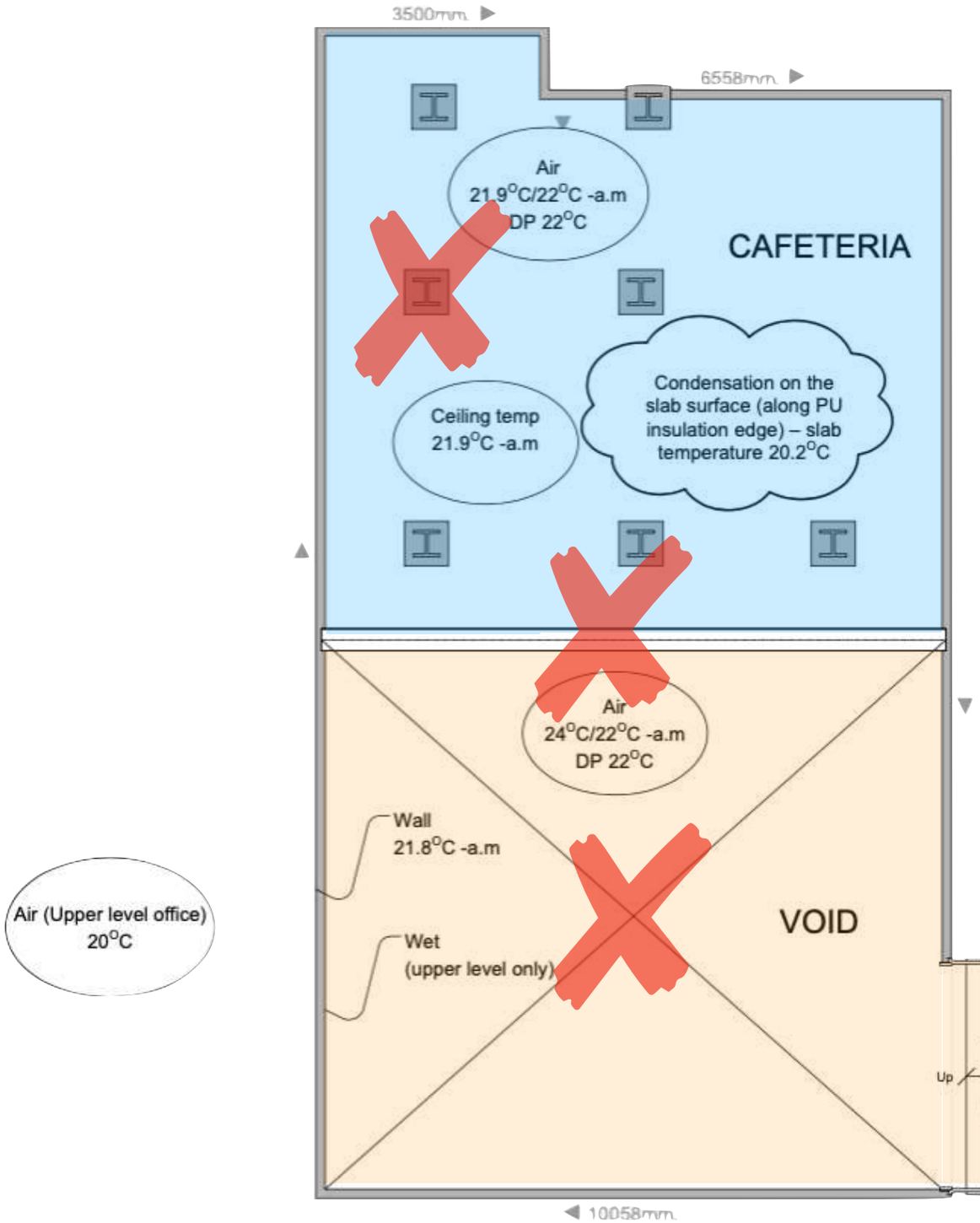
PENILAIAN TERHADAP OPERASI SISTEM HAWA DINGIN DI HOSPITAL SULTAN ISMAIL JOHOR BHARU
TARIKH LAPORAN 12HB JUN 2007

Kondensasi di Cafetaria Level 2

Ppunca kulat

Suhu udara didalam cafeteria adalah 21.9oC DB dan 22oC WB pada relative humidity 92%

Suhu permukaan siling didapati rendah dibandingkan dengan suhu dewpoint pada sianghari dan menyebabkan berlakunya kondensasi dan tompokan kulat.



Air (Upper level office)
20°C

HSI

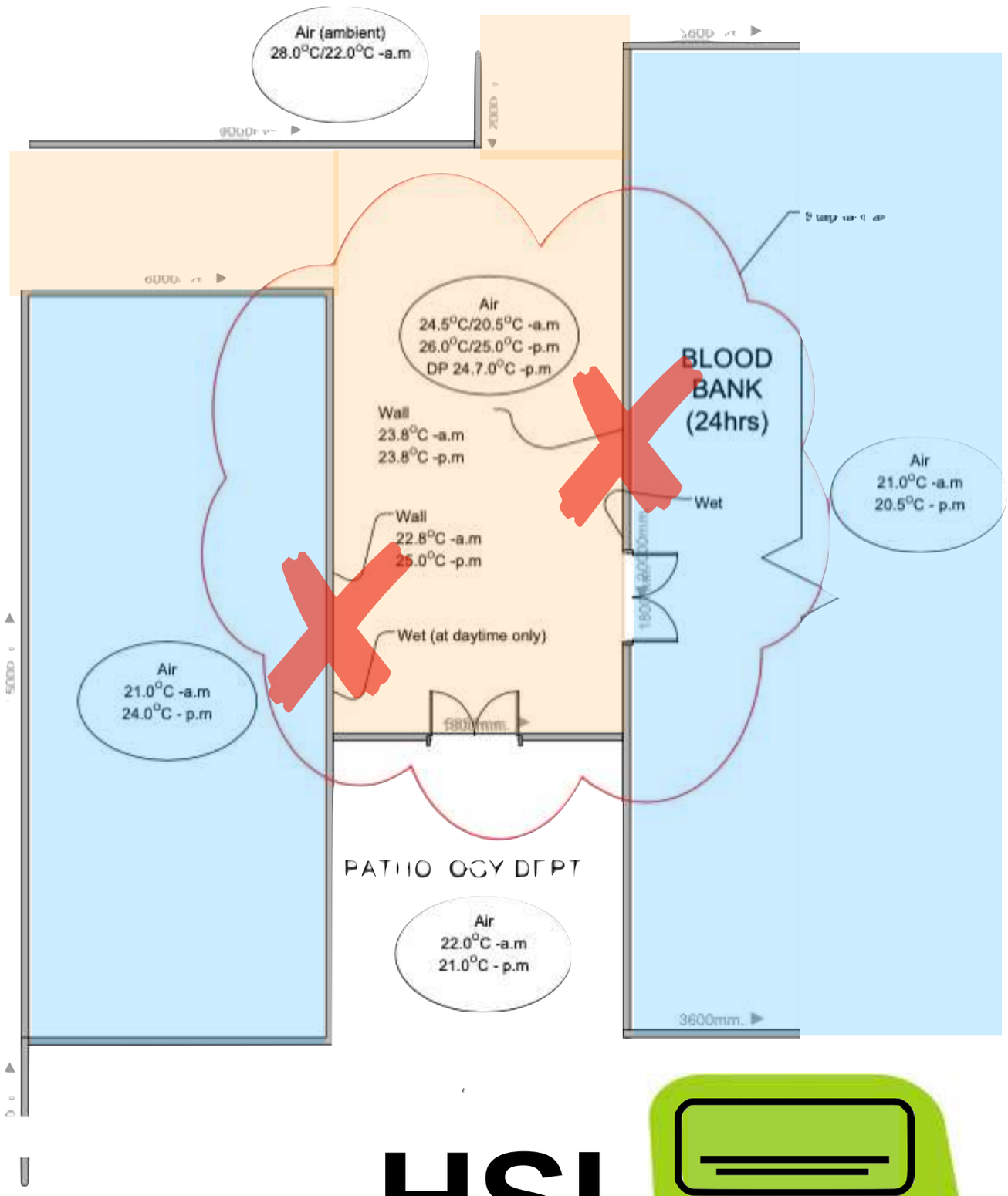
PENILAIAN TERHADAP OPERASI SISTEM HAWA DINGIN DI HOSPITAL SULTAN ISMAIL JOHOR BHARU
TARIKH LAPORAN 12HB JUN 2007

Kondensasi di Jabatan Pathology

PUNCA KULAT

kondensasi di dinding dan luar pintu masuk ke jabatan Patologi

Kondensasi pada waktu siang dan malam iaitu apabila suhu dinding lebih rendah dari suhu dewpoint udara sekeliling. Bilik sebelahnya adalah beroperasi 24 jam walaupun tiada penghuni atau aktiviti.



HSI

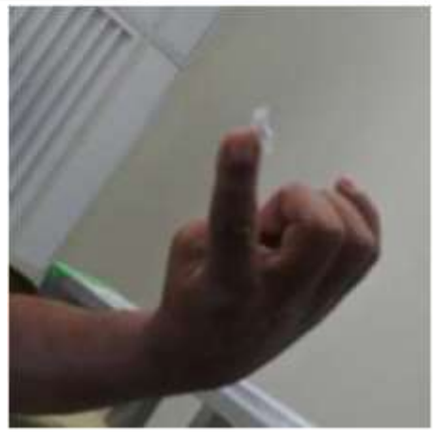
PENILAIAN TERHADAP OPERASI SISTEM HAWA DINGIN DI HOSPITAL SULTAN ISMAIL JOHOR BHARU
TARIKH LAPORAN 12HB JUN 2007

KLINIK KESIHATAN JENIS 3 MERLIMAU, MELAKA

Mould growth on ceiling
Due to temperature differences in the room and above the ceiling

Source: Laporan Forensik, Caw. Kej. Mekanikal IPJKR 2013

KOMPLEKS OBSTETRIK HOSPITAL TENGKU AMPUAN RAHIMAH, KLANG, SELANGOR DARUL EHSAN – FASA 2



Mould growth on wall

Due to stagnant air, temperature not consistent (condensation), water splash and nutrients for fungus to grow (dust).

Source: Laporan Awalan Isu Pembentukan Kulat (JKR&Pasukan projek) 2019

KLINIK KESIHATAN JENIS 3 MERLIMAU, MELAKA

Mould growth on ceiling
Due to temperature differences in the room and above the ceiling

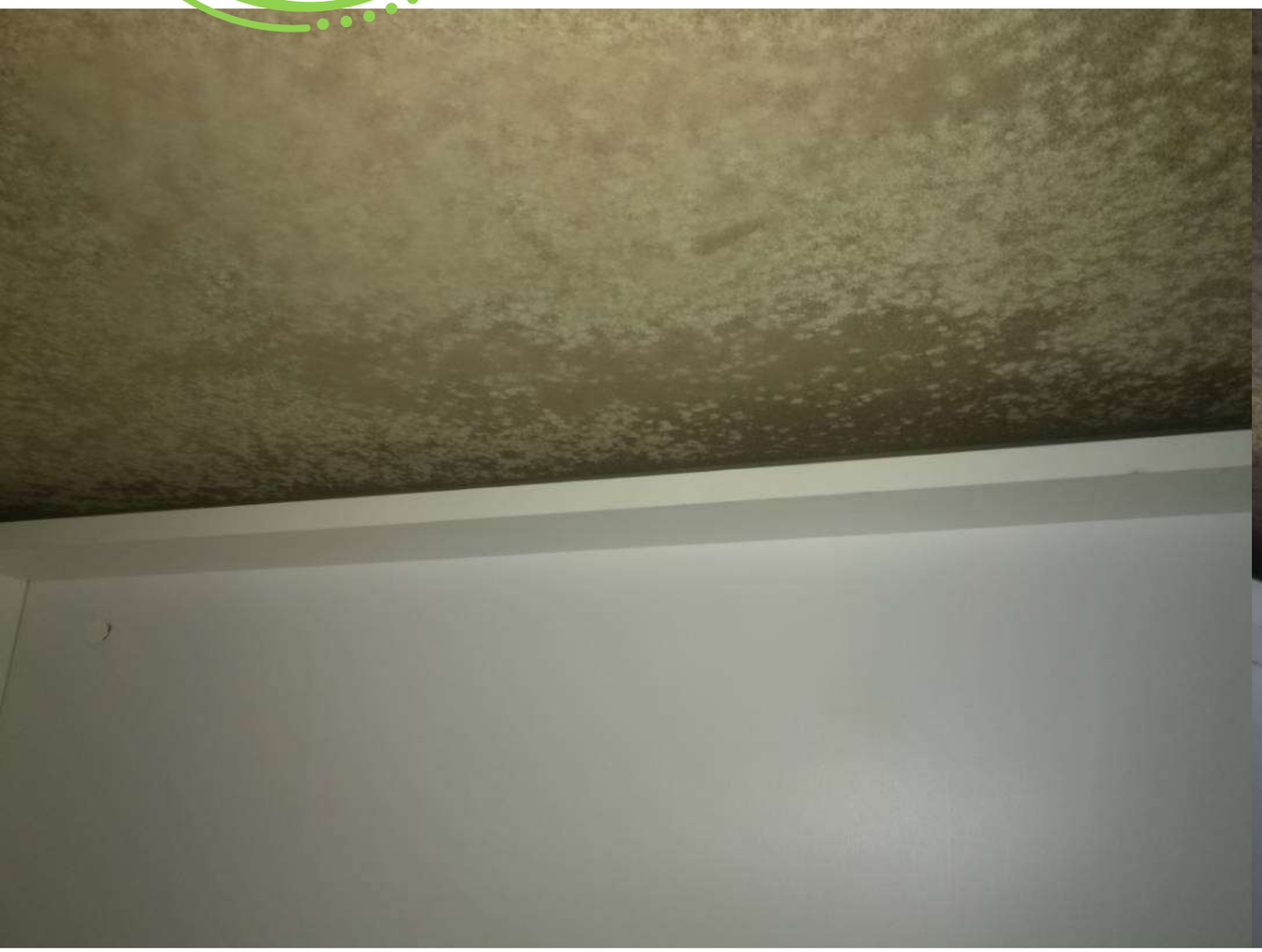
Source: Laporan Forensik, Caw. Kej. Mekanikal IPJKR 2013

KLINIK KESIHATAN JENIS 3 LUKUT, NEGERI SEMBILAN

Mould growth on wall
Due to temperature differences (AC24 hrs. Vs 8 hrs.) in the rooms by using single wall design

Source: Wilham insulation Far East

WOMEN & CHILDREN HOSPITAL
KUALA LUMPUR



Mould underneath built-in furniture
Due to humidity

Source: BRBF Kesihatan 2, CA JKR

WOMEN & CHILDREN HOSPITAL KUALA LUMPUR

Mould growth on ceiling
Due to condensation on the above mechanical ducting

Source: BRBF Kesihatan 2, CA JKR

INTRO MOULD AKA FUNGI

TIMELINE

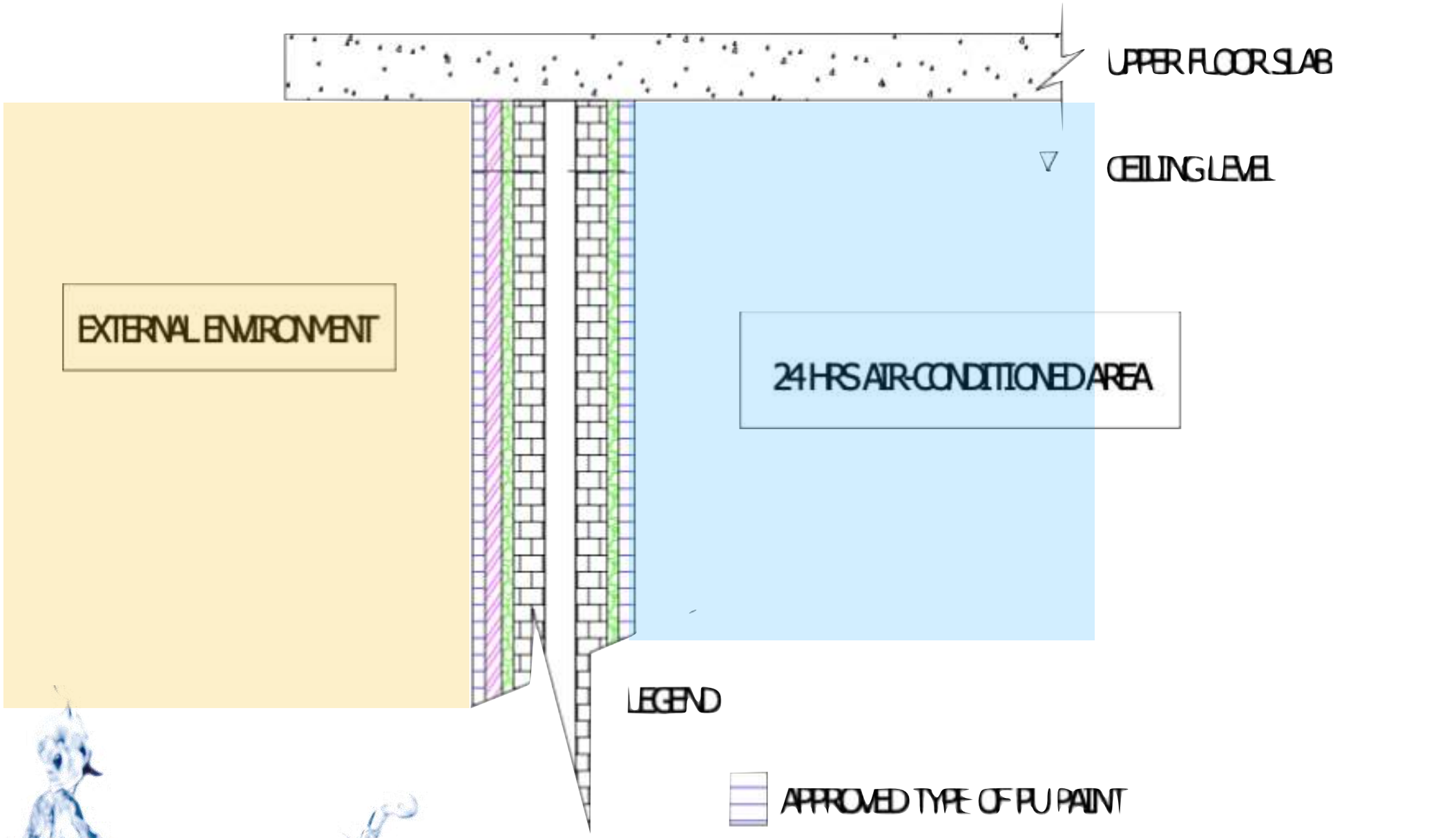
FACTORS OF MOULD GROW

DESIGN STRATEGIES

LESSON LEARNT & WAY FORWARD

Guidelines on the Prevention of Mould Growth in Buildings.

Jabatan Kerja Raya Malaysia. (2009).



WALL

ARCHITECTURAL CONSIDERATIONS

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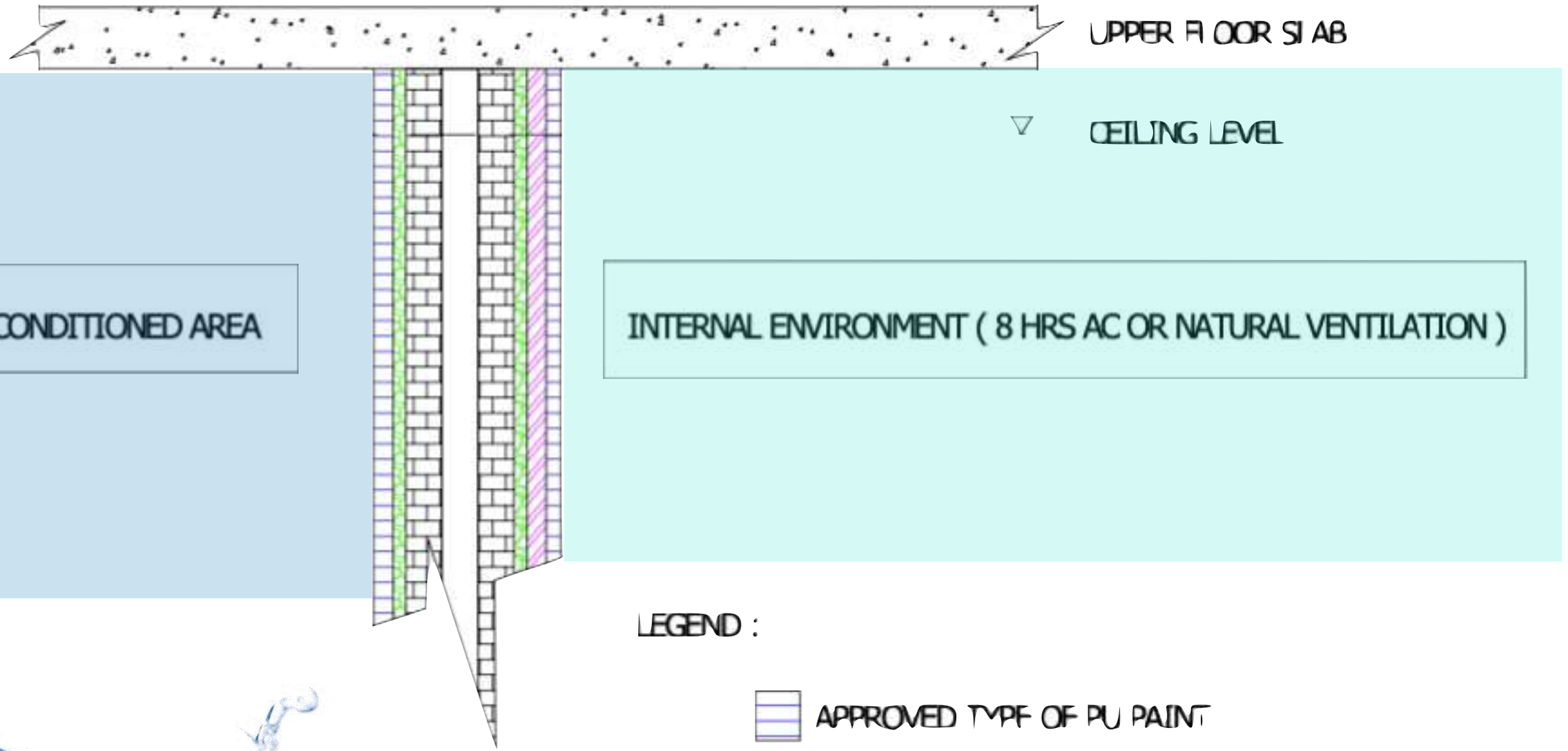

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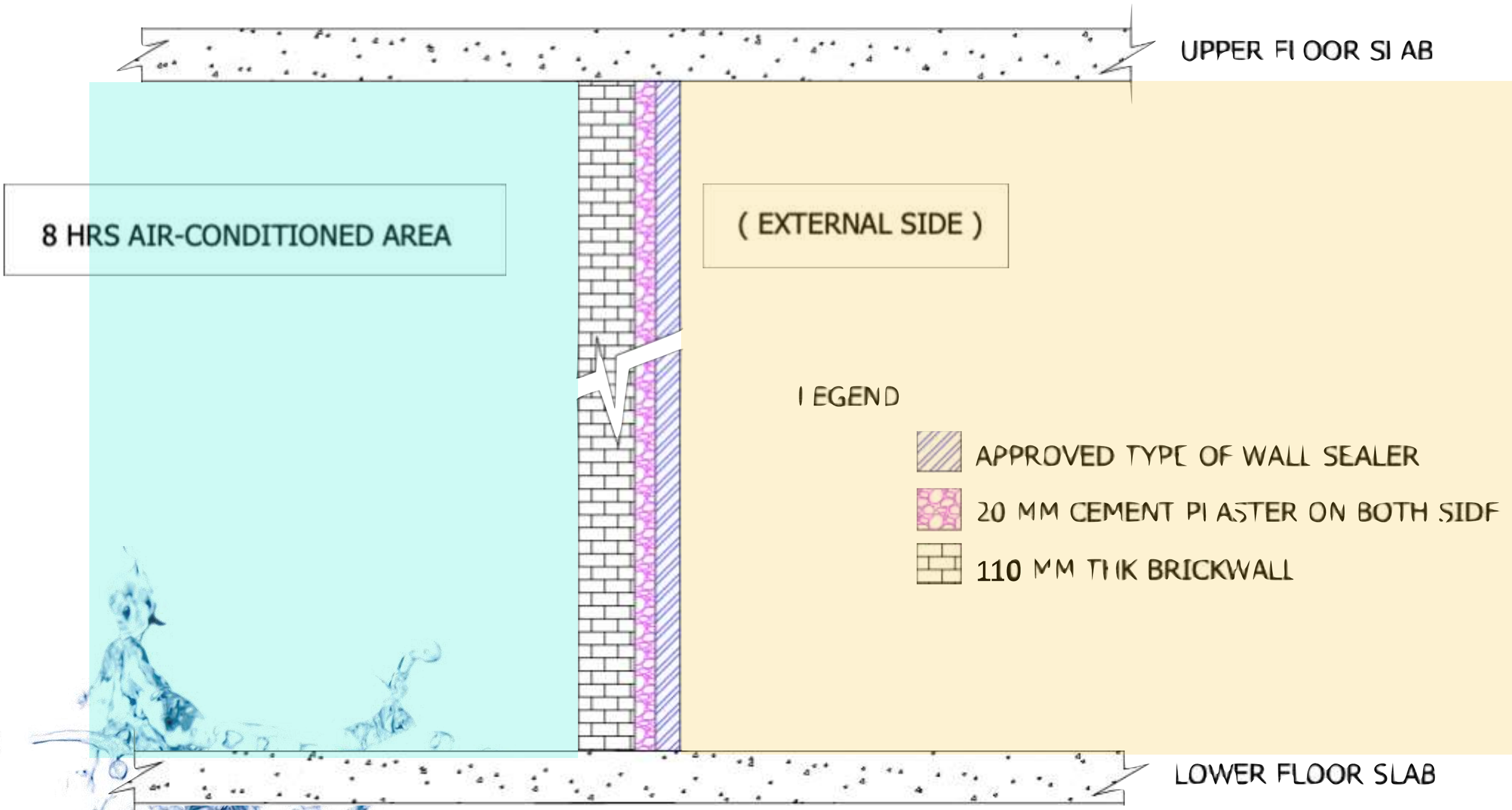

WALL

ARCHITECTURAL CONSIDERATIONS

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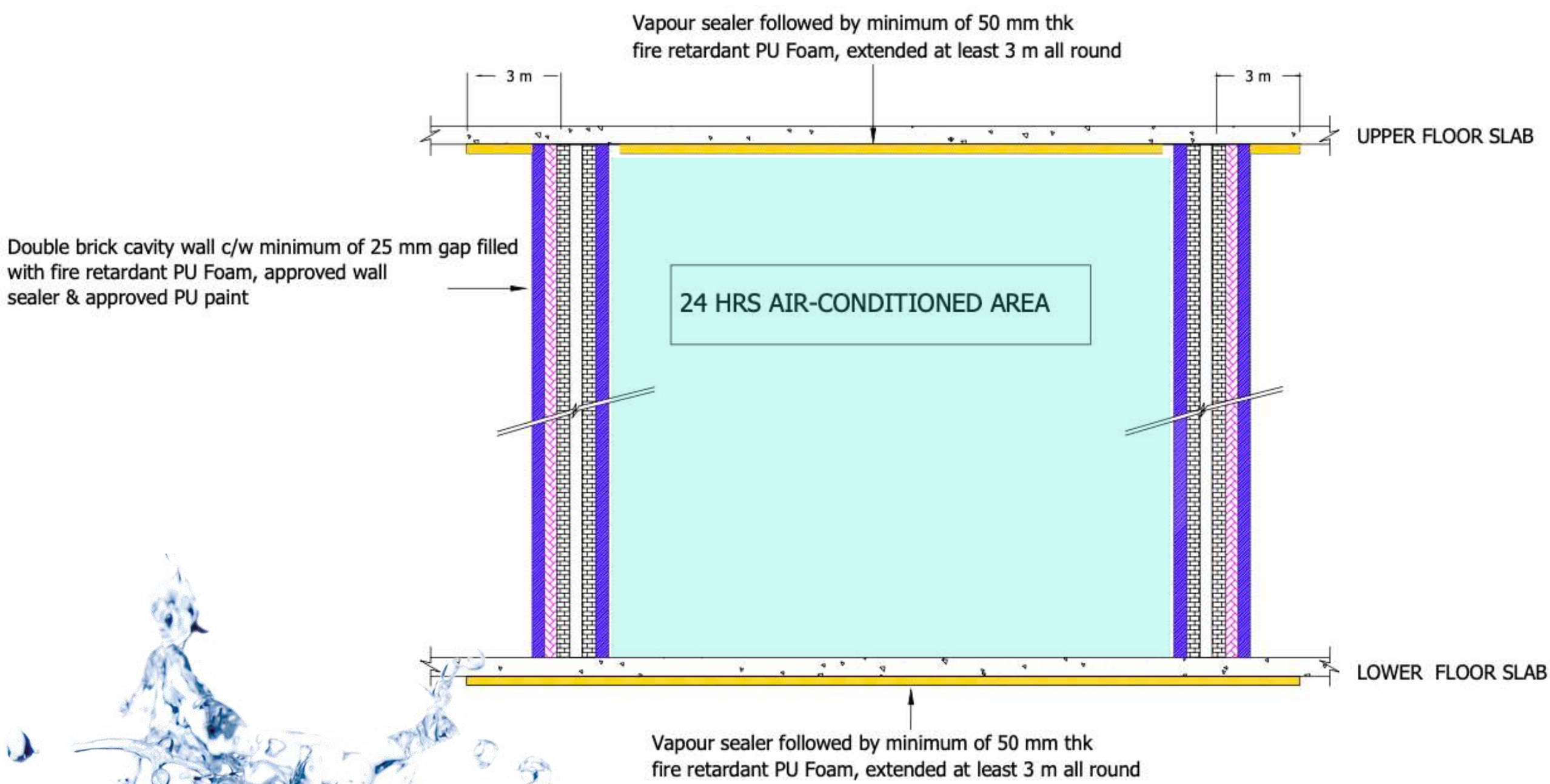
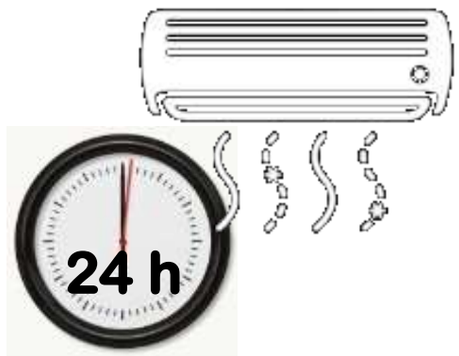


FLOOR

ARCHITECTURAL CONSIDERATIONS

Jabatan Kerja Raya Malaysia. (2009). Guidelines on the Prevention of Mould Growth in Buildings.

DESIGN STRATEGIES



STEP 1

+ Avoid deep planning design
+ to design layout with considering HVAC zoning

STEP 2

Identify the 24 hrs air conditioning area / rooms

STEP 3

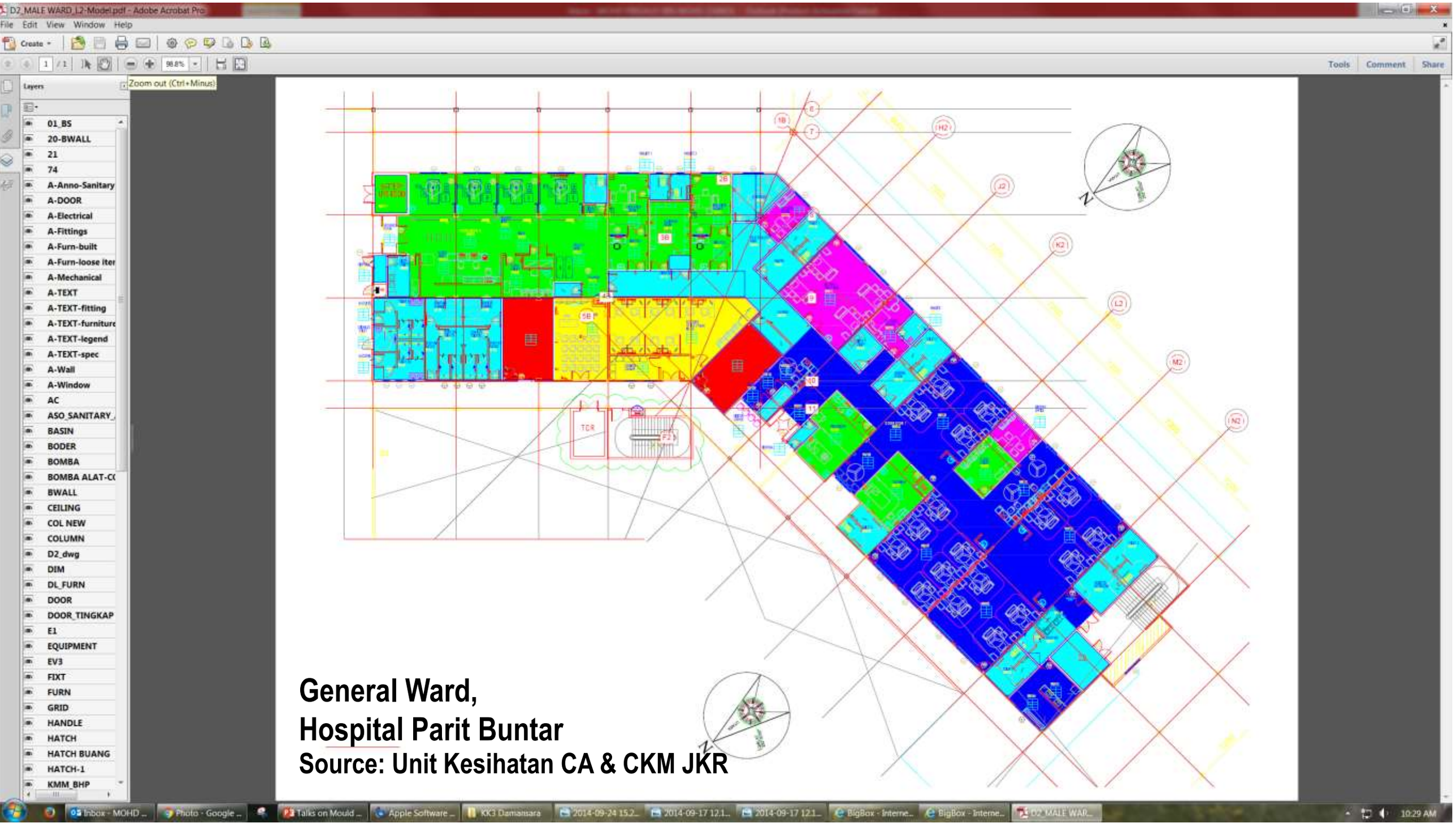
Specify double cavity walls with insulation as per guideline

STEP 1

+ Avoid deep planning design
+ to design layout with considering HVAC zoning

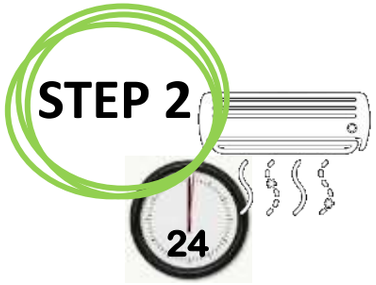
STEP 2

Identify the 24 hrs air conditioning area / rooms

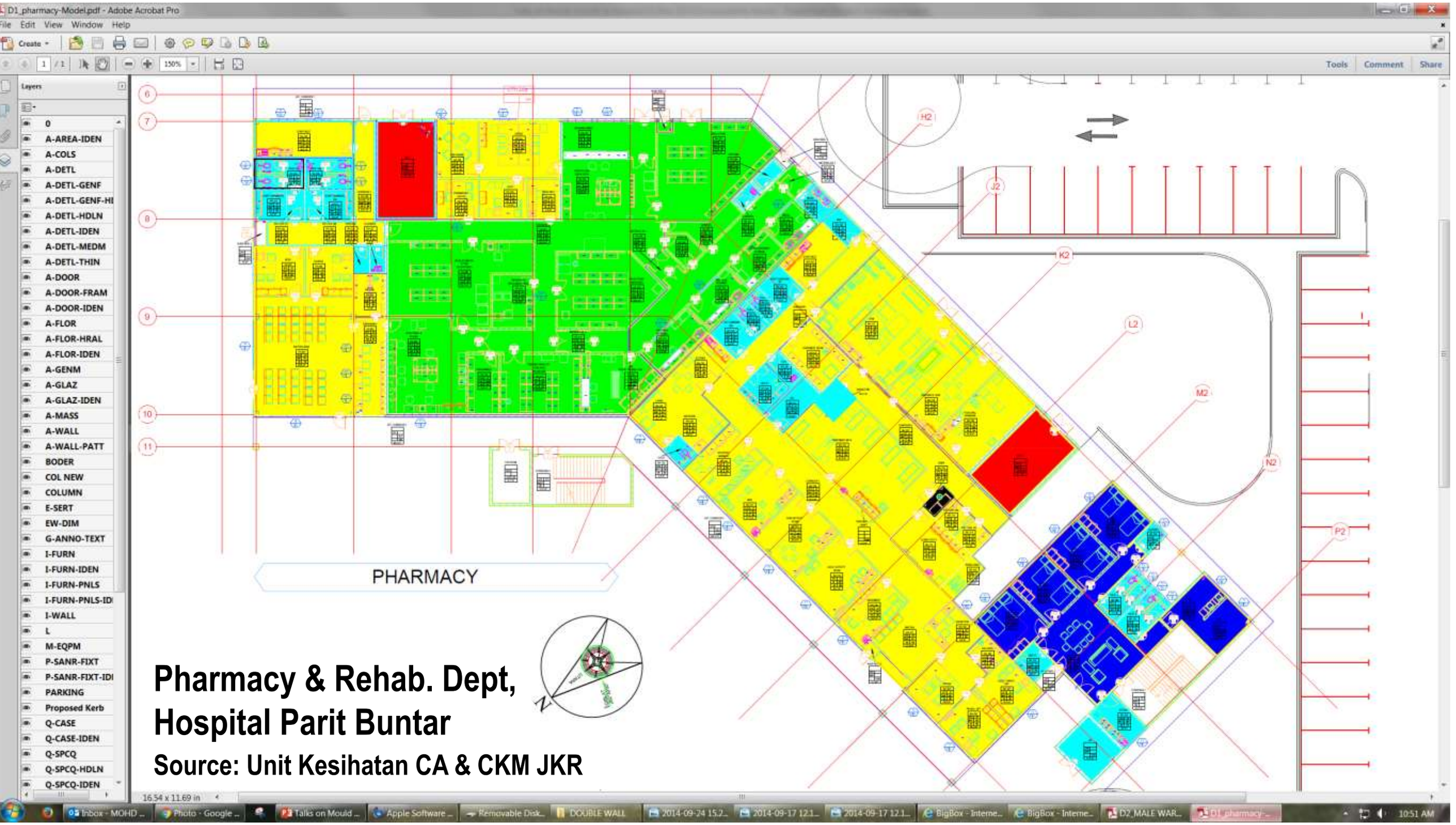


General Ward,
Hospital Parit Buntar
Source: Unit Kesihatan CA & CKM JKR

+ Avoid deep planning design
+ to design layout with considering HVAC zoning



Identify the 24 hrs air conditioning area / rooms

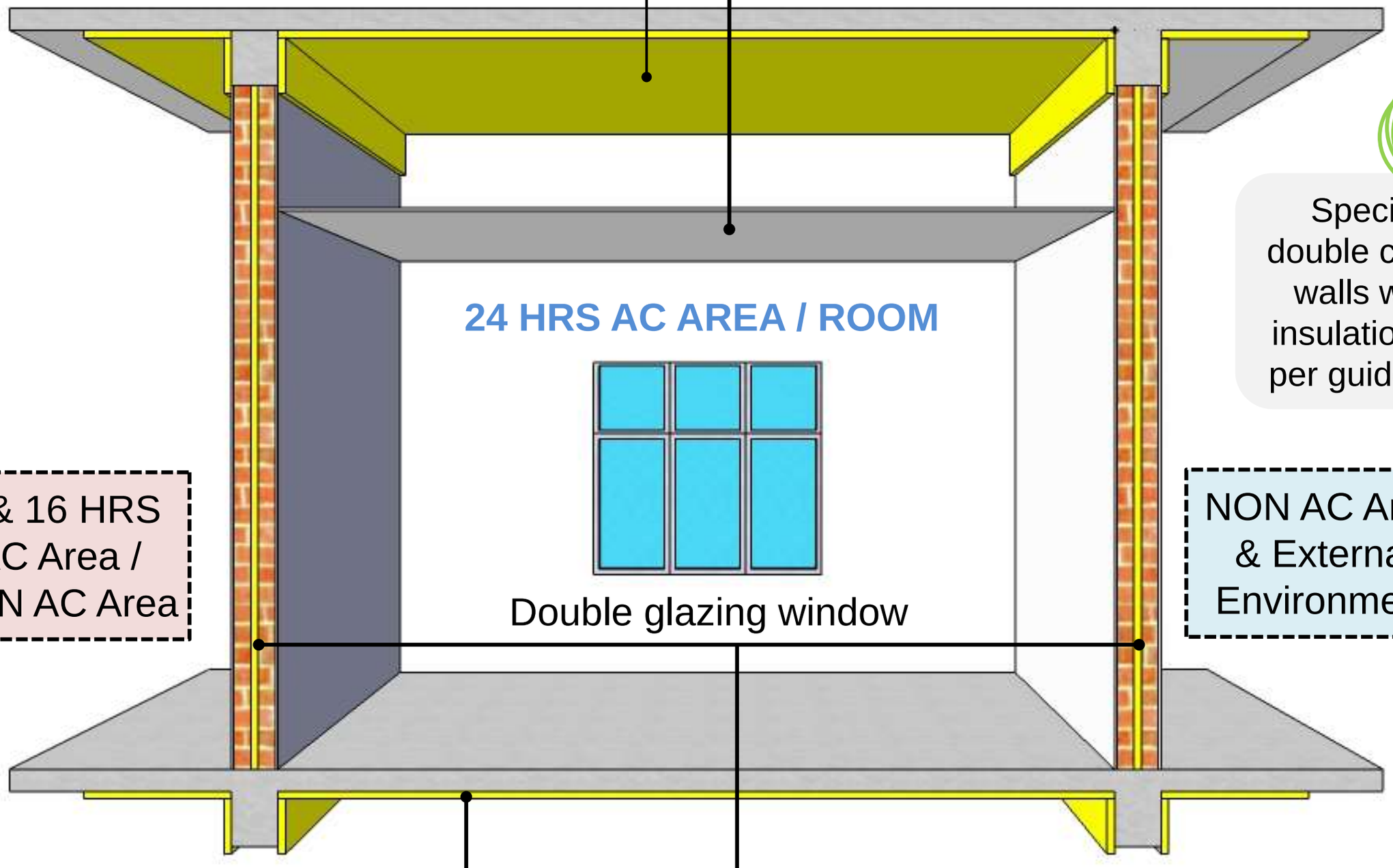


Pharmacy & Rehab. Dept, Hospital Parit Buntar

Source: Unit Kesihatan CA & CKM JKR

50mm thick insulation, extended at least 1m – 3m all round

PVC laminated gypsum board / seamless gypsum board with anti fungus paint



STEP 3

Specify double cavity walls with insulation as per guideline

8 & 16 HRS AC Area / NON AC Area

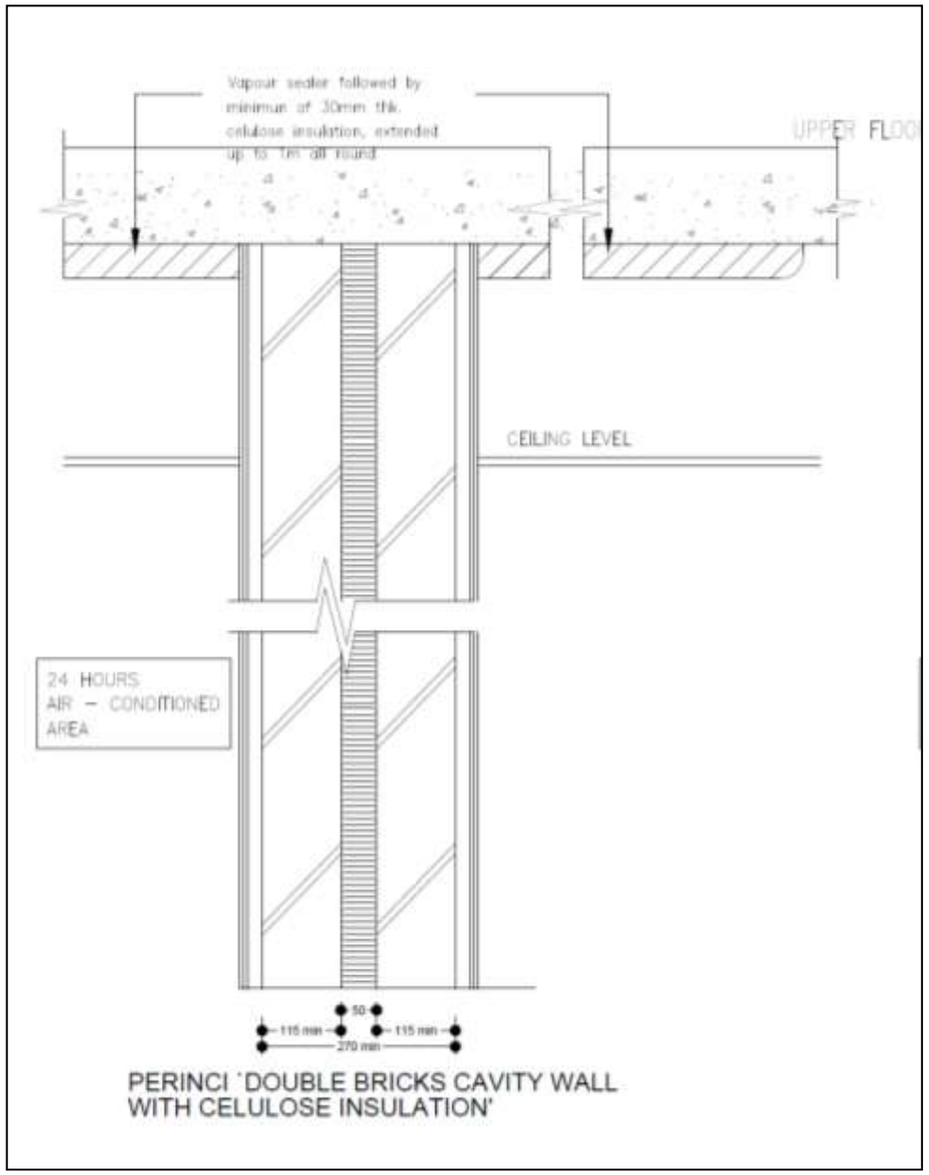
NON AC Area & External Environment

50mm thick insulation, extended at least 1m – 3m all round

Cavity wall c/w min. 25 -50mm gap filled with insulation, approved type plaster & paint on both side (anti fungus paint on 24 hrs AC area)

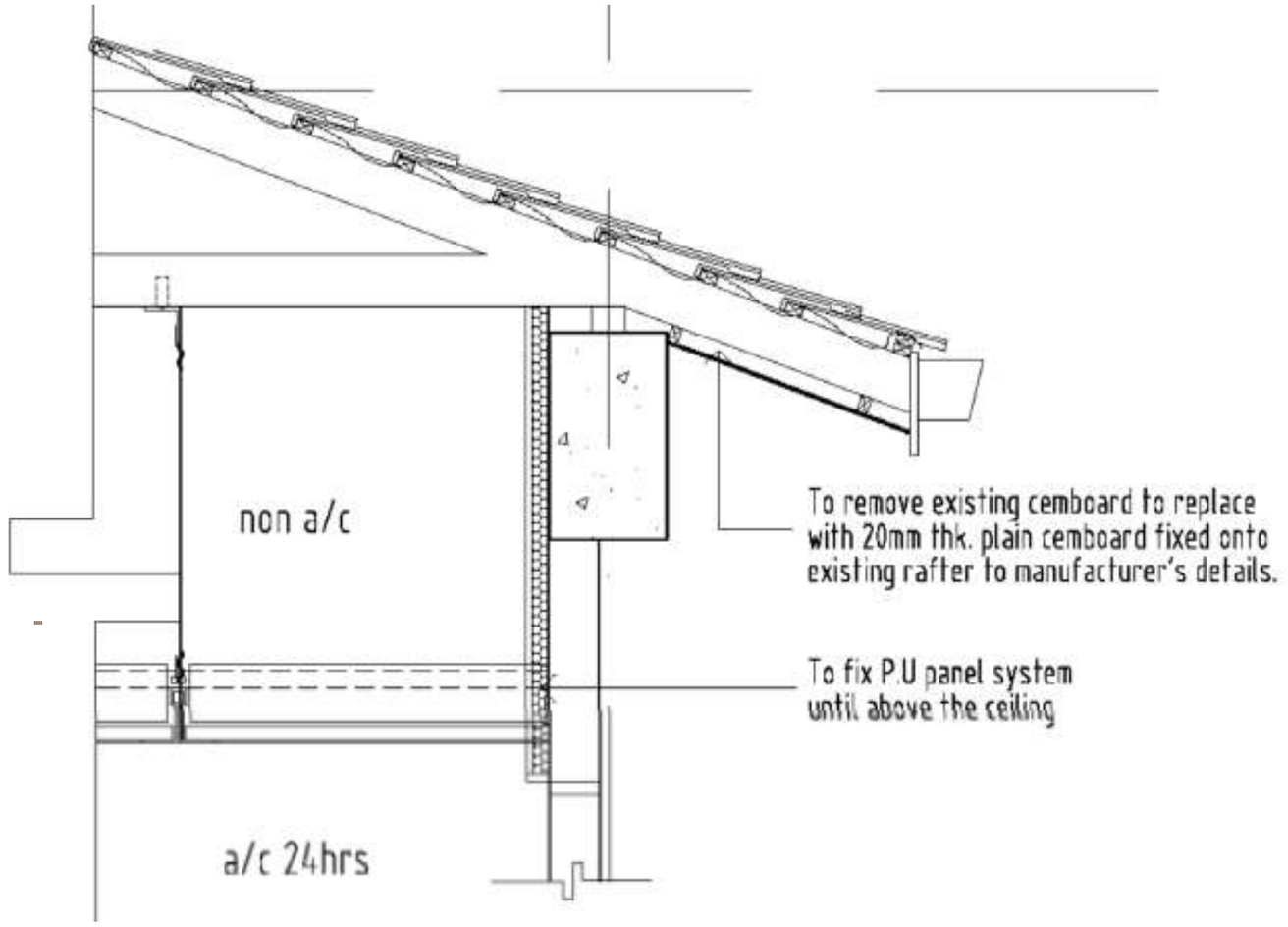
STEP 3

Specify double cavity walls with insulation as per guideline



PERINCI 'DOUBLE BRICKS CAVITY WALL
WITH CELULOSE INSULATION'

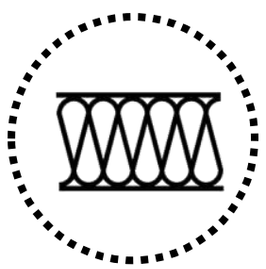
Installation of PU foam insulation on soffit slab of the top most floor below roof trusses



Installation of rockwool insulation on cement board below roof trusses

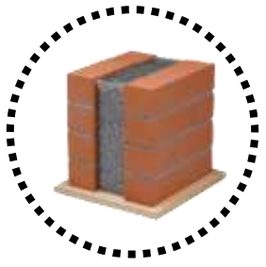
PU foam on soffit slab at Operation Room (OR)

Wall materials should have a total U-VALUE of not more than 0.85 W/m2K



INSULATION – wall, soffit, slab

- **PU foam (non hazardous type), cellulose, rock wool**



CAVITY WALL

- **Clay brick (115mm), Aerated Autoclave Concrete – 125/150mm (AAC) etc.**

ANTI FUNGUS PAINT

- **PU paint, epoxy paint etc.**

Source: Guideline on the prevention of mould growth in building, JKR 2009

EXAMPLE OF U-VALUE CALCULATION

ANALYSIS OF U VALUE OF CAVITY WALL WITH CELLULOSE FIBRE

		Thickness
k Value of Brickwork (outer leaf)	0.77 W/mK	100 mm
k Value of Brickwork (Inner leaf)	0.56 W/mK	100 mm
k Value of Cellulose Fibre	0.029 W/mK	50 mm

R Value = Thickness / k Value

R Value of Brickwork (outer leaf)	=	0.1/0.77	=	0.13
R Value of Cellulose Fibre	=	0.05/0.029	=	1.72
R Value of Brickwork (Inner leaf)	=	0.1/0.56	=	0.18
Total R				2.03

U Value	=	1/R	=	1/2.03
			=	0.49

Remarks : R values of plaster and PU Paints to both sides of wall were not taken into account in the above analysis

THERMAL CONDUCTIVITY
K - VALUE

Surface finishes		
External rendering	1300	0.57
Plaster (dense)	1300	0.57
Plaster (lightweight)	600	0.18
Roofs		
Aerated concrete slab	500	0.16
Asphalt	2100	0.7
Felt/bitumen layers	1100	0.23
Screed	1200	0.41
Stone chippings	2000	2.0
Tiles (clay)	2000	1.0
Tiles (concrete)	2100	1.5
Wood wool slab	500	0.1
Floors		
Cast concrete	2000	1.35
Metal tray (steel)	7800	50.0
Screed	1200	0.41
Timber (softwood), plywood, chipboard	500	0.13
Timber (hardwood)	700	0.18
Insulation		
Expanded polystyrene (EPS) board	15	0.04
Mineral wool quilt	12	0.042
Mineral wool batt	25	0.038
Phenolic foam board	30	0.025
Polyurethane board	30	0.025

Note
If available, certified test values should be used in preference to those in the table.

Building materials

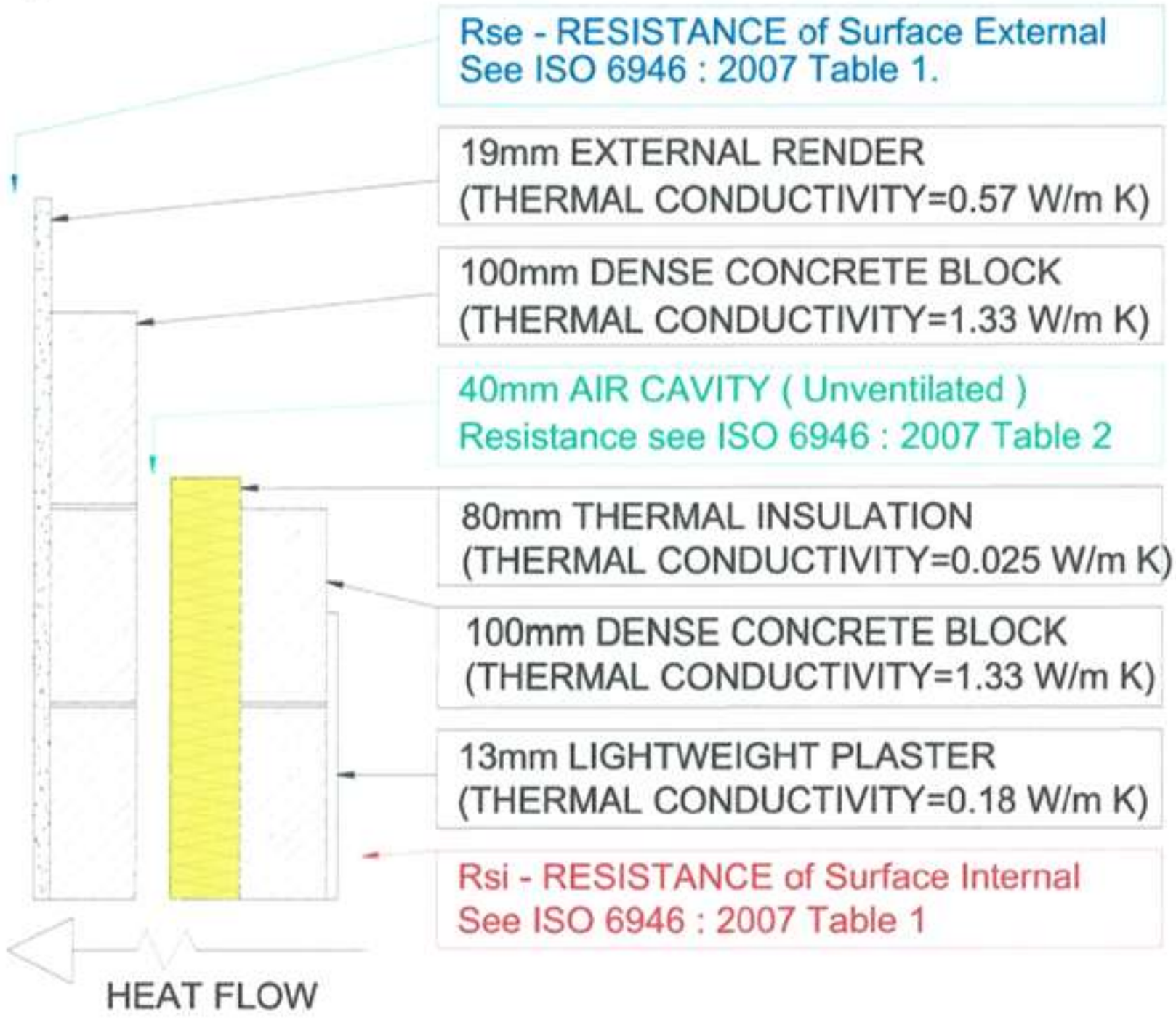
Table A19 Thermal conductivity of some common building materials

	Density (kg/m³)	Conductivity (W/m·K)
Walls		
Brickwork (outer leaf)	1700	0.77
Brickwork (inner leaf)	1700	0.56
Lightweight aggregate concrete block	1400	0.57
Autoclaved aerated concrete block	600	0.18
Concrete (medium density) (inner leaf)	1800	1.13
	2000	1.33
	2200	1.59
Concrete (high density)	2400	1.93
Reinforced concrete (1% steel)	2300	2.3
Reinforced concrete (2% steel)	2400	2.5
Mortar (protected)	1750	0.88
Mortar (exposed)	1750	0.94
Gypsum	600	0.18
	900	0.3
	1200	0.43
Gypsum plasterboard	900	0.25
Sandstone	2600	2.3
Limestone (soft)	1800	1.1
Limestone (hard)	2200	1.7
Fibreboard	400	0.1
Plasterboard	900	0.25
Tiles (ceramic)	2300	1.3
Timber (softwood, plywood, chipboard)	500	0.13
Timber (hardwood)	700	0.18
Wall ties (stainless steel)	7900	17.0
Surface finishes		
External rendering	1300	0.57
Plaster (dense)	1300	0.57

SAMPLE U – VALUE CALCULATION

– simple construction

PARTIALLY FILLED CAVITY



SAMPLE U – VALUE CALCULATION

- continued.

- U-value = thermal transmittance,
- For a simple construction the U-value is equal to the inverse of the sum of the thermal resistances of each layer.
- U-value =

$$\frac{1}{\text{sum of thermal resistance of each layer}}$$

- U-value =

$$\frac{1}{R_{se} + R_{render} + R_{block} + R_{air} + R_{insulatn} + R_{block} + R_{plaster} + R_{si}}$$

SAMPLE U – VALUE CALCULATION

Sum of thermal resistance for all layersfor this simple calculation

Layer / Surface	Thickness (d) (m)	Conductivity (λ) (W / m K)	Resistance (R=d/λ) (m^2 K / W)
External surface (Rse)	- - -	- - -	0.040
External render	0.019	0.57	0.033
Concrete block	0.100	1.33	0.075
Air cavity (Ra)	- - -	- - -	0.180
Insulation	0.080	0.025	3.200
Concrete block	0.100	1.33	0.075
Plaster (lightweight)	0.013	0.18	0.072
Internal surface (Rsi)	- - -	- - -	0.130
Total Resistance	- - -	- - -	3.805

Note: Values of Rse, Ra and Rsi taken from I.S. EN ISO 6946 Table 1 and Table 2.
Thermal conductivity values used are indicative only.
Certified values should be used, if available.

SAMPLE U – VALUE CALCULATION

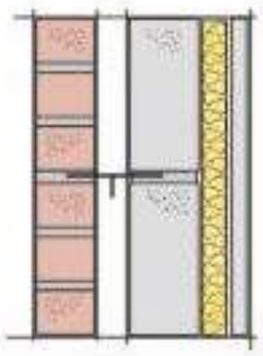
- U-value = $\frac{1}{\text{sum of thermal resistance of each layer}}$

- U-value = thermal transmittance
  = 1 / 3.805

- U-value = 0.26 W / m²K

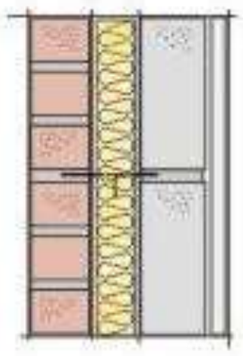
U Value 0.30W/m²K (approx)

Clear cavity



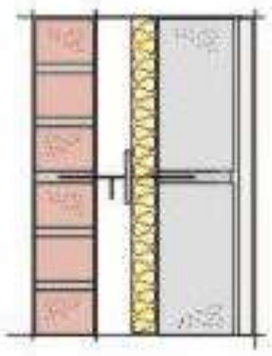
103mm facing brick
50mm clear cavity
115mm aerated block
40mm thermal board

Filled cavity



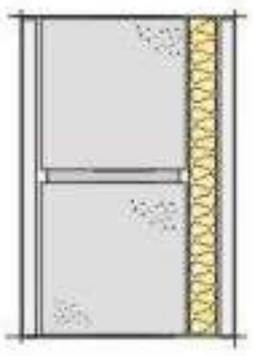
103mm facing brick
75mm cavity batts
115mm aerated block
any plaster finish

Partial cavity



103mm facing brick
30 - 50mm cavity board
50mm cavity retained
125 mm aerated block
any plaster finish

Solid



15mm render
215mm aerated block
30mm thermal board

HEALTH FACILITY PROJECTS

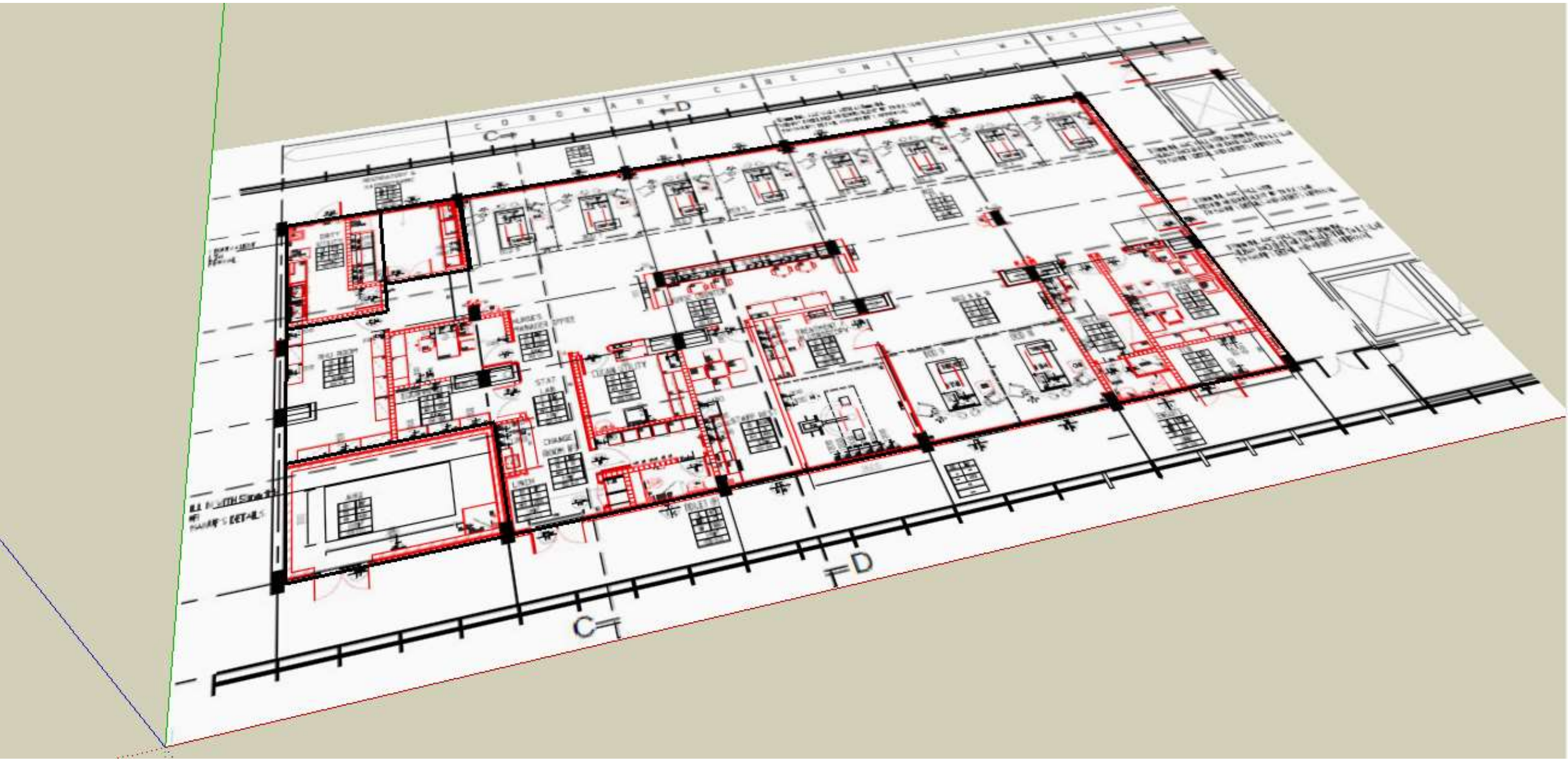
UPGRADING WORKS AT CORONARY CARE UNIT (CCU) HOSPITAL TUANKU JAAFAR, SEREMBAN

Handing over: September 2018

STEP 1

Avoid deep planning design

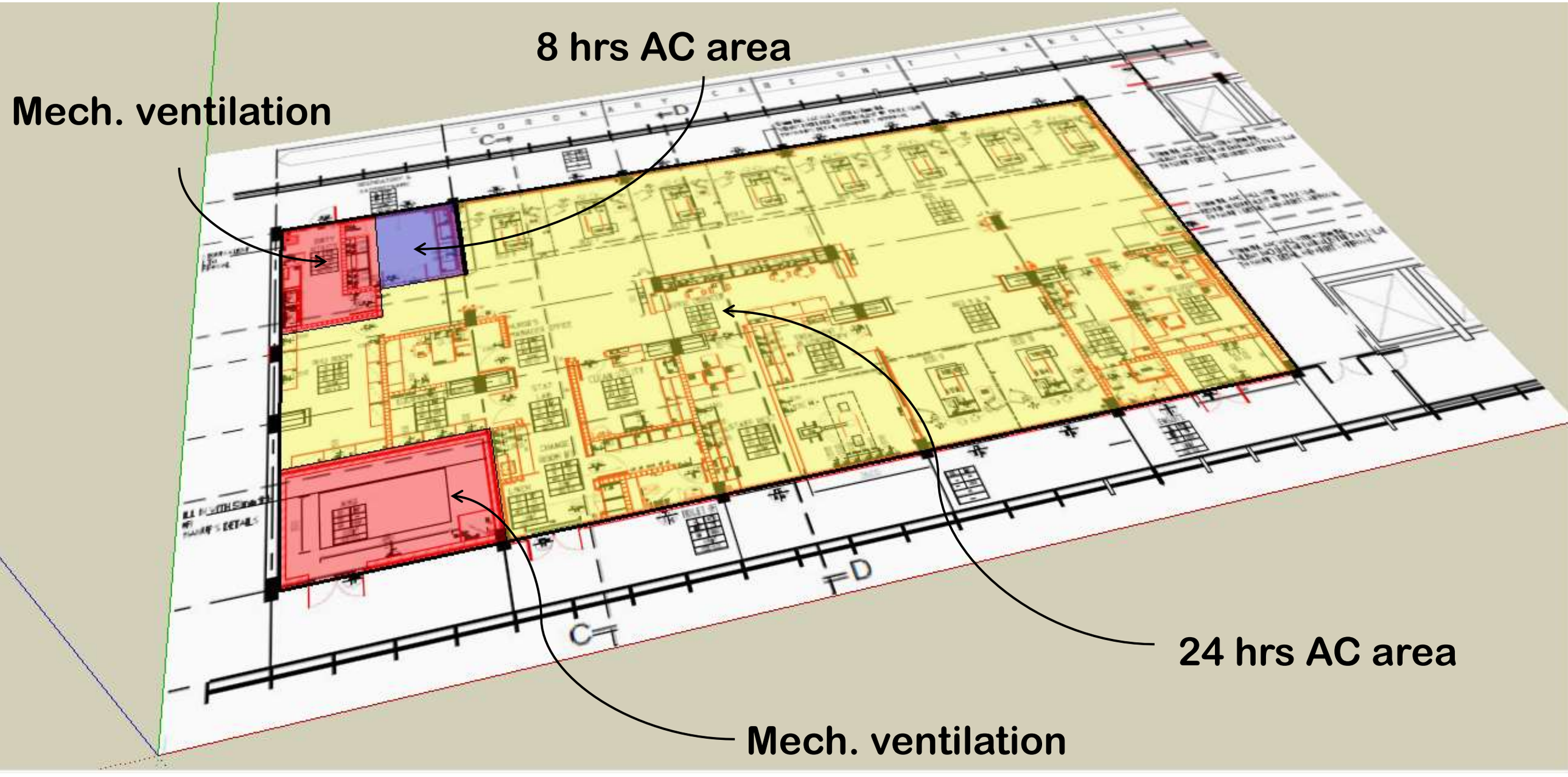
Arrange HVAC zoning



STEP 2

Identify different types of ventilation system

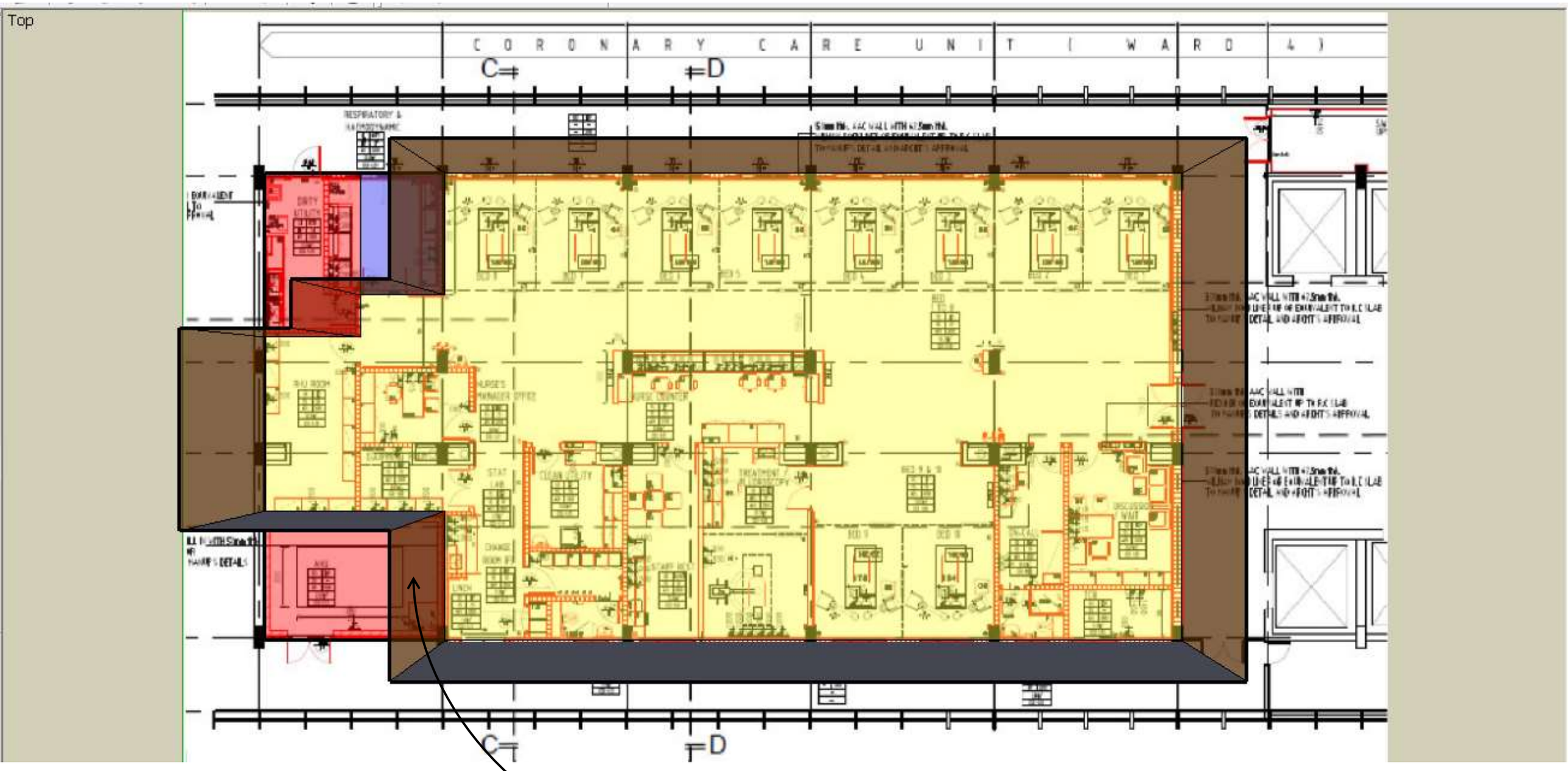
Prepare drawing that indicate diff. types of HVAC system



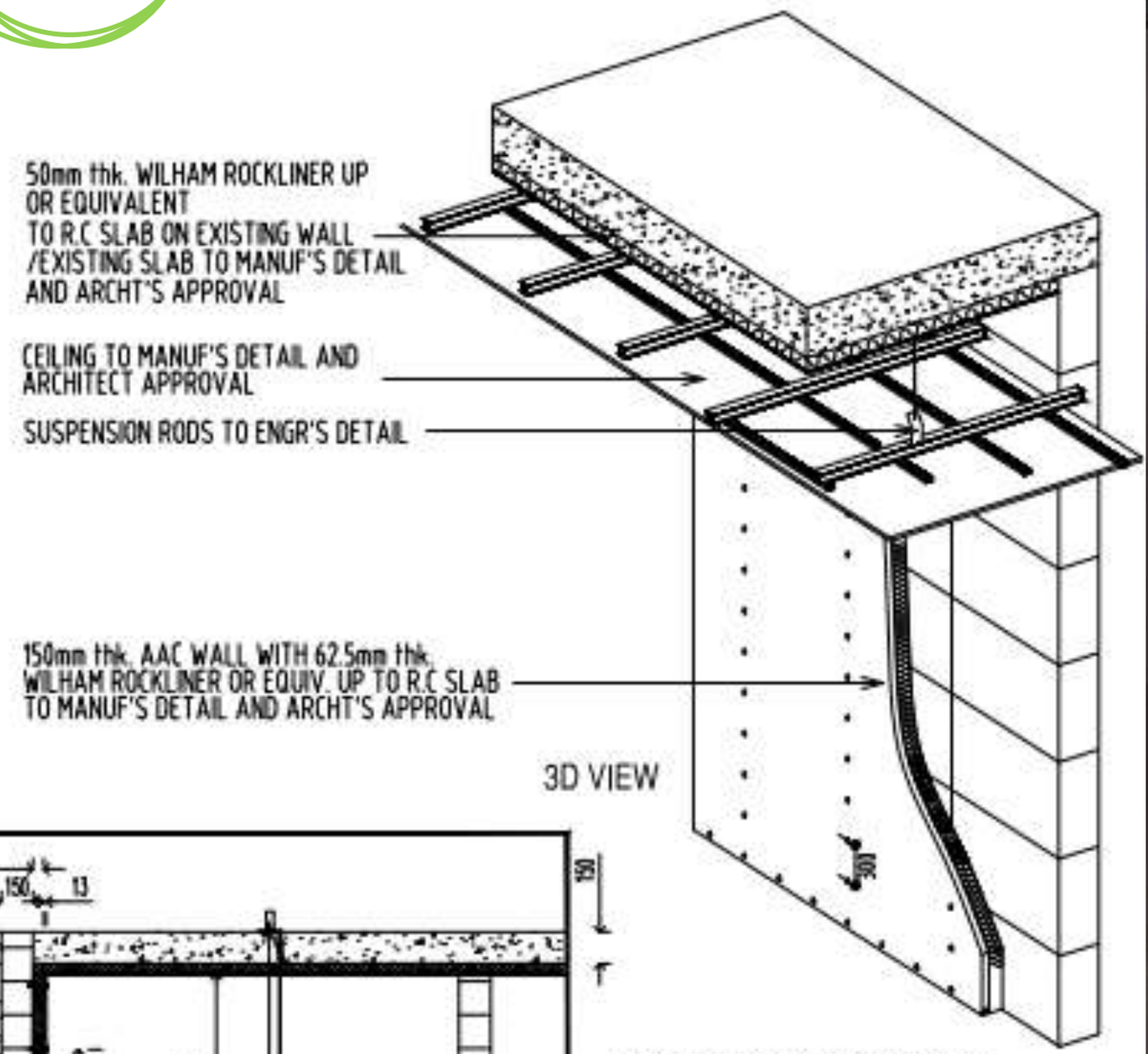
STEP 3

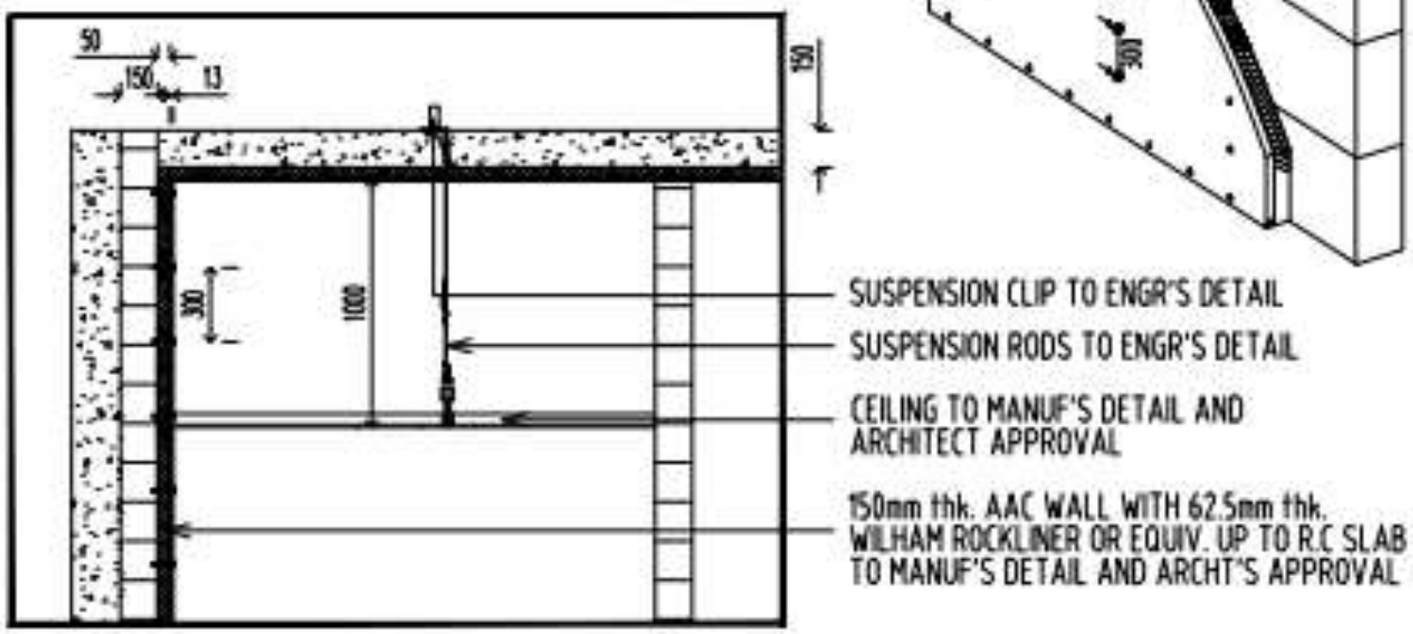
Prepare specifications and detail drawings for cavity walls

Specify in the drawings



D Details & installation





SECTION 2

Rock wool & cement board installation on AAC wall at CCU HTJ

Rock wool installation on AAC wall at CCU HTJ

BEFORE

Mould growth on wall

AFTER

Coronary Care Unit (CCU) Hospital Tuanku Jaafar,

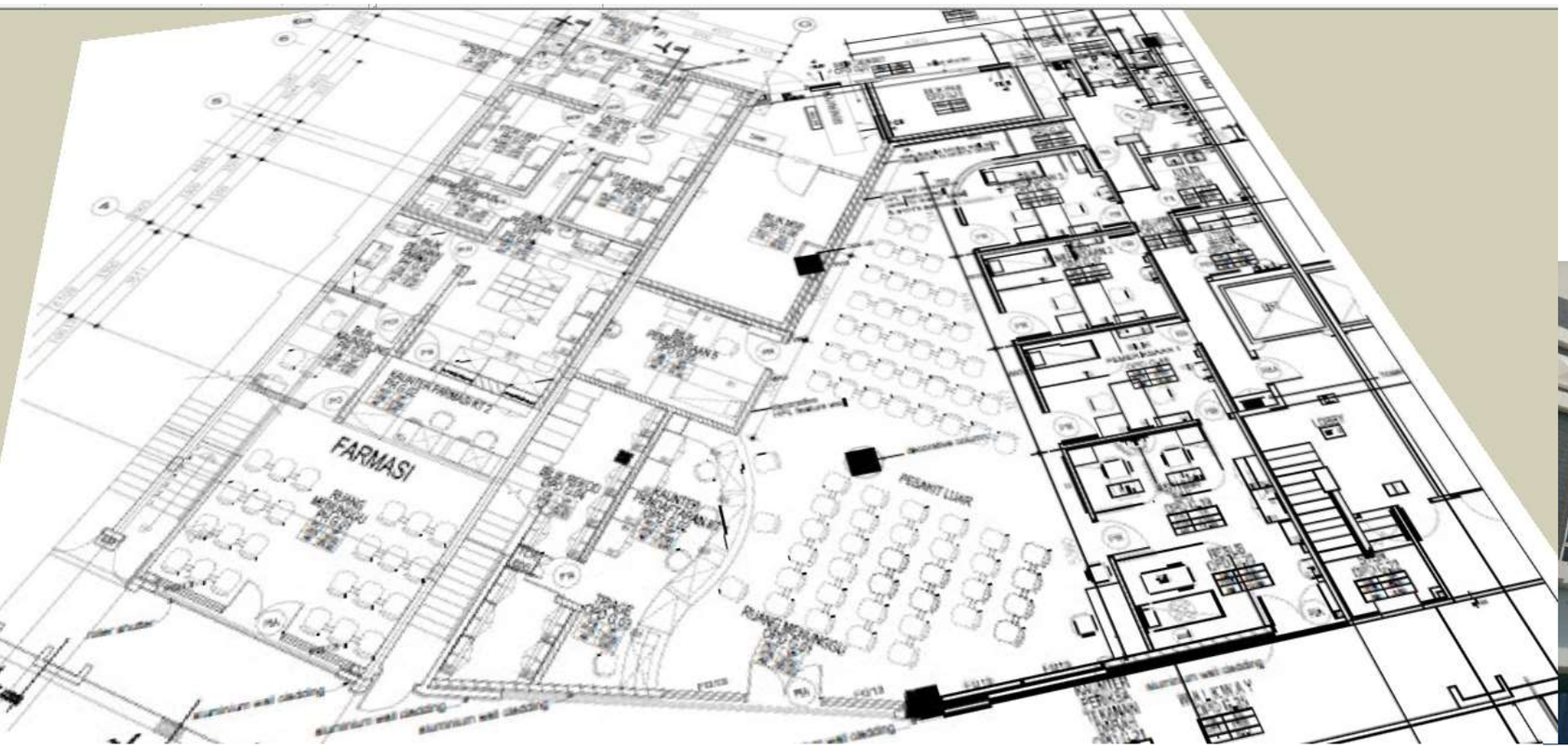
SHOPHOUSE RENOVATION FOR HEALTH CLINIC TYPE 3 AT KOTA DAMANSARA

Handing over: September 2016

STEP 1

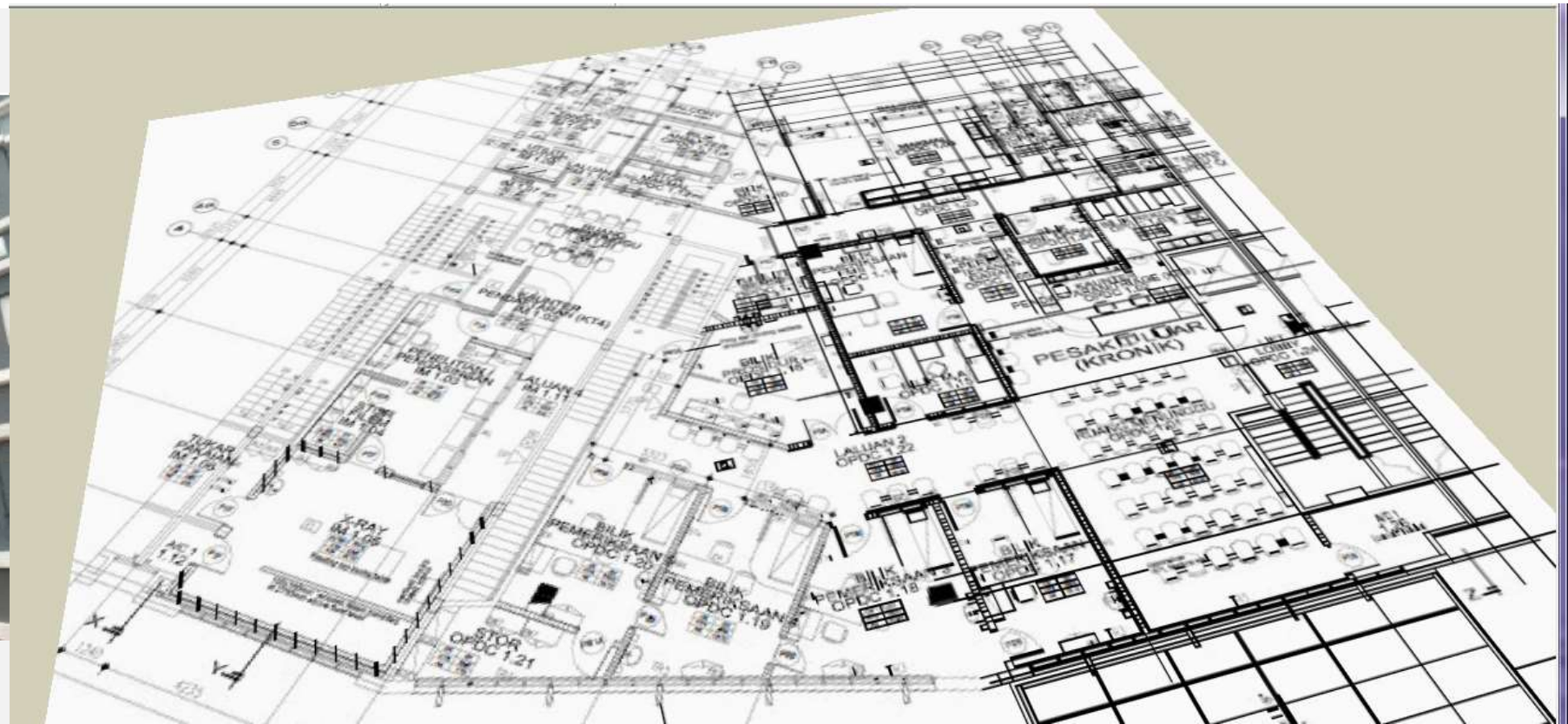
Avoid deep planning design

Arrange HVAC zoning



GROUND FLOOR

FIRST FLOOR



STEP 2

Identify different types of ventilation system

Prepare drawing that indicate diff. types of HVAC system

GROUND FLOOR

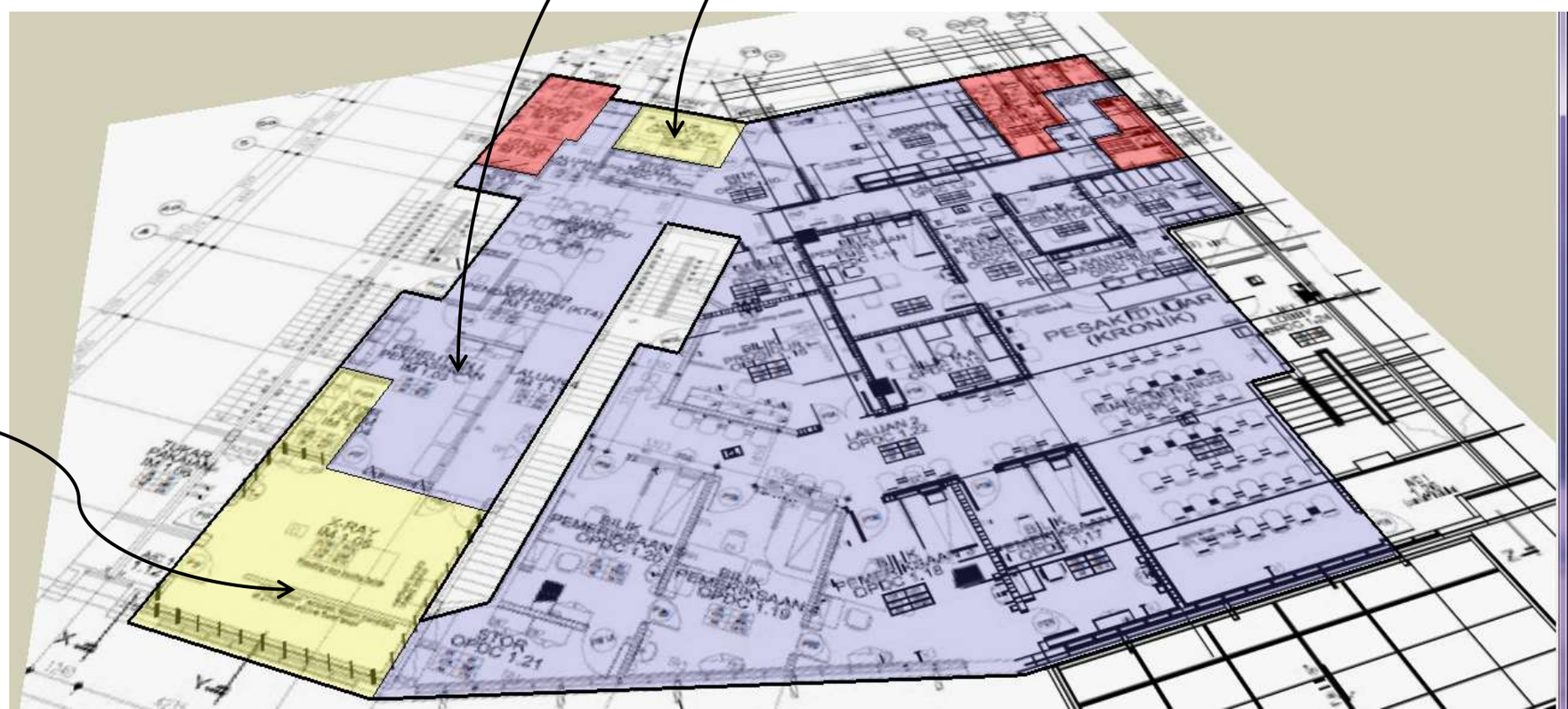
Mech. ventilation

8 hrs AC area

24 hrs AC area (analyser room)

24 hrs AC area (Pharmacy)

24 hrs AC area (X-ray room)



FIRST FLOOR

STEP 3

Prepare specifications and detail drawings for cavity walls

Specify in the drawings

GROUND FLOOR

Mech. ventilation

8 hrs AC area

24 hrs AC area (analyser room)

24 hrs AC area (Pharmacy)

24 hrs AC area (X-ray room)

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DESIGN

COMMUNICATION

QUALITY

RISK

PLANNING

PRE DESIGN

PROCUREMENT

DESIGN

CONSTRUCTION

HANDING OVER

DLP

CMGD/ CLOSE ACCOUNT

TERIMA KASIH