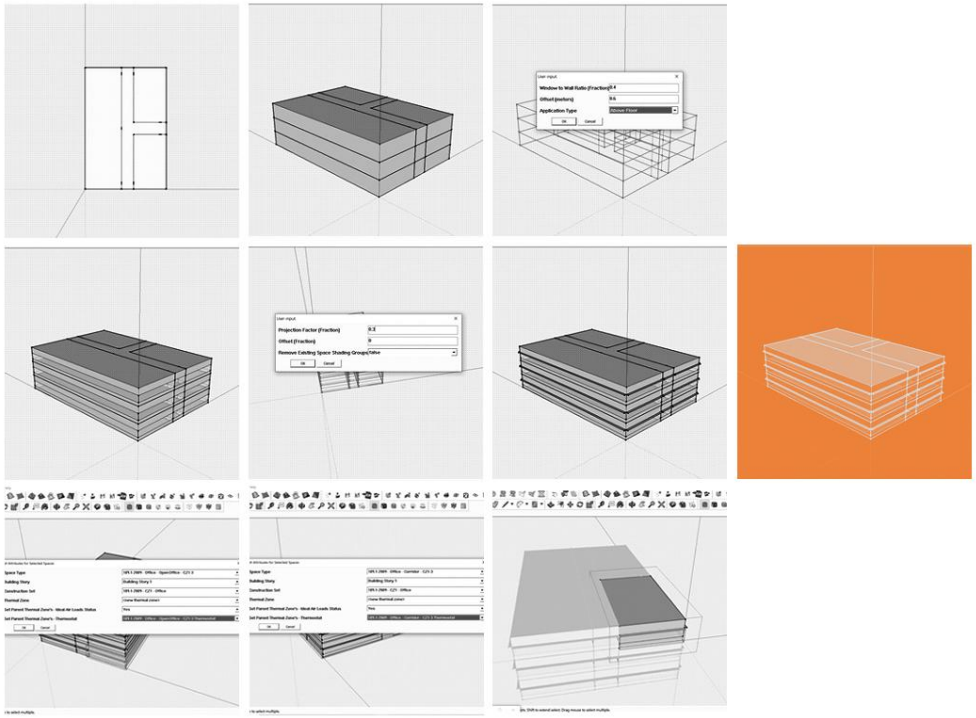
OPEN STUDIO PROJECT

TECHNICAL
ENVIRONMENTAL
SYSTEM



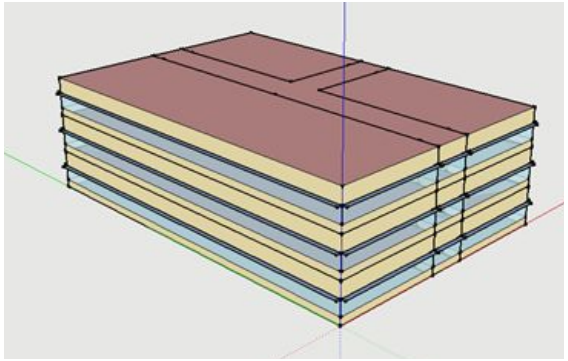
GROUP MEMBERS:

Ranjana Siva, 10717668
Srividya Mushty, 10663951
Sumaita Tahseen, 10720296
Anashwara Jayakumar, 10700740

POLITECNICO
MILANO 1863

PROJECT INFORMATION

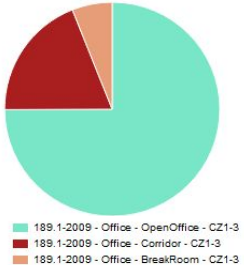
BUILDING

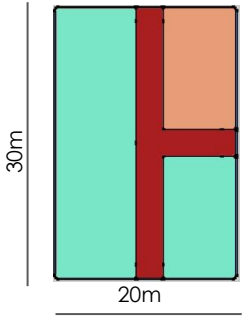


Geometry:

Building type- Office
No.of floors- 3
Dimensions- 20m x 30m
Window-Wall Ratio- 40%

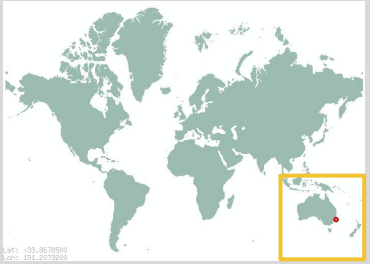
Characteristics:





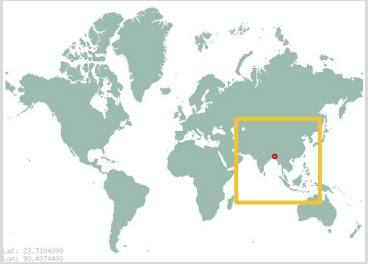
Floor Areas (SQFT):
Open Office- 14519
Break Room- 1170
Corridor- 3686

CITIES



Warm | Temperate

Sydney, Australia



Hot | Humid

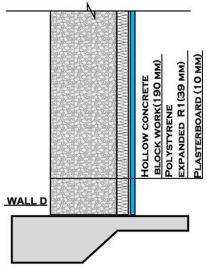
Dhaka, Bangladesh

Cool | Temperate

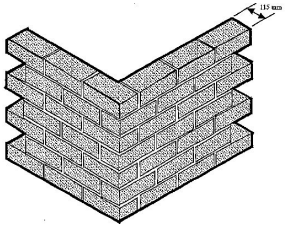
Helsinki, Finland

WALL TYPES

Wall 1
(Base type)
200mm thick
Lightweight Concrete



Wall 2
(Better Option)
*Concrete- 190 mm
*PolyUrethane Rigid Foam- 39 mm
*Plaster Board- 10mm



Wall 3
(Worse Option)
115mm thick
Brickwork

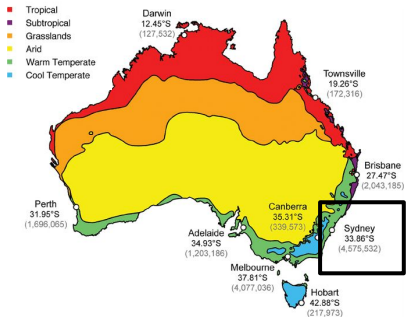
OVERVIEW OF THE PROCEDURE

1. The designed commercial building is modelled on Sketchup Make 2016.
2. For the cities we chose, the different climatic thermal zones are identified.
3. The Sketchup model is then saved as an Open Studio Model for further simulations.
4. The thermal zones for the various spaces in the building are accordingly allotted.
5. For each particular city, the climatic files of .ddy and .epw files are downloaded from the Energy Plus site and loaded to Open Studio Model.
6. The results are used for further analysis.

CLIMATIC AND WEATHER DATA

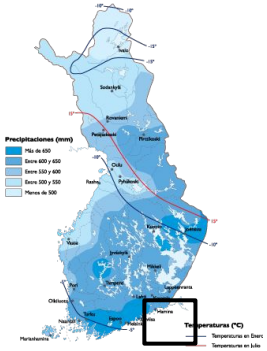
SYDNEY, AUSTRALIA

Hottest Month -January
Coldest Month - July
Wettest Month - March



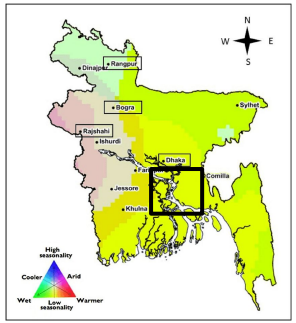
HELSINKI, FINLAND

Hottest Month -July
Coldest Month - February
Wettest Month - August

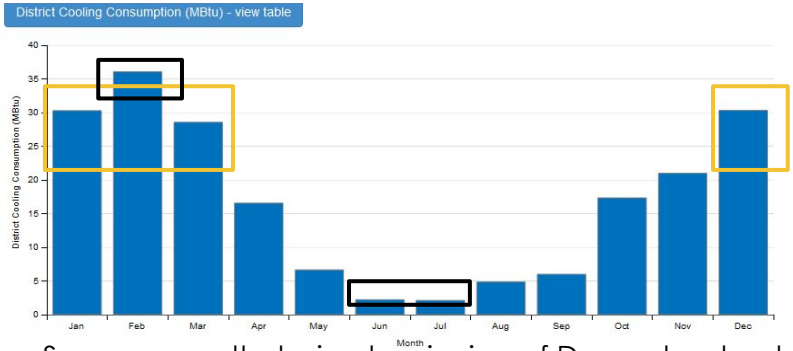


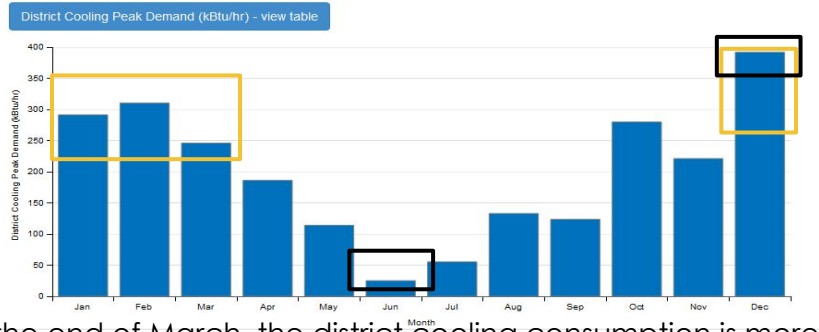
DHAKA, BANGLADESH

Hottest Month -June
Coldest Month - January
Wettest Month - August

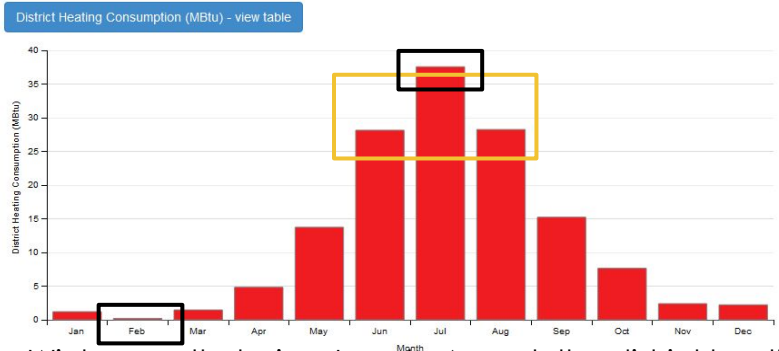


BASE CASE (Monthly Analysis): SYDNEY, Australia





Summer months being beginning of December to almost the end of March, the district cooling consumption is more in these months and highest being in the February month(37 MBtu approximately). And district cooling peak demand being highest in December(390 kBtu/hr approximately).



Winter months being June to August, the district heating consumption is more in these months and highest being in the month of July(38 MBtu approximately) and district heating peak demand being highest in July month(470 kBtu/hr approximately).

COMPARATIVE STUDY (Annual overview): SYDNEY | DHAKA | HELSINKI

SYDNEY

Net Site Energy=
795,664 kBtu
EUI= **41.07 kBtu/ft^2**

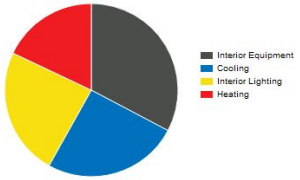
DHAKA

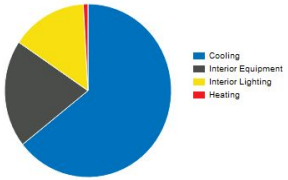
Net Site Energy=
1,297,524 kBtu
EUI= **66.97 kBtu/ft^2**

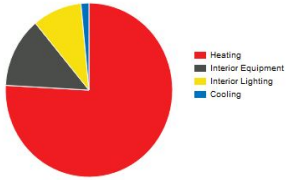
HELSINKI

Net Site Energy=
1,995,316 kBtu
EUI= **102.98 kBtu/ft^2**

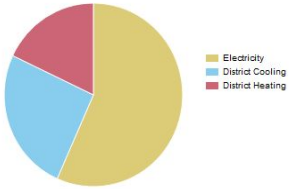
End Use

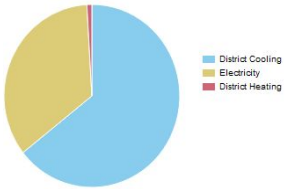


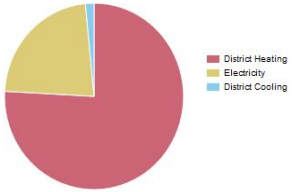




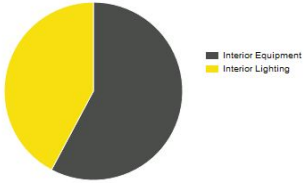
Energy Use

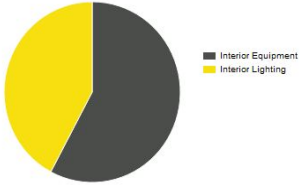


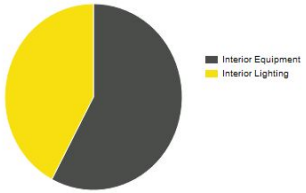




Energy Use Index- Electricity

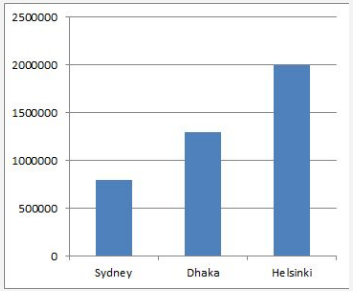




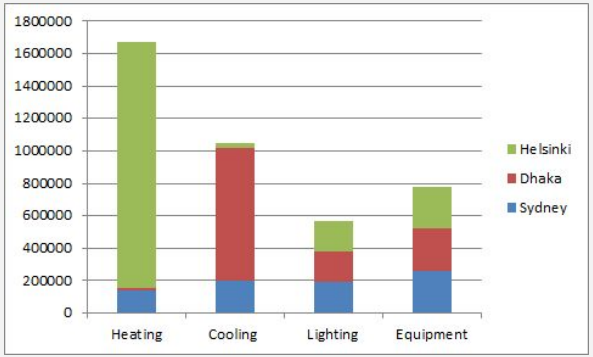


ANALYSIS

Net Site Energy (or EUI):
The same building block when placed in Helsinki, consumes around 2.5 times the energy it consumes when placed in Sydney, and 1.5 times that when placed in Dhaka

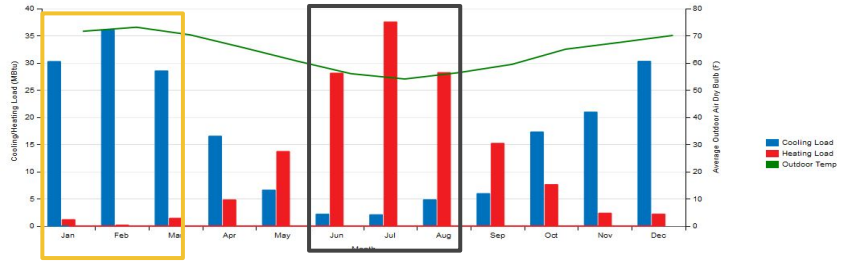


Heating | Cooling | Lighting | Equipment :
Helsinki has the highest heating load of 10.5 times more than Sydney, while Dhaka has the highest cooling load of approx. 4 times more than Sydney. Lighting and equipment consumption remains constant due to fixed building type.



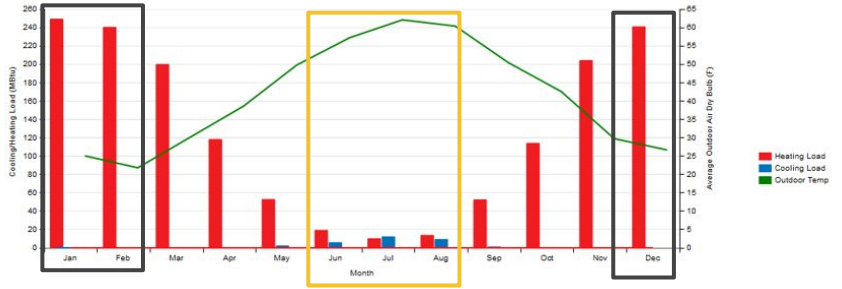
COMPARATIVE STUDY (Monthly overview): SYDNEY | DHAKA | HELSINKI

SYDNEY



DHAKA

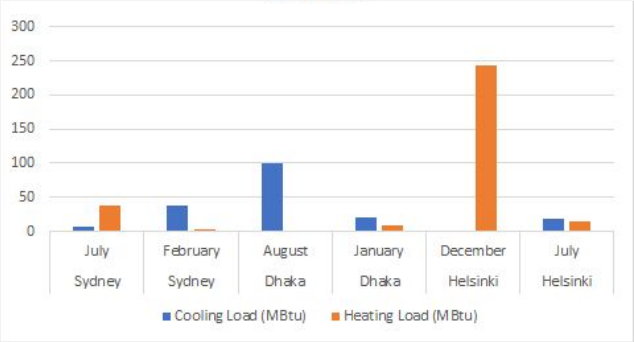
HELSINKI



ANALYSIS :

Load Profiles with respect to outdoor temperature

Heating, Cooling Loads with respect to months:



The highest heating load is for Helsinki in the month of December compared to highest heating loads of Sydney(in July) and Dhaka which does not need any in August.

The highest cooling load is for Dhaka in the month of August compared to the highest cooling loads of Sydney(in February) and Helsinki which does not need any in December.

U-VALUES : WALL TYPES

WALL 1 - LIGHTWEIGHT CONCRETE

$$U = \frac{1}{R_{conc}}$$

Considering Unit Thermal Resistance of Lightweight Concrete,

$$R_{conc} = 1.17$$

$$U = \frac{1}{1.17} = 0.854 \ \frac{W}{m^2 °C}$$

$$A_{ext.wall} = (72.8+97.2)x3 = 510 \ m^2$$

Total Overall Heat Transfer Coefficient,

$$U_{tot} = 0.854 \ \frac{W}{m^2 °C} \ x \ 510 \ m^2$$

$$= 435.54 \ \frac{W}{°C}$$

WALL 2 - CONCRETE WITH PU FOAM

$$U = \frac{1}{R_{tot}}$$

Considering Unit Thermal Resistance of heavyweight Concrete, Urethane Rigid Foam and plaster,

$$R_{tot} = R_{conc} + R_{foam} + R_{pl}$$
$$= 0.12 + 0.98 + 0.079$$
$$= 1.179$$

$$U = \frac{1}{1.179} = 0.848 \ \frac{W}{m^2 °C}$$

$$A_{ext.wall} = (72.8+97.2)x3 = 510 \ m^2$$

Total Overall Heat Transfer Coefficient,

$$U_{tot} = 0.848 \ \frac{W}{m^2 °C} \ x \ 510 \ m^2$$

$$= 432.48 \ \frac{W}{°C}$$

WALL 3- BRICKWORK

$$U = \frac{1}{R_{brick}}$$

Considering Unit Thermal Resistance of Brick,

$$R_{brick} = 0.12$$

$$U = \frac{1}{0.12} = 8.33 \ \frac{W}{m^2 °C}$$

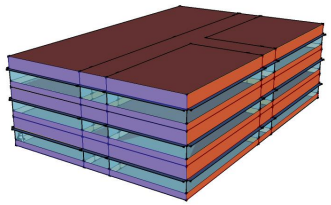
$$A_{ext.wall} = (72.8+97.2)x3 = 510 \ m^2$$

Total Overall Heat Transfer Coefficient,

$$U_{tot} = 8.33 \ \frac{W}{m^2 °C} \ x \ 510 \ m^2$$

$$= 4248.3 \ \frac{W}{°C}$$

TOTAL AREA



218.4 sq.m

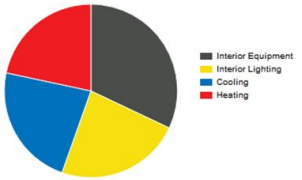
291.6 sq.m

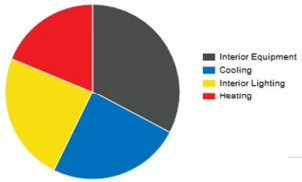
Total Area = 510 sq.m

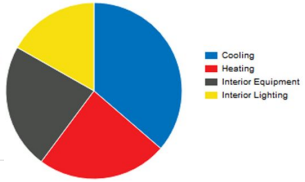
COMPARATIVE STUDY : WALL TYPES

WALL 1	WALL 2	WALL 3
Net Site Energy= **813,284 kBtu** EUI= **41.98 kBtu/ft^2**	Net Site Energy= **796,233 kBtu** EUI= **41.10 kBtu/ft^2**	Net Site Energy= **1,132,319 kBtu** EUI= **58.44 kBtu/ft^2**

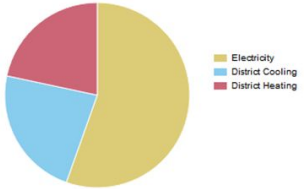
End Use

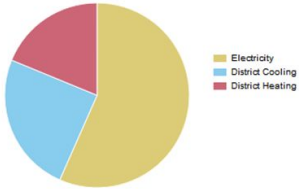


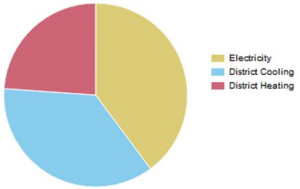




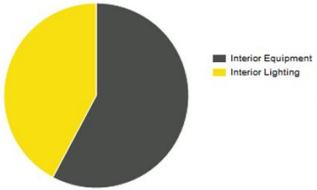
Energy Use

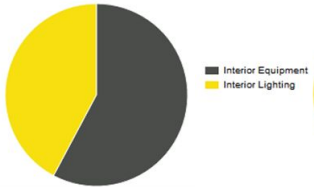


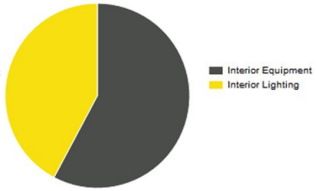




Energy Use Index- Electricity

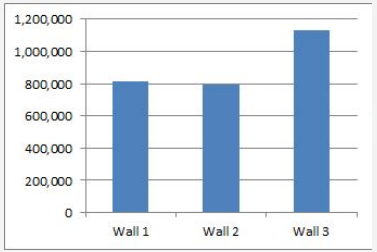




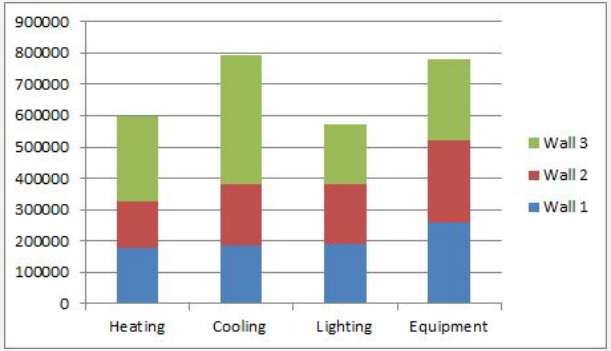


ANALYSIS

Net Site Energy (or EUI):
The base wall [1] (Lightweight concrete) has an energy consumption almost comparable to the better wall option [2] (concrete wall with PU foam insulation), while in the case of the brick wall [3], it is the highest.

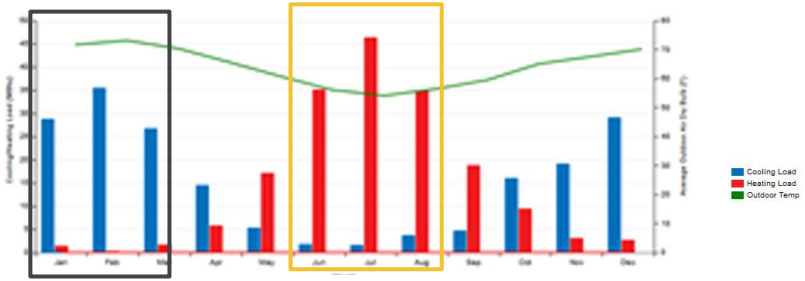


Heating | Cooling | Lighting | Equipment :
Wall 1 works slightly better than Wall 2 for minimising cooling load, Wall 2 works best for minimising heating load consumption, while Wall 3 has the poorest performance in both cases.

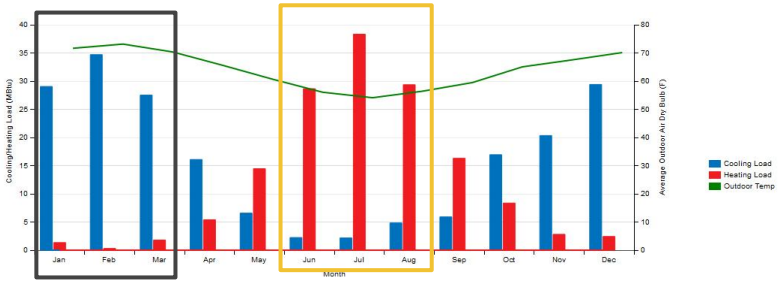


COMPARATIVE STUDY : WALL TYPES

WALL 1



WALL 2

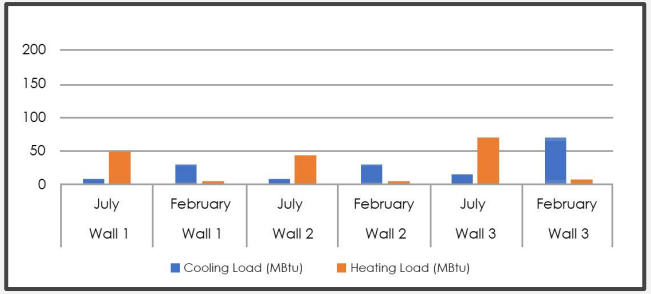


WALL 3

ANALYSIS :

Load Profiles with respect to outdoor temperature

<u>Heating, Cooling Loads with respect to months:</u>



The highest heating load is of Wall 3(Brickwork) in the month of July compared to highest heating loads of Sydney(in July). On the contrary, Wall 1 and Wall 2 has almost similar heating load.

The highest cooling load is also of Wall 3 in the month of February compared to the highest cooling loads of Sydney(in February). Again, Wall 1 and Wall 2 has same cooling load.

CONCLUSION

HEATING LOAD ANALYSIS

Dhaka	Sydney	Helsinki
13 MBtu	146 MBtu	1527 MBtu

Least → Highest

COOLING LOAD ANALYSIS

Helsinki	Sydney	Dhaka
24 MBtu	205 MBtu	820 MBtu

Least → Highest

The overall highest heating load is for Helsinki while Dhaka being the least.
The overall highest cooling load is for Dhaka while Helsinki being the least.
In both the cases, Sydney stands in between both the cities(Dhaka and Helsinki).

NET SITE ENERGY CONSUMPTION ANALYSIS

Sydney	Dhaka	Helsinki
41.07 kBtu/ft2	66.97 kBtu/ft2	102.98 kBtu/ft2

Least → Highest

The overall energy consumption in an year for the designed commercial building is highest in Helsinki (with high cooling load).
Whereas, the least is in Sydney (with less cooling load compared to Dhaka, and less heating load compared to Helsinki).

WALL TYPE ANALYSIS

Net Energy Consumption

Concrete with PU foam	Lightweight concrete	Brickwork
41.10 kBtu/ft2	41.98 kBtu/ft2	58.44 kBtu/ft2

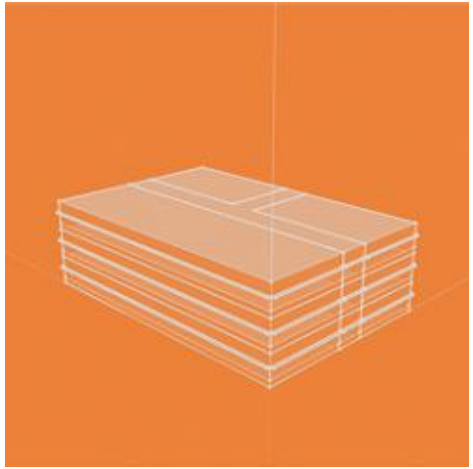
Least → Highest

U Value

Concrete with PU foam	Lightweight concrete	Brickwork
432.48 W/c	435.54 W/c	4248.3 W/c

Least → Highest

The net energy consumption and the U value is highest for brickwork wall and least for concrete with PU foam, where light weight concrete is in between both of them.
The difference of these values between concrete with PU foam and lightweight concrete isn't much. Whereas there is huge difference between brickwork wall and these two.
Which implies that concrete with PU foam and lightweight concrete are equally good wall types. And better than brickwork wall.



THANK YOU