POLITECNICO DI MILAMO
SUSTAINABLE ARCHITECTURE AND LANDSCAPE DESIGN

ENERGY PERFORMANCE

TECHNICAL ENVIRONMENT SYSTEMS
STUDY ON ENERGY PERFORMANCE OF BUILDINGS

JANA HAJER
TANG FANYI
TANG YUCHEN

PROF. RENZO MARCHESI
PROF. BEHZAD NAJAFI

PIACENZA
HELSINKI
HONG KONG

ENERGY PERFORMANCE COMPARISON OF A BUILDING IN THREE DIFFERENT LOCATIONS

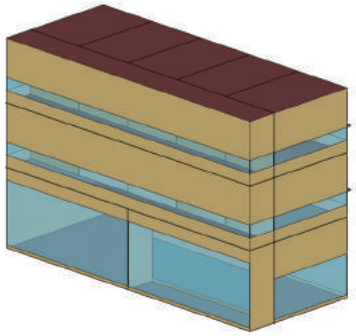
1.1 EXPERIMENTAL OBJECTIVE & REQUIREMENT

Experimental Objective: Analysis the energy performance of the same building in different cities.

Experimental Requirement: The influences of building structure and energy consumption were analyzed by the analysis of rainfall, temperature, sunshine, altitude, soil, vegetation, air quality, wind direction, wind speed, latitude and longitude, climate, hydrology, time zone and axis between two cities.

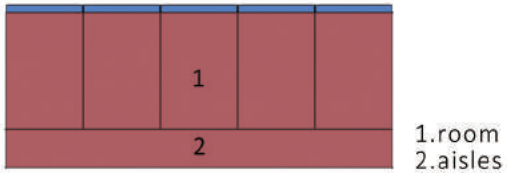
1.2 OVERALL BUILDING INTRODUCTION

We chose a small three-story hotel as our research object for the study of energy of buildings. Due to the hotel's functionality, for example, service and residence, making the building a variety of spatial forms. Also the activities of various groups in the building are more diverse.

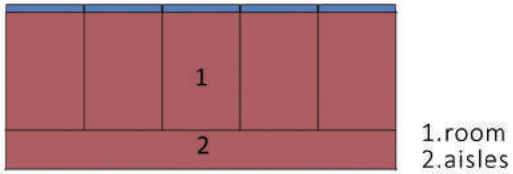


PLAN OF 1st FLOOR

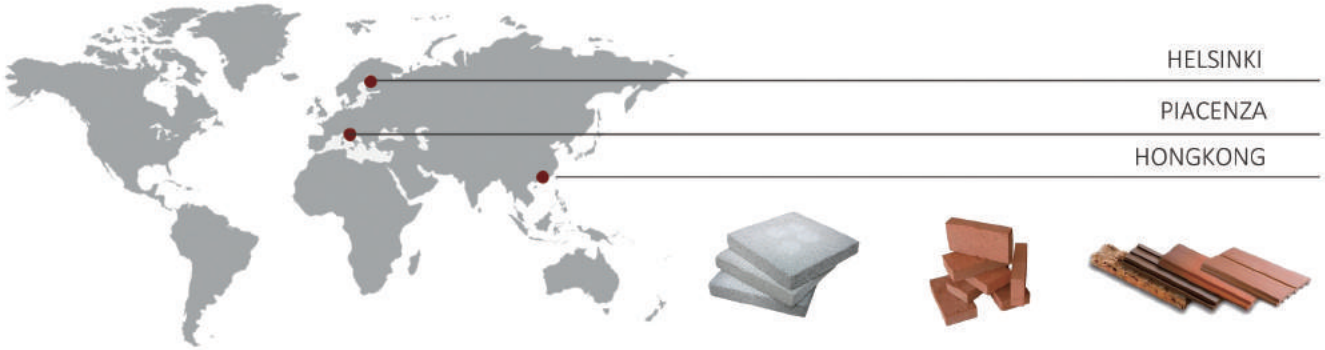
At the first floor, there is the reception desk, the dining room and the staircase. On the second floor and the third floor, there are the rooms and aisles. Also the opening of the windows is different according to the usage of different floors, so that the energy consumption of each floor is different.



PLAN OF 2nd FLOOR



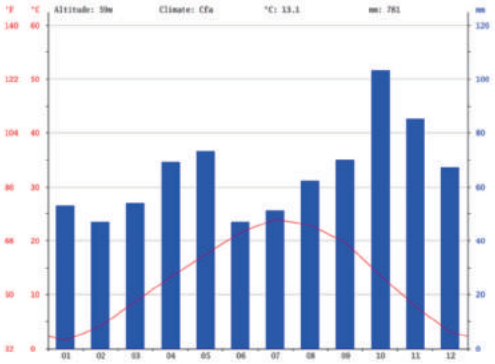
PLAN OF 3rd FLOOR



In this project, there are 3 positions in different climatic conditions, Piacenza in Italy, Hongkong in China and Helsinki in Finland. Also there are 3 different materials of the wall: the concrete, the brick and the wood.

PIACENZA

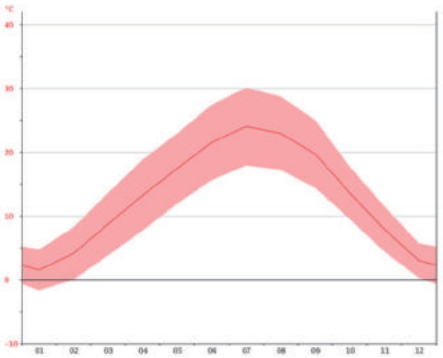
Latitude: 44.92
Longitude: 9.73
Elevation: 134
Time zone: 1



Climograph
source: https://en.climate-data.org/location/764497/

	January	February	March	April	May	June	July	August	Sep-tember	October	No-vember	Decem-ber
Avg. Temperature (°C)	1.5	4.1	8.7	13.2	17.4	21.5	24	22.9	19.7	13.6	7.9	3
Min. Temperature (°C)	-1.7	0	3.8	7.7	11.9	15.6	17.9	17.2	14.4	9.5	4.4	0.3
Max. Temperature (°C)	4.7	8.2	13.6	18.8	22.9	27.4	30.1	28.7	25	17.7	11.5	5.7
Avg. Temperature (°F)	34.7	39.4	47.7	55.8	63.3	70.7	75.2	73.2	67.5	56.5	46.2	37.4
Min. Temperature (°F)	28.9	32.0	38.8	45.9	53.4	60.1	64.2	63.0	57.9	49.1	39.9	32.5
Max. Temperature (°F)	40.5	46.8	56.5	65.8	73.2	81.3	86.2	83.7	77.0	63.9	52.7	42.3
Precipitation / Rainfall (mm)	53	47	54	69	73	47	51	62	70	103	85	67

Climate Table//Historical Weather Data



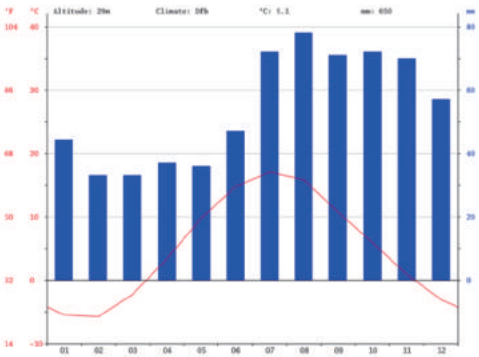
Temperature Graph

The climate in Piacenza is warm and temperate. The is a great deal of rainfall in Piacenza, even in the driest month. This climate is considered to be Cfa according to the Köppen-Geiger climate classification. The average temperature in Piacenza is 13.1 °C. In a year, the average rainfall is 781 mm. The driest month is February, with 47 mm of rain. The greatest amount of precipitation occurs in October, with an average of 103 mm.
July is the warmest month of the year. The temperature in July averages 24.0 °C. The lowest average temperatures in the year occur in January, when it is around 1.5 °C.

Design Day Name	Day of Month	Month	Day Type	Max Dry Bulb T	Daily Dry Bulb T range	Humidity Conditions at Max Dry Bulb	Barometric Pressure	Wind Speed	Wind Direction
Piacenza Ann Clg .4% Condns DB=>MWB	21	8	Summer	33.1	11.90	22.70	99726.00	2.30	90.00
Piacenza Ann Clg .4% Condns DP=>MDB	21	8	Summer	27.4	11.90	23.00	99726.00	2.30	90.00
Piacenza Ann Clg .4% Condns Enth=>MDB	21	8	Summer	30.3	11.90	74900.00	99726.00	2.30	90.00
Piacenza Ann Clg .4% Condns WB=>MDB	21	8	Summer	30.1	11.90	24.60	99726.00	2.30	90.00
Piacenza Ann Htg 99.6% Condns DB	21	1	Winter	-6.1	0.00	-6.10	99726.00	2.00	250.00
Piacenza Ann Htg Wind 99.6% Condns WS=>MCDB	21	1	Winter	5.8	0.00	5.80	99726.00	8.90	250.00
Piacenza Ann Hum_n 99.6% Condns DP=>MCDB	21	1	Winter	3.5	0.00	-11.30	99726.00	2.00	250.00

HELSINKI

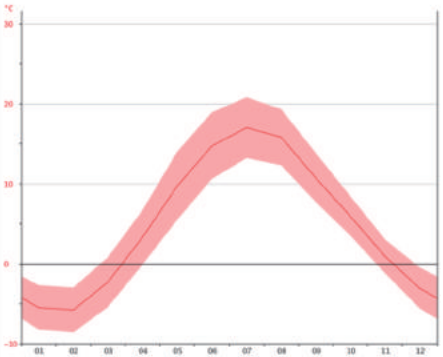
Latitude: 60.32
Longitude: 24.97
Elevation: 56
Time zone: 2



Climograph
source: https://en.climate-data.org/location/5971/

	January	February	March	April	May	June	July	August	September	October	November	December
Avg. Temperature (°C)	-5.5	-5.8	-2.3	3.3	9.7	14.7	17	15.8	10.7	5.9	0.9	-3.1
Min. Temperature (°C)	-8.2	-8.6	-5.4	-0.1	5.5	10.6	13.2	12.3	7.7	3.5	-1.2	-5.6
Max. Temperature (°C)	-2.7	-3	0.8	6.7	14	18.9	20.8	19.3	13.8	8.4	3	-0.5
Avg. Temperature (°F)	22.1	21.6	27.9	37.9	49.5	58.5	62.6	60.4	51.3	42.6	33.6	26.4
Min. Temperature (°F)	17.2	16.5	22.3	31.8	41.9	51.1	55.8	54.1	45.9	38.3	29.8	21.9
Max. Temperature (°F)	27.1	26.6	33.4	44.1	57.2	66.0	69.4	66.7	56.8	47.1	37.4	31.1
Precipitation / Rainfall (mm)	44	33	33	37	36	47	72	78	71	72	70	57

Climate Table//Historical Weather Data



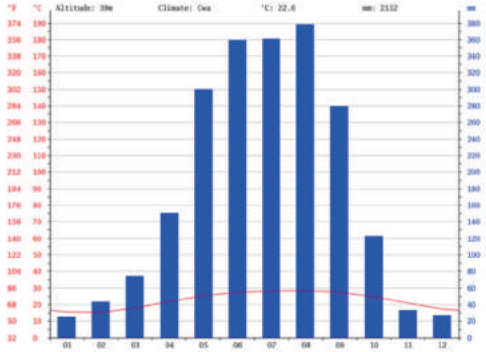
Temperature Graph

In Helsinki, the climate is cold and temperate. Helsinki has a significant amount of rainfall during the year. This climate is considered to be Dfb according to the Köppen-Geiger climate classification. The temperature here averages 5.1 °C. The average annual rainfall is 650 mm.
The driest month is February, with 33 mm of rainfall. With an average of 78 mm, the most precipitation falls in August. The warmest month of the year is July, with an average temperature of 17.0 °C. February has the lowest average temperature of the year. It is -5.8 °C.
The difference in precipitation between the driest month and the wettest month is 45 mm. During the year, the average temperatures vary by 22.8 °C.

Design Day Name	Day of Month	Month	Day Type	Max Dry Bulb T	Daily Dry Bulb T range	Humidity Conditions at Max Dry Bulb	Barometric Pressure	Wind Speed	Wind Direction
HELSINKI Ann Clg .4% Condns DB=>MWB	21	7	Summer	26.7	9.50	17.90	100654.00	4.50	160.00
HELSINKI Ann Clg .4% Condns DP=>MDB	21	7	Summer	20.5	9.50	17.20	100654.00	4.50	160.00
HELSINKI Ann Clg .4% Condns Enth=>MDB	21	7	Summer	23.8	9.50	54300.00	100654.00	4.50	160.00
HELSINKI Ann Clg .4% Condns WB=>MDB	21	7	Summer	24.0	9.50	19.10	100654.00	4.50	160.00
HELSINKI Ann Htg 99.6% Condns DB	21	2	Winter	-22.8	0.00	-22.80	100654.00	2.70	0.00
HELSINKI Ann Htg Wind 99.6% Condns WS=>MCDB	21	2	Winter	0.4	0.00	0.40	100654.00	11.30	0.00
HELSINKI Ann Hum_n 99.6% Condns DP=>MCDB	21	2	Winter	-22.7	0.00	-25.40	100654.00	2.70	0.00

HONG KONG

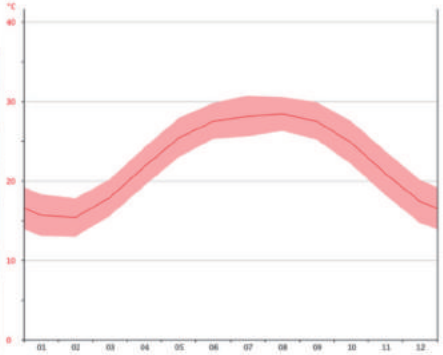
Latitude: 22.32
Longitude: 114.17
Elevation: 65
Time zone: 8



Climograph
source: https://en.climate-data.org/location/977986/

	January	February	March	April	May	June	July	August	Sep-tember	October	No-vember	Decem-ber
Avg. Temperature (°C)	15.7	15.4	17.9	21.8	25.4	27.5	28.1	28.4	27.5	24.8	20.9	17.4
Min. Temperature (°C)	13.1	13	15.6	19.4	23	25.3	25.6	26.3	25.2	22.1	18.2	14.7
Max. Temperature (°C)	18.3	17.8	20.2	24.2	27.9	29.8	30.7	30.5	29.9	27.5	23.7	20.1
Avg. Temperature (°F)	60.3	59.7	64.2	71.2	77.7	81.5	82.6	83.1	81.5	76.6	69.6	63.3
Min. Temperature (°F)	55.6	55.4	60.1	66.9	73.4	77.5	78.1	79.3	77.4	71.8	64.8	58.5
Max. Temperature (°F)	64.9	64.0	68.4	75.6	82.2	85.6	87.3	86.9	85.8	81.5	74.7	68.2
Precipitation / Rainfall (mm)	25	43	74	150	300	359	361	378	279	123	33	27

Climate Table//Historical Weather Data



Temperature Graph

The climate in Hong Kong is warm and temperate. In winter, there is much less rainfall in Hong Kong than in summer. This climate is considered to be Cwa according to the Köppen-Geiger climate classification. The average annual temperature is 22.6 °C in Hong Kong. Precipitation here averages 2152 mm. The driest month is January, with 25 mm of rain. With an average of 378 mm, the most precipitation falls in August. August is the warmest month of the year, with an average of 28.4 °C. February has the lowest average temperature of the year. It is 15.4 °C. There is a difference of 353 mm of precipitation between the driest and wettest months.

Design Day Name	Day of Month	Month	Day Type	Max Dry Bulb T	Daily Dry Bulb T range	Humidity Conditions at Max Dry Bulb	Barometric Pressure	Wind Speed	Wind Direction
HONG KONG Ann Clg .4% Condns DB=>MWB	21	7	Summer	33.8	4.70	26.50	100547.00	5.00	240.00
HONG KONG Ann Clg .4% Condns DP=>MDB	21	7	Summer	30.0	4.70	26.90	100547.00	5.00	240.00
HONG KONG Ann Clg .4% Condns Enth=>MDB	21	7	Summer	31.3	4.70	88300.00	100547.00	5.00	240.00
HONG KONG Ann Clg .4% Condns WB=>MDB	21	7	Summer	30.8	4.70	27.70	100547.00	5.00	240.00
HONG KONG Ann Htg 99.6% Condns DB	21	1	Winter	9.0	0.00	9.00	100547.00	4.20	30.00
HONG KONG Ann Htg Wind 99.6% Condns WS=>MCDB	21	1	Winter	18.1	0.00	18.10	100547.00	10.50	30.00
HONG KONG Ann Hum_n 99.6% Condns DP=>MCDB	21	1	Winter	13.7	0.00	-3.20	100547.00	4.20	30.00

2.1 EXPERIMENTAL PROCEDURE

1. Using software Sketchup to complete a simple model mass;
2. Using the software plug-in Openstudio, and then put the simple model mass into the Openstudio;
3. Choosing three different cities as our site and three diferent materials of the wall;
4. Calculate the yearly heating and cooling. Recording the data of experiments. Then do the analysis and comparision between the data.

2.2 EXPERIMENTAL RESULT

Building Summary

Information	Value	Units
Building Name	Building 1	building_name
Net Site Energy	1,012,790	kBtu
Total Building Area	5,167	ft^2
EUI (Based on Net Site Energy and Total Building Area)	196.02	kBtu/ft^2
OpenStudio Standards Building Type		

building summary in HELSINKI

Weather Summary

	Value
Weather File	HELSINKI - FIN IWEC Data WMO#=029740
Latitude	60.32
Longitude	24.97
Elevation	184 (ft)
Time Zone	2.00
North Axis Angle	0.00
ASHRAE Climate Zone	2B

weather summary in HELSINKI

Building Summary

Information	Value	Units
Building Name	Building 1	building_name
Net Site Energy	756,292	kBtu
Total Building Area	5,167	ft^2
EUI (Based on Net Site Energy and Total Building Area)	146.38	kBtu/ft^2
OpenStudio Standards Building Type		

building summary in HONGKONG

Weather Summary

	Value
Weather File	HONG KONG SAR CHN CityUHK-45007 WMO#=450070
Latitude	22.32
Longitude	114.17
Elevation	213 (ft)
Time Zone	8.00
North Axis Angle	0.00
ASHRAE Climate Zone	

weather summary in HONGKONG

Building Summary

Information	Value	Units
Building Name	Building 1	building_name
Net Site Energy	839,102	kBtu
Total Building Area	5,167	ft^2
EUI (Based on Net Site Energy and Total Building Area)	162.41	kBtu/ft^2
OpenStudio Standards Building Type		

building summary in PIACENZA

Weather Summary

	Value
Weather File	Piacenza - ITA IGDG WMO#=160840
Latitude	44.92
Longitude	9.73
Elevation	440 (ft)
Time Zone	1.00
North Axis Angle	0.00
ASHRAE Climate Zone	

weather summary in PIACENZA

From the above data, we can see that, due to the different climatic conditions in the three locations, the same type of construction results in a large difference in the energy consumption of the building, in the same case that the materials of wall is brick.

Helsinki belongs to a temperate maritime climate, with an elevation of 184m, which the Net Site energy and the EUI is the highest among the three locations.

Hongkong belongs to a maritime subtropical monsoon climate with an elevation of 213m, which the Net Site energy and the EUI is the lowest among the three locations.

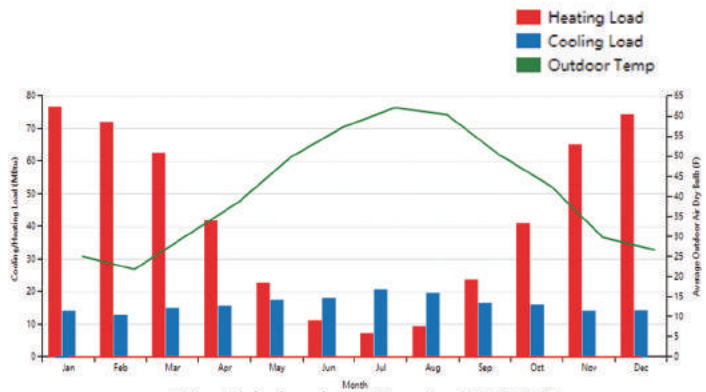
Piacenza belongs to a temperate climate with an elevation of 440m, in a medium position of Net Site energy and the EUI.

2.2 EXPERIMENTAL RESULT

Sizing Period Design Days

	Maximum Dry Bulb (F)	Daily Temperature Range (R)	Humidity Value	Humidity Type	Wind Speed (mph)	Wind Direction
HELSINKI ANN CLG .4% CONDNS DB=>MWB	80.06	17.1	64.22	Wetbulb [F]	10.07	160.0
HELSINKI ANN CLG .4% CONDNS DP=>MDB	68.9	17.1	62.96	Dewpoint [F]	10.07	160.0
HELSINKI ANN CLG .4% CONDNS ENTH=>MDB	74.84	17.1	23.34	Enthalpy [Btu/lb]	10.07	160.0
HELSINKI ANN CLG .4% CONDNS WB=>MDB	75.2	17.1	66.38	Wetbulb [F]	10.07	160.0
HELSINKI ANN HTG 99.6% CONDNS DB	-9.04	0.0	-9.04	Wetbulb [F]	6.04	0.0
HELSINKI ANN HTG WIND 99.6% CONDNS WS=>MCDB	32.72	0.0	32.72	Wetbulb [F]	25.28	0.0
HELSINKI ANN HUM_N 99.6% CONDNS DP=>MCDB	-8.86	0.0	-13.72	Dewpoint [F]	6.04	0.0

sizing period design days in HELSINKI

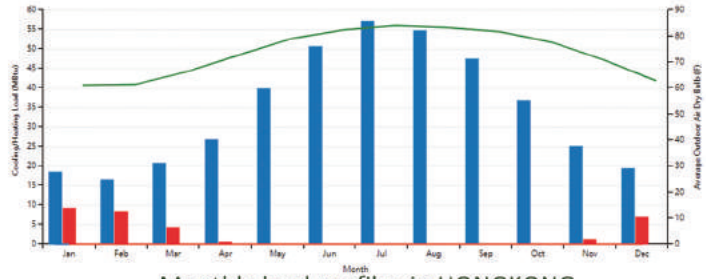


Monthly load profiles in HELSINKI

Sizing Period Design Days

	Maximum Dry Bulb (F)	Daily Temperature Range (R)	Humidity Value	Humidity Type	Wind Speed (mph)	Wind Direction
HONG KONG ANN CLG .4% CONDNS DB=>MWB	92.84	8.46	79.7	Wetbulb [F]	11.18	240.0
HONG KONG ANN CLG .4% CONDNS DP=>MDB	86.0	8.46	80.42	Dewpoint [F]	11.18	240.0
HONG KONG ANN CLG .4% CONDNS ENTH=>MDB	88.34	8.46	37.96	Enthalpy [Btu/lb]	11.18	240.0
HONG KONG ANN CLG .4% CONDNS WB=>MDB	87.44	8.46	81.86	Wetbulb [F]	11.18	240.0
HONG KONG ANN HTG 99.6% CONDNS DB	48.2	0.0	48.2	Wetbulb [F]	9.4	30.0
HONG KONG ANN HTG WIND 99.6% CONDNS WS=>MCDB	64.58	0.0	64.58	Wetbulb [F]	23.49	30.0
HONG KONG ANN HUM_N 99.6% CONDNS DP=>MCDB	56.66	0.0	26.24	Dewpoint [F]	9.4	30.0

sizing period design days in HONGKONG

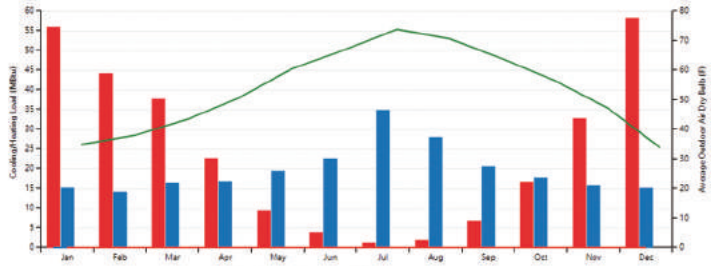


Monthly load profiles in HONGKONG

Sizing Period Design Days

	Maximum Dry Bulb (F)	Daily Temperature Range (R)	Humidity Value	Humidity Type	Wind Speed (mph)	Wind Direction
PIACENZA ANN CLG .4% CONDNS DB=>MWB	91.58	21.42	72.86	Wetbulb [F]	5.14	90.0
PIACENZA ANN CLG .4% CONDNS DP=>MDB	81.32	21.42	73.4	Dewpoint [F]	5.14	90.0
PIACENZA ANN CLG .4% CONDNS ENTH=>MDB	86.54	21.42	32.2	Enthalpy [Btu/lb]	5.14	90.0
PIACENZA ANN CLG .4% CONDNS WB=>MDB	86.18	21.42	76.28	Wetbulb [F]	5.14	90.0
PIACENZA ANN HTG 99.6% CONDNS DB	21.02	0.0	21.02	Wetbulb [F]	4.47	250.0
PIACENZA ANN HTG WIND 99.6% CONDNS WS=>MCDB	42.44	0.0	42.44	Wetbulb [F]	19.91	250.0
PIACENZA ANN HUM_N 99.6% CONDNS DP=>MCDB	38.3	0.0	11.66	Dewpoint [F]	4.47	250.0

sizing period design days in PIACENZA

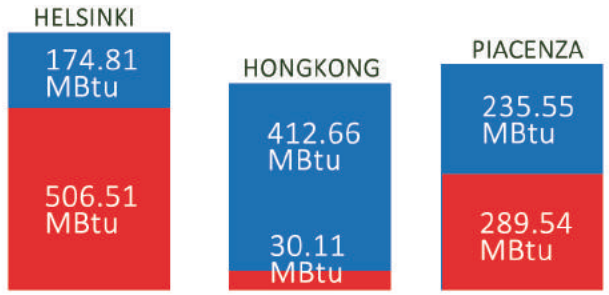


Monthly load profiles in PIACENZA

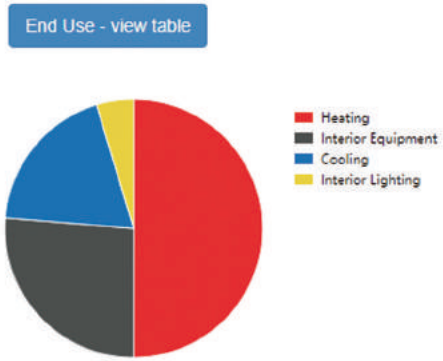
As can be seen from the data, the daily temperature range is influenced by lots of factors, the wind speed and the wind direction. The daily temperature range in Piacenza is almost 3 times of Hongkong.

From the data of monthly load profiles in three sites, we could find that the heating and cooling load connect closely to the outdoor temperature. According to the EUI and the Net Site Energy, we could find that the extreme temperature changes over the course of the year necessitated an increase in both heating and cooling, resulting in an increase in building energy consumption.

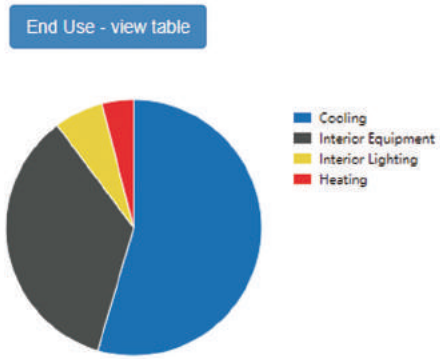
Yearly load profiles



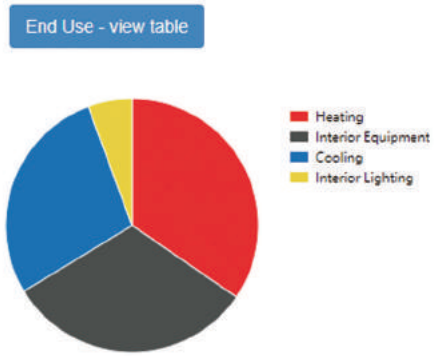
2.2 EXPERIMENTAL RESULT



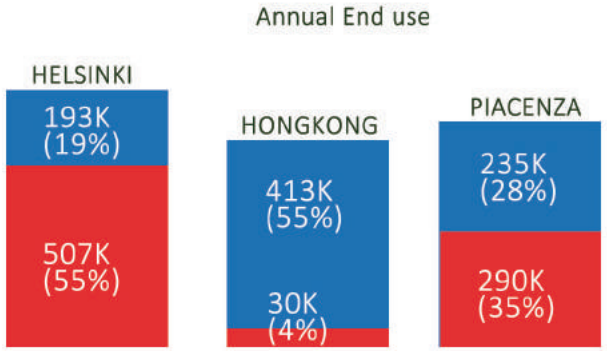
End use in HELSINKI



End use in HONGKONG

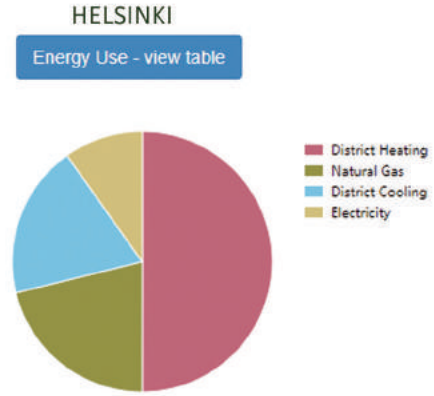


End use in PIACENZA

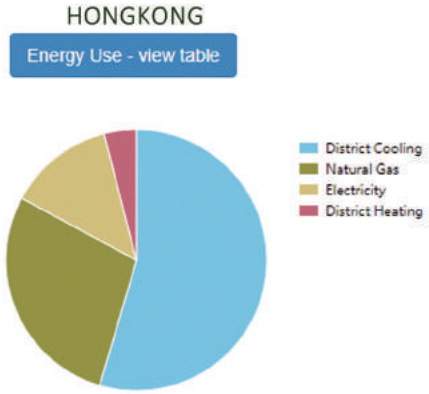


The data from the three pie charts shows that the energy output of the same building in different sites is very different due to the weather and the temperature. The distribution of energy is concentrated due to the change of climate and the control of indoor temperature. The proportion of interior equipment and the interior lighting, as the internal needs, are stable in three sites.

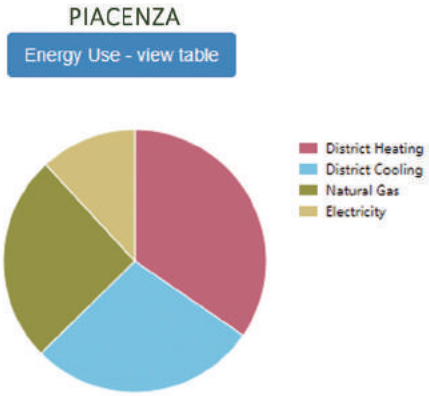
HELSINKI

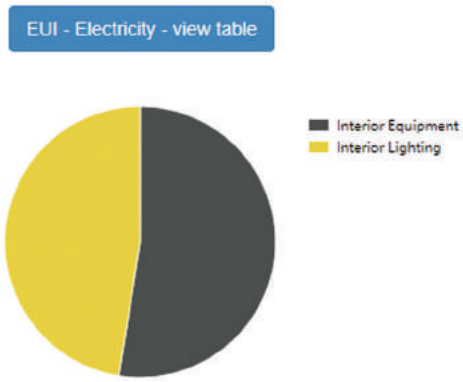


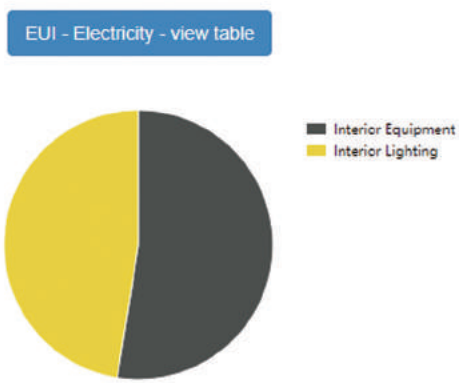
HONGKONG

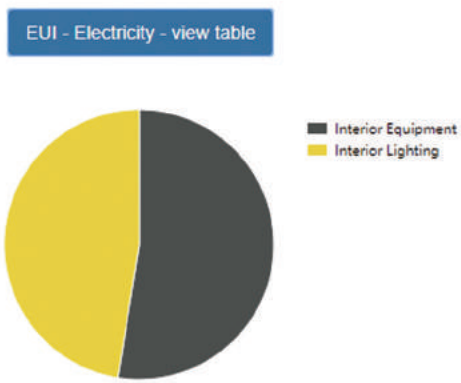


PIACENZA



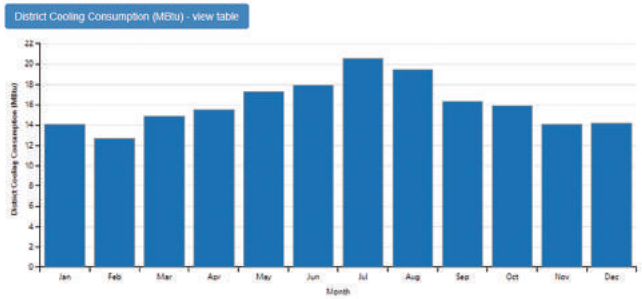




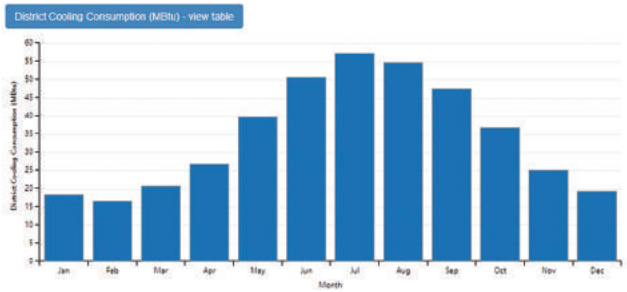


The data from the three pie charts shows that at the situation that the EUI of three sites are almost the same, the proportion of the electricity in 3 sites are almost the same (Helsinki 10%; Hongkong 13%; Piacenza 12%). The proportion of heating and cooling in both end use and the energy use are same. But because the use of interior equipment also need the eletricity, the proportion in Energy use is a little bit more than the proportion in End use pie chart.

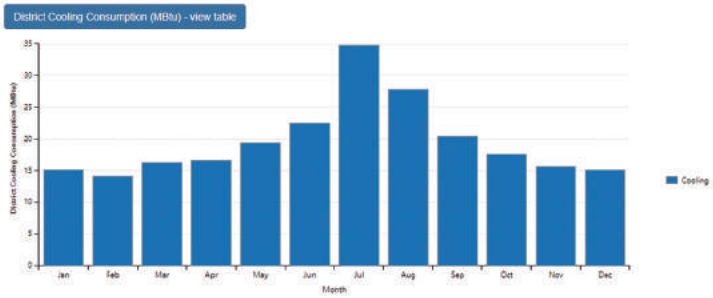
2.2 EXPERIMENTAL RESULT



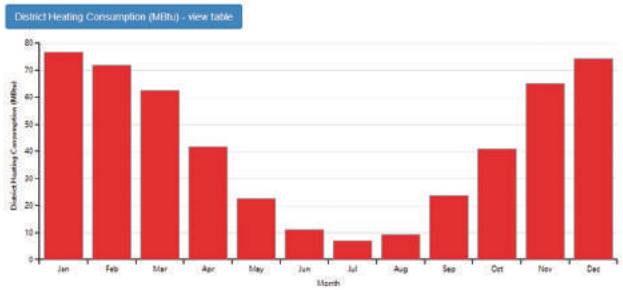
District cooling consumption(MBtu) in HELSINKI



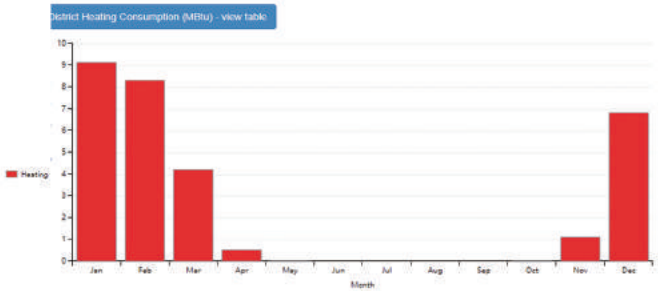
District cooling consumption(MBtu in HONGKONG



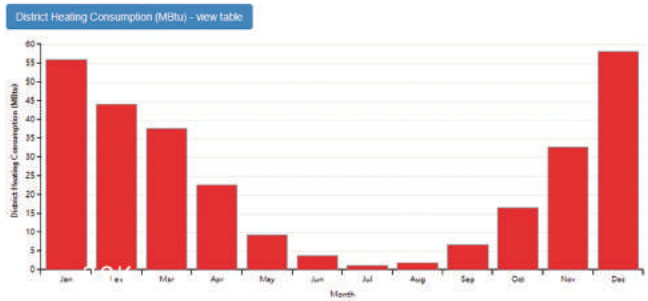
District cooling consumption(MBtu in PIACENZA



District heating consumption(MBtu) in HELSINKI



District heating consumption(MBtu in HONGKONG



District heating consumption(MBtu in PIACENZA

The consumption of cooling load in Piacenza is normal due to the temperature difference and seasonal variation. Normally it can reach a peak of energy consumption in July. The distribution of the remaining months are more uniform. For Helsinki, the distribution of the 12 months are all uniform. The cooling laod would be increase during summer, which is very reasonable. As for Hongkong, the peak of energy consumption is from June to September.

The consumption of heating load in Helsinki is continuous. Even during the summer, there would still be heating load due to the windy weather there. Normally it can reach a peak of energy consumption from December to March. For Hongkong, the heating would stop from May to October. The heating in two months, from January to February, would reach the peak. The heating laod would be also continuous during the whole year in Piacenza. But the heating consumption in summer is not as much as the one in Helsinki.

2.2 EXPERIMENTAL RESULT

Site and Source Energy

Site and Source Energy in HELSINKI

	Total Energy (kBtu)	Energy Per Total Building Area (kBtu/ft^2)	Energy Per Conditioned Building Area (kBtu/ft^2)
Total Site Energy	1012790.0	196.0	196.0
Net Site Energy	1012790.0	196.0	196.0
Total Source Energy	2580422.6	499.4	499.4
Net Source Energy	2580422.6	499.4	499.4

Site and Source Energy

Site and Source Energy in HONGKONG

	Total Energy (kBtu)	Energy Per Total Building Area (kBtu/ft^2)	Energy Per Conditioned Building Area (kBtu/ft^2)
Total Site Energy	756291.7	146.4	146.4
Net Site Energy	756291.7	146.4	146.4
Total Source Energy	1091127.0	211.2	211.2
Net Source Energy	1091127.0	211.2	211.2

Site and Source Energy

Site and Source Energy in PIACENZA

	Total Energy (kBtu)	Energy Per Total Building Area (kBtu/ft^2)	Energy Per Conditioned Building Area (kBtu/ft^2)
Total Site Energy	839102.5	162.4	162.4
Net Site Energy	839102.5	162.4	162.4
Total Source Energy	1843475.8	356.8	356.8
Net Source Energy	1843475.8	356.8	356.8

Site to Source Energy Conversion Factors

	Site=>Source Conversion Factor
Electricity	3.167
Natural Gas	1.084
District Cooling	1.056
District Heating	3.613

From the table of Site and Source Energy, we could find that the building in Helsinki has the highest site and source energy, almost as twice as Hongkong.- To be more precise, total site energy is 1012790.0(kBtu) while the one in piacenza is 756291.7(kBtu) . Total source energy is another important measure of site and source energy. Total source energy in Helsinki is 2680422.6(kBtu), in Hongkong is 1091127.0(kBtu), in piacenza is 1843475.8(kBtu).

From the table of site to source conversion factors, it gives us the different proportion of 4 factors. Site to source conversion factor can help us to see each index clearly. The eletricity and district heating are the highest, the eletricity is 3.167, district heating is 3,613. While the natural gas and district cooling are not that high, natural gas is 1.084 and the district cooling is 1.056.

BRICK
CONCRETE
WOOD

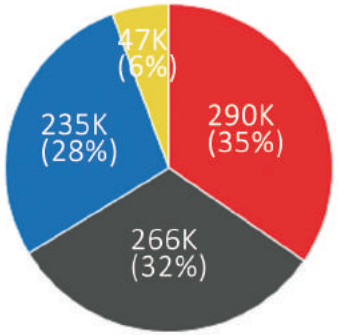
ENERGY PERFORMANCE COMPARISON OF A BUILDING IN THREE DIFFERENT CASES OF THE FACADE WALL IN 3 DIFFERENT CITIES

PIACENZA

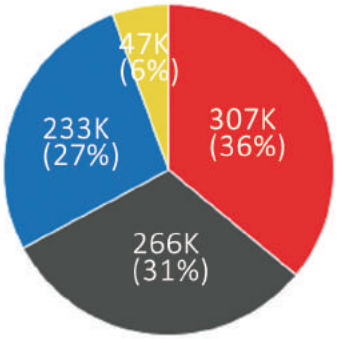
ENERGY PERFORMANCE COMPARISON OF A BUILDING IN THREE DIFFERENT CASES OF THE FACADE WALL (BRICK, CONCRETE, WOOD)

2.2 EXPERIMENTAL RESULT——Annual Overview

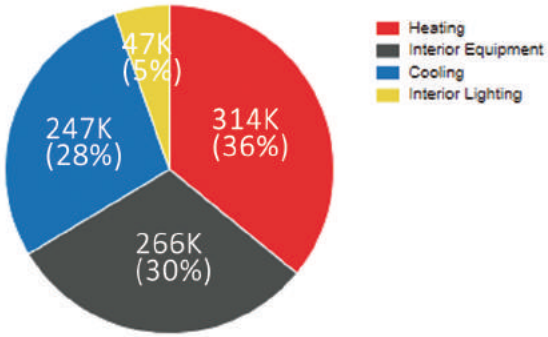
End Use - view table



End use (brick)



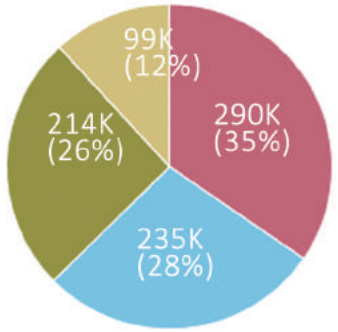
End use (concrete)



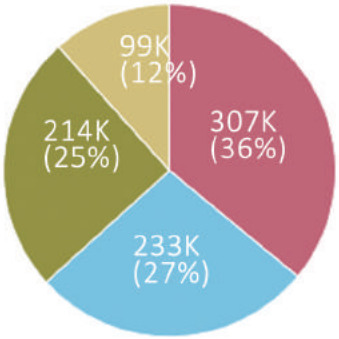
End use (wood)

The data from the three pie charts shows that the annual energy end use of buildings with different materials in Piacenza is almost the same but a little unequal due to the insulation property of the materials. According to the data of district heating energy, wood building is the highest while brick building is the lowest. When it comes to district cooling, also is the the wood building consume the most and the concrete one cosume the least.

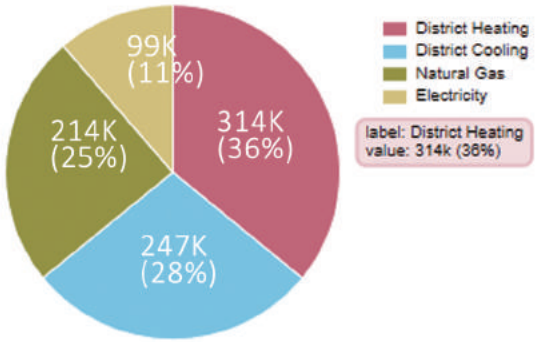
Energy Use - view table



Energy use (brick)



Energy use (concrete)



Energy use (wood)

The data from the three pie charts shows that the energy output of buildings with different materials in Piacenza is almost the same but a little unequal due to the insulation property of the materials. According to the data of district heating energy, wood building is the highest while brick building is the lowest. When it comes to district cooling, also is the the wood building consume the most and the concrete one cosume the least.

2.2 EXPERIMENTAL RESULT

Base Surface Constructions

Construction	Net Area (ft^2)	Surface Count	R Value (ft^2*h*R/Btu)
ASHRAE 189.1-2009 ExtRoof IEAD ClimateZone 2-5	3,444	9	24.73
ASHRAE 189.1-2009 ExtWall brick ClimateZone 4	6,872	32	12.83

base surface construction-brick

Base Surface Constructions

Construction	Net Area (ft^2)	Surface Count	R Value (ft^2*h*R/Btu)
ASHRAE 189.1-2009 ExtRoof IEAD ClimateZone 2-5	3,444	9	24.73
ASHRAE 189.1-2009 ExtWall concrete ClimateZone 4	6,872	32	7.70

base surface construction-concrete

Base Surface Constructions

Construction	Net Area (ft^2)	Surface Count	R Value (ft^2*h*R/Btu)
ASHRAE 189.1-2009 ExtRoof IEAD ClimateZone 2-5	3,444	9	24.73
ASHRAE 189.1-2009 ExtWall Mass ClimateZone 4	6,872	32	9.17

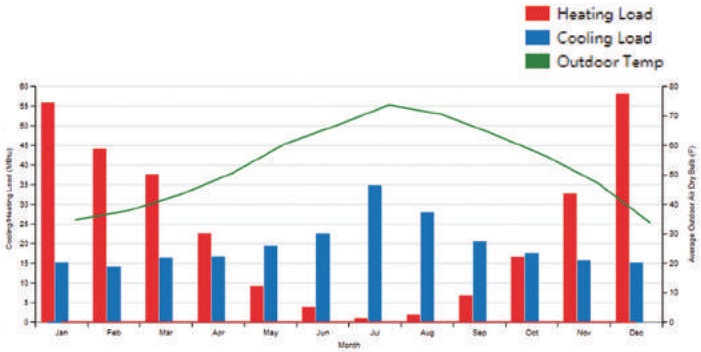
base surface construction-wood

From the above data, we can see that, in Piacenza, due to the different constructions of the buildings, the thermal resistances are different. The brick exterior wall has 12.83 m^2*K/W thermal resistance, while the value of concrete exterial wall is 7.70 m^2*K/W, and the wood one is 9.17m^2*K/W.

2.2 EXPERIMENTAL RESULT——HVAC load

Monthly Load Profiles - view table

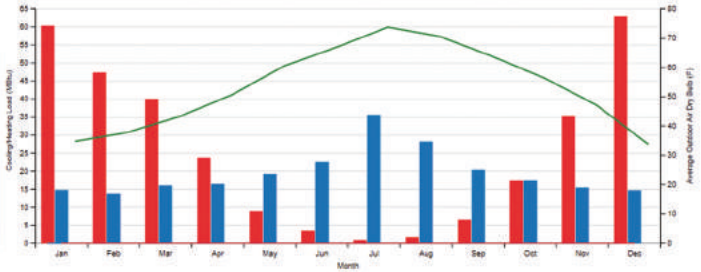
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Outdoor Air Dry Bulb (F)	34.8	37.9	43.3	50.6	60.5	66.8	73.8	70.6	63.8	56.4	47.2	33.7
Cooling Load (MBtu)	15.15	14.11	16.29	16.61	19.36	22.52	34.77	27.88	20.45	17.57	15.67	15.1
Heating Load (MBtu)	55.85	44.06	37.6	22.57	9.22	3.76	1.06	1.92	6.73	16.53	32.65	58.13



Monthly load profiles (brick)

Monthly Load Profiles - view table

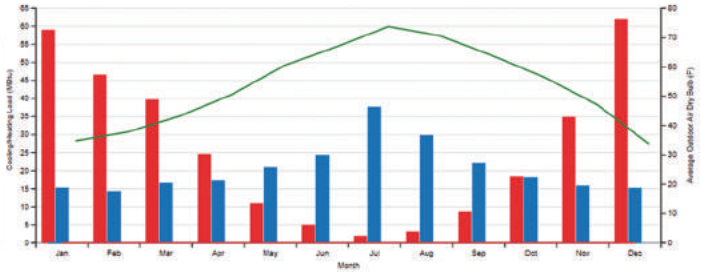
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Outdoor Air Dry Bulb (F)	34.8	37.9	43.3	50.6	60.5	66.8	73.8	70.6	63.8	56.4	47.2	33.7
Cooling Load (MBtu)	14.68	13.72	15.92	16.33	19.12	22.53	35.49	28.09	20.25	17.28	15.34	14.61
Heating Load (MBtu)	60.23	47.26	39.93	23.62	8.88	3.34	0.81	1.6	6.43	17.25	35.17	62.91



Monthly load profiles (concrete)

Monthly Load Profiles - view table

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Outdoor Air Dry Bulb (F)	34.8	37.9	43.3	50.6	60.5	66.8	73.8	70.6	63.8	56.4	47.2	33.7
Cooling Load (MBtu)	15.24	14.23	16.54	17.17	20.86	24.26	37.6	29.73	21.96	18.17	15.8	15.15
Heating Load (MBtu)	58.94	46.5	39.62	24.53	10.92	4.97	1.84	3.01	8.51	18.39	34.79	61.93



Monthly load profiles (wood)

From the data of monthly load profiles of the three buildings with different materials and constructions, we could find that the heating and cooling load of HVAC is almost the same, and the cosumption of heating load is higher in winter while cooling machine is used more in summer.

2.2 EXPERIMENTAL RESULT——Zone Condition

Temperature (Table values represent hours spent in each temperature range)

Zone	Unmet Htg (hr)	Unmet Htg - Occ (hr)	< 56 (F)	56-61 (F)	61-66 (F)	66-68 (F)	68-70 (F)	70-72 (F)	72-74 (F)	74-76 (F)	76-78 (F)	78-83 (F)	83-88 (F)	>= 88 (F)	Unmet Clg (hr)	Unmet Clg - Occ (hr)	Mean Temp (F)
THERMAL ZONE 1	0	0	0	0	0	0	6217	779	646	1118	0	0	0	0	0	0	70.8 (F)
THERMAL ZONE 2	0	0	0	0	0	0	4647	738	278	3097	0	0	0	0	0	0	71.9 (F)
THERMAL ZONE 3	0	0	0	0	0	0	6848	500	323	1089	0	0	0	0	0	0	70.6 (F)
THERMAL ZONE 4	0	0	0	0	0	0	4113	996	995	2656	0	0	0	0	0	0	71.9 (F)

brick

Humidity (Table values represent hours spent in each Humidity range)

Zone	< 30 (%)	30-35 (%)	35-40 (%)	40-45 (%)	45-50 (%)	50-55 (%)	55-60 (%)	60-65 (%)	65-70 (%)	70-75 (%)	75-80 (%)	>= 80 (%)	Mean Relative Humidity (%)
THERMAL ZONE 1	2630	725	537	614	725	864	867	656	417	282	229	214	43.9 (%)
THERMAL ZONE 2	2938	666	563	1709	505	544	557	409	225	163	156	325	40.7 (%)
THERMAL ZONE 3	2645	762	509	533	720	686	788	687	452	329	245	404	44.9 (%)
THERMAL ZONE 4	2715	784	636	919	1420	1008	692	319	151	88	27	1	39.9 (%)

brick

Temperature (Table values represent hours spent in each temperature range)

Zone	Unmet Htg (hr)	Unmet Htg - Occ (hr)	< 56 (F)	56-61 (F)	61-66 (F)	66-68 (F)	68-70 (F)	70-72 (F)	72-74 (F)	74-76 (F)	76-78 (F)	78-83 (F)	83-88 (F)	>= 88 (F)	Unmet Clg (hr)	Unmet Clg - Occ (hr)	Mean Temp (F)
THERMAL ZONE 1	0	0	0	0	0	0	6208	738	619	1195	0	0	0	0	0	0	70.8 (F)
THERMAL ZONE 2	0	0	0	0	0	0	4479	737	403	3141	0	0	0	0	0	0	72.0 (F)
THERMAL ZONE 3	0	0	0	0	0	0	6819	509	352	1080	0	0	0	0	0	0	70.6 (F)
THERMAL ZONE 4	0	0	0	0	0	0	4239	914	963	2644	0	0	0	0	0	0	71.9 (F)

concrete

Humidity (Table values represent hours spent in each Humidity range)

Zone	< 30 (%)	30-35 (%)	35-40 (%)	40-45 (%)	45-50 (%)	50-55 (%)	55-60 (%)	60-65 (%)	65-70 (%)	70-75 (%)	75-80 (%)	>= 80 (%)	Mean Relative Humidity (%)
THERMAL ZONE 1	2629	723	526	595	740	832	898	710	443	319	228	117	43.8 (%)
THERMAL ZONE 2	2936	666	562	1716	509	556	566	402	236	168	185	258	40.5 (%)
THERMAL ZONE 3	2643	764	501	534	714	686	796	680	464	334	250	394	44.9 (%)
THERMAL ZONE 4	2698	770	637	938	1456	1085	663	313	143	49	7	1	39.7 (%)

concrete

Temperature (Table values represent hours spent in each temperature range)

Zone	Unmet Htg (hr)	Unmet Htg - Occ (hr)	< 56 (F)	56-61 (F)	61-66 (F)	66-68 (F)	68-70 (F)	70-72 (F)	72-74 (F)	74-76 (F)	76-78 (F)	78-83 (F)	83-88 (F)	>= 88 (F)	Unmet Clg (hr)	Unmet Clg - Occ (hr)	Mean Temp (F)
THERMAL ZONE 1	0	0	0	0	0	0	6298	627	486	1349	0	0	0	0	0	0	70.9 (F)
THERMAL ZONE 2	0	0	0	0	0	0	4663	554	289	3254	0	0	0	0	0	0	72.0 (F)
THERMAL ZONE 3	0	0	0	0	0	0	6817	439	318	1186	0	0	0	0	0	0	70.7 (F)
THERMAL ZONE 4	0	0	0	0	0	0	4305	966	920	2569	0	0	0	0	0	0	71.8 (F)

wood

Humidity (Table values represent hours spent in each Humidity range)

Zone	< 30 (%)	30-35 (%)	35-40 (%)	40-45 (%)	45-50 (%)	50-55 (%)	55-60 (%)	60-65 (%)	65-70 (%)	70-75 (%)	75-80 (%)	>= 80 (%)	Mean Relative Humidity (%)
THERMAL ZONE 1	2636	738	560	691	836	893	818	575	331	261	193	228	43.4 (%)
THERMAL ZONE 2	2942	664	564	1766	525	541	531	401	224	160	151	291	40.4 (%)
THERMAL ZONE 3	2646	770	519	541	718	719	797	689	420	310	241	390	44.7 (%)
THERMAL ZONE 4	2741	758	625	992	1343	951	672	362	173	101	38	4	40.0 (%)

wood

From the above data, we can see that, due to the three different construction the values of temperature and humidity are close to each other.

2.2 EXPERIMENTAL RESULT

Site and Source Energy

	Total Energy (kBtu)	Energy Per Total Building Area (kBtu/ft^2)	Energy Per Conditioned Building Area (kBtu/ft^2)
Total Site Energy	839102.5	162.4	162.4
Net Site Energy	839102.5	162.4	162.4
Total Source Energy	1843475.8	356.8	356.8
Net Source Energy	1843475.8	356.8	356.8

Site and Source Energy (brick)

Site and Source Energy

	Total Energy (kBtu)	Energy Per Total Building Area (kBtu/ft^2)	Energy Per Conditioned Building Area (kBtu/ft^2)
Total Site Energy	854343.4	165.4	165.4
Net Site Energy	854343.4	165.4	165.4
Total Source Energy	1903975.1	368.5	368.5
Net Source Energy	1903975.1	368.5	368.5

Site and Source Energy (concrete)

Site and Source Energy

	Total Energy (kBtu)	Energy Per Total Building Area (kBtu/ft^2)	Energy Per Conditioned Building Area (kBtu/ft^2)
Total Site Energy	874190.7	169.2	169.2
Net Site Energy	874190.7	169.2	169.2
Total Source Energy	1941565.4	375.8	375.8
Net Source Energy	1941565.4	375.8	375.8

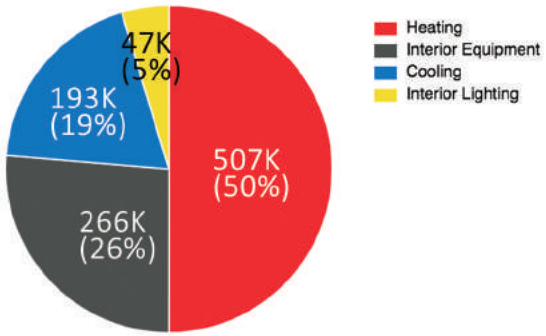
Site and Source Energy (wood)

From the table of Site and Source Energy, we could find that the wood building has the highest site and source energy (1941565.4 kBtu total source energy), while the brick building has the lowest (1843475.8 kBtu total source energy).

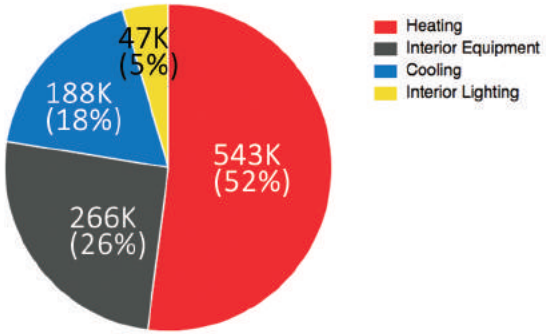
HELSINKI

ENERGY PERFORMANCE COMPARISON OF A BUILDING IN THREE DIFFERENT CASES OF THE FACADE WALL (BRICK, CONCRETE, WOOD)

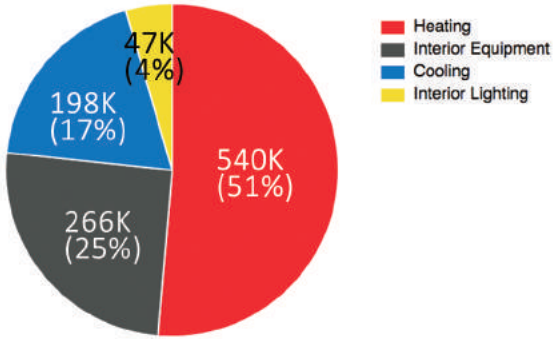
2.2 EXPERIMENTAL RESULT——Annual Overview



End use (brick)

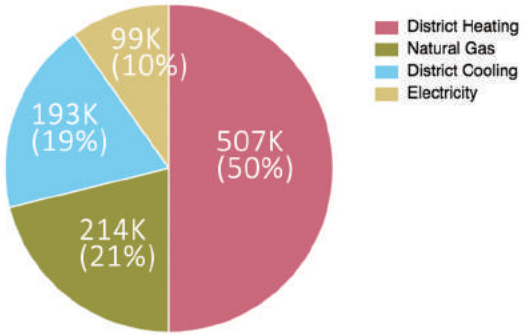


End use (concrete)

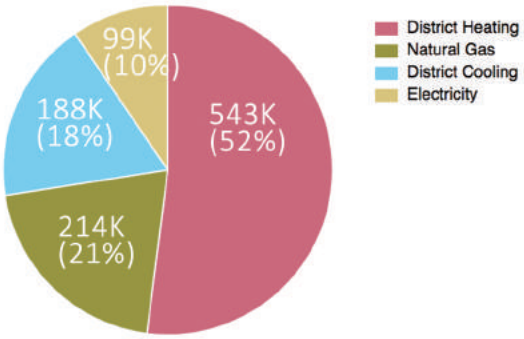


End use (wood)

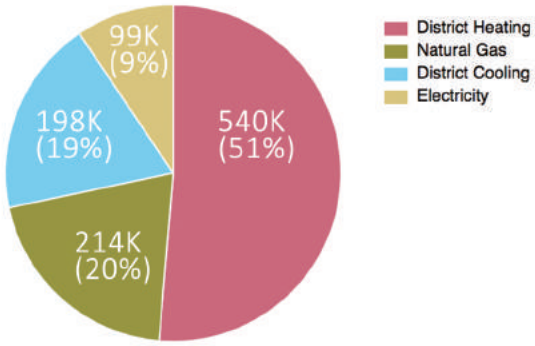
The data from the three pie charts shows that the annual energy end use of buildings with different materials in Helsinki are almost the same but a little unequal due to the insulation property of the materials. According to the data of district heating energy, concrete building is the highest while brick building is the lowest. When it comes to district cooling, it is the the wood building that consumes the most and the concrete one cosume the least.



Energy use (brick)



Energy use (concrete)



Energy use (wood)

The data from the three pie charts shows that the energy output of buildings with different materials in Helsinki is almost the same but a little unequal due to the insulation property of the materials. According to the data of district heating energy, concrete building is the highest while the wood building is the lowest. When it comes to district cooling, is the the wood building consume the most and the concrete one cosume the least.

2.2 EXPERIMENTAL RESULT

Base Surface Constructions

Construction	Net Area (ft^2)	Surface Count	R Value (ft^2*h*R/Btu)
ASHRAE 189.1-2009 ExtRoof IEAD ClimateZone 2-5	3,444	9	24.73
ASHRAE 189.1-2009 ExtWall brick ClimateZone 4	6,872	32	12.83

base surface constraction-brick

Base Surface Constructions

Construction	Net Area (ft^2)	Surface Count	R Value (ft^2*h*R/Btu)
ASHRAE 189.1-2009 ExtRoof IEAD ClimateZone 2-5	3,444	9	24.73
ASHRAE 189.1-2009 ExtWall concrete ClimateZone 4	6,872	32	7.70

base surface constraction-concrete

Base Surface Constructions

Construction	Net Area (ft^2)	Surface Count	R Value (ft^2*h*R/Btu)
ASHRAE 189.1-2009 ExtRoof IEAD ClimateZone 2-5	3,444	9	24.73
ASHRAE 189.1-2009 ExtWall Mass ClimateZone 4	6,872	32	9.17

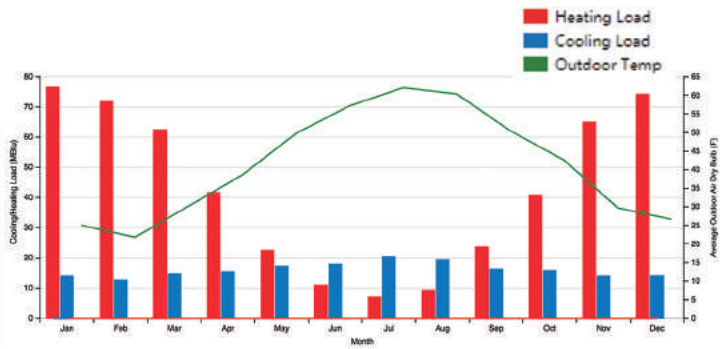
base surface constraction-wood

From the above data, we can see that, in Helsinki, due to the different construction of the buildings, the thermal resistances are different. The brick exterior wall has 12.83 m^2*K/W thermal resistance, while the value of concrete external wall is 7.70 m^2*K/W, and the wood one is 9.17 m^2*K/W, exactly the same as for Piacenza.

2.2 EXPERIMENTAL RESULT——HVAC load

Monthly Load Profiles - view table

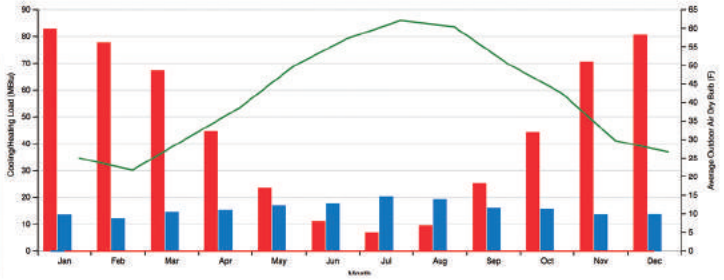
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Outdoor Air Dry Bulb (F)	25.0	21.8	30.2	38.6	49.7	57.2	62.1	60.4	50.4	42.5	29.7	26.6
Cooling Load (MBtu)	14.06	12.66	14.88	15.49	17.27	17.92	20.53	19.47	16.34	15.88	14.07	14.16
Heating Load (MBtu)	76.61	71.96	62.48	41.69	22.55	11.02	7.09	9.31	23.65	40.84	65.03	74.29



Monthly load profiles (brick)

Monthly Load Profiles - view table

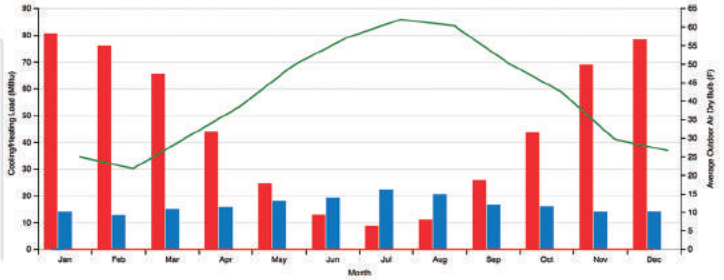
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Outdoor Air Dry Bulb (F)	25.0	21.8	30.2	38.6	49.7	57.2	62.1	60.4	50.4	42.5	29.7	26.6
Cooling Load (MBtu)	13.48	12.1	14.37	15.1	16.96	17.66	20.15	19.17	16.04	15.48	13.54	13.59
Heating Load (MBtu)	82.85	77.71	67.27	44.52	23.51	11.09	6.8	9.36	25.16	44.16	70.54	80.51



Monthly load profiles (concrete)

Monthly Load Profiles - view table

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Outdoor Air Dry Bulb (F)	25.0	21.8	30.2	38.6	49.7	57.2	62.1	60.4	50.4	42.5	29.7	26.6
Cooling Load (MBtu)	14.07	12.67	15.07	15.81	17.99	19.12	22.25	20.59	16.61	16.02	14.07	14.15
Heating Load (MBtu)	80.64	76.06	65.48	43.99	24.54	12.8	8.79	11.09	25.8	43.64	69.05	78.35



Monthly load profiles (wood)

From the data of monthly load profiles about the three buildings with different materials and construction, we could find that the heating and cooling load of HVAC is almost the same, and the cosumption of heating load is higher in winter while colling machine is used more in summer.

2.2 EXPERIMENTAL RESULT——Zone Condition

Temperature (Table values represent hours spent in each temperature range)

Zone	Unmet Htg (hr)	Unmet Htg - Occ (hr)	< 56 (F)	56-61 (F)	61-66 (F)	66-68 (F)	68-70 (F)	70-72 (F)	72-74 (F)	74-76 (F)	76-78 (F)	78-83 (F)	83-88 (F)	>= 88 (F)	Unmet Clg (hr)	Unmet Clg - Occ (hr)	Mean Temp (F)
THERMAL ZONE 1	0	0	0	0	0	0	7859	402	251	248	0	0	0	0	0	0	70.1 (F)
THERMAL ZONE 2	0	0	0	0	0	0	5375	384	79	2922	0	0	0	0	0	0	71.7 (F)
THERMAL ZONE 3	0	0	0	0	0	0	8231	186	114	229	0	0	0	0	0	0	70.0 (F)
THERMAL ZONE 4	0	0	0	0	0	0	5941	920	804	1095	0	0	0	0	0	0	70.9 (F)

brick

Humidity (Table values represent hours spent in each Humidity range)

Zone	< 30 (%)	30-35 (%)	35-40 (%)	40-45 (%)	45-50 (%)	50-55 (%)	55-60 (%)	60-65 (%)	65-70 (%)	70-75 (%)	75-80 (%)	>= 80 (%)	Mean Relative Humidity (%)
THERMAL ZONE 1	4993	752	708	519	588	497	366	197	86	35	14	5	30.2 (%)
THERMAL ZONE 2	5242	730	699	870	436	385	226	90	51	18	13	0	28.3 (%)
THERMAL ZONE 3	4998	776	653	513	564	448	389	216	120	49	27	7	30.4 (%)
THERMAL ZONE 4	5075	886	745	693	628	437	212	73	8	3	0	0	28.8 (%)

brick

Temperature (Table values represent hours spent in each temperature range)

Zone	Unmet Htg (hr)	Unmet Htg - Occ (hr)	< 56 (F)	56-61 (F)	61-66 (F)	66-68 (F)	68-70 (F)	70-72 (F)	72-74 (F)	74-76 (F)	76-78 (F)	78-83 (F)	83-88 (F)	>= 88 (F)	Unmet Clg (hr)	Unmet Clg - Occ (hr)	Mean Temp (F)
THERMAL ZONE 1	0	0	0	0	0	0	7940	388	245	187	0	0	0	0	0	0	70.0 (F)
THERMAL ZONE 2	0	0	0	0	0	0	5420	339	76	2925	0	0	0	0	0	0	71.7 (F)
THERMAL ZONE 3	0	0	0	0	0	0	8249	188	113	210	0	0	0	0	0	0	70.0 (F)
THERMAL ZONE 4	0	0	0	0	0	0	6153	926	736	945	0	0	0	0	0	0	70.8 (F)

concrete

Humidity (Table values represent hours spent in each Humidity range)

Zone	< 30 (%)	30-35 (%)	35-40 (%)	40-45 (%)	45-50 (%)	50-55 (%)	55-60 (%)	60-65 (%)	65-70 (%)	70-75 (%)	75-80 (%)	>= 80 (%)	Mean Relative Humidity (%)
THERMAL ZONE 1	4990	741	698	533	579	491	383	202	88	34	16	5	30.3 (%)
THERMAL ZONE 2	5242	731	701	868	435	388	223	91	50	18	13	0	28.3 (%)
THERMAL ZONE 3	4998	768	658	510	566	449	391	216	121	49	27	7	30.4 (%)
THERMAL ZONE 4	5056	861	768	662	633	458	236	75	8	3	0	0	29.0 (%)

concrete

Temperature (Table values represent hours spent in each temperature range)

Zone	Unmet Htg (hr)	Unmet Htg - Occ (hr)	< 56 (F)	56-61 (F)	61-66 (F)	66-68 (F)	68-70 (F)	70-72 (F)	72-74 (F)	74-76 (F)	76-78 (F)	78-83 (F)	83-88 (F)	>= 88 (F)	Unmet Clg (hr)	Unmet Clg - Occ (hr)	Mean Temp (F)
THERMAL ZONE 1	0	0	0	0	0	0	7706	417	226	411	0	0	0	0	0	0	70.2 (F)
THERMAL ZONE 2	0	0	0	0	0	0	5291	395	112	2962	0	0	0	0	0	0	71.7 (F)
THERMAL ZONE 3	0	0	0	0	0	0	8158	179	130	293	0	0	0	0	0	0	70.0 (F)
THERMAL ZONE 4	0	0	0	0	0	0	6094	809	675	1182	0	0	0	0	0	0	70.9 (F)

wood

Humidity (Table values represent hours spent in each Humidity range)

Zone	< 30 (%)	30-35 (%)	35-40 (%)	40-45 (%)	45-50 (%)	50-55 (%)	55-60 (%)	60-65 (%)	65-70 (%)	70-75 (%)	75-80 (%)	>= 80 (%)	Mean Relative Humidity (%)
THERMAL ZONE 1	5005	784	712	544	597	459	352	177	84	27	16	3	30.0 (%)
THERMAL ZONE 2	5241	740	718	878	422	367	221	94	49	17	13	0	28.2 (%)
THERMAL ZONE 3	5002	793	651	522	553	455	377	211	117	47	25	7	30.3 (%)
THERMAL ZONE 4	5089	872	743	693	611	407	242	75	22	6	0	0	28.9 (%)

wood

From the above data, we can see that, due to the three different constructions, the values of temperature and humidity are close to each other.

2.2 EXPERIMENTAL RESULT

Site and Source Energy

	Total Energy (kBtu)	Energy Per Total Building Area (kBtu/ft^2)	Energy Per Conditioned Building Area (kBtu/ft^2)
Total Site Energy	1012790.0	196.0	196.0
Net Site Energy	1012790.0	196.0	196.0
Total Source Energy	2580422.6	499.4	499.4
Net Source Energy	2580422.6	499.4	499.4

Site and Source Energy (brick)

Site and Source Energy

	Total Energy (kBtu)	Energy Per Total Building Area (kBtu/ft^2)	Energy Per Conditioned Building Area (kBtu/ft^2)
Total Site Energy	1044655.6	202.2	202.2
Net Site Energy	1044655.6	202.2	202.2
Total Source Energy	2708558.0	524.2	524.2
Net Source Energy	2708558.0	524.2	524.2

Site and Source Energy (concrete)

Site and Source Energy

	Total Energy (kBtu)	Energy Per Total Building Area (kBtu/ft^2)	Energy Per Conditioned Building Area (kBtu/ft^2)
Total Site Energy	1052190.7	203.7	203.7
Net Site Energy	1052190.7	203.7	203.7
Total Source Energy	2708264.3	524.2	524.2
Net Source Energy	2708264.3	524.2	524.2

Site and Source Energy (wood)

From the table of Site and Source Energy, we could find that the concrete building has the highest site and source energy (2708558.0 kBtu total source energy), while the brick building has the lowest (2580442.6 kBtu total source energy).

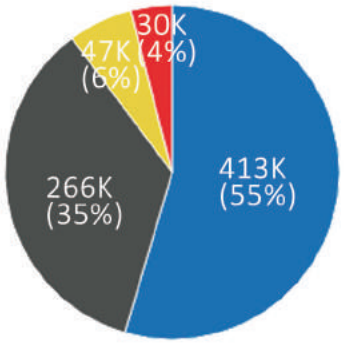
HONG KONG

ENERGY PERFORMANCE COMPARISON OF A BUILDING IN THREE DIFFERENT CASES OF THE FACADE WALL (BRICK, CONCRETE, WOOD)

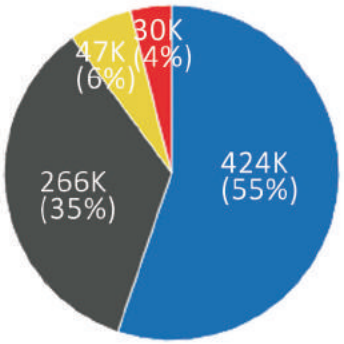
2.2 EXPERIMENTAL RESULT —— ANNUAL OVERVIEW

HONGKNG

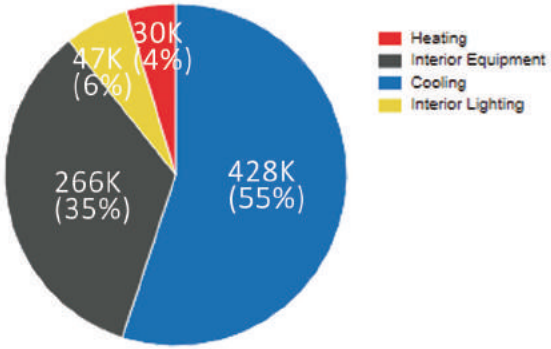
1KBtu ≈1 00 cf ≈2.83 m³



End use (brick)



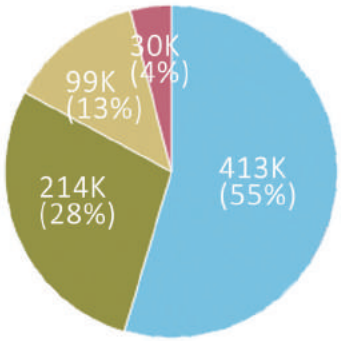
End use (concrete)



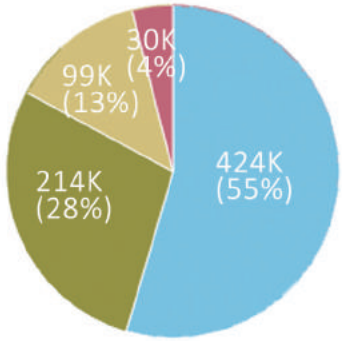
End use (wood)

The data from the three pie charts shows that the annual energy end use of buildings with different materials in Hongkong is almost the same but a little unequal due to the insulation property of the materials. According to the data of district heating, interal lighting and internal equipment energy, the use of 3 materials are all the same. When it comes to district cooling, there are tiny differences between the 3 different materials.

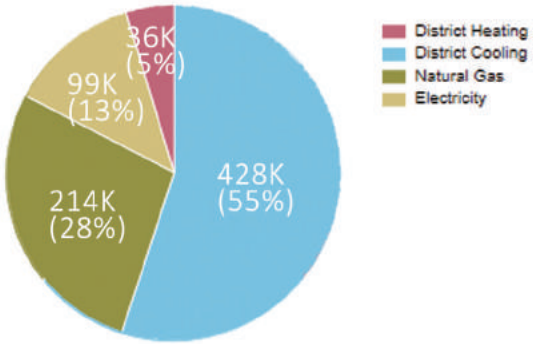
Energy Use - view table



End use (brick)



End use (concrete)



End use (wood)

The data from the three pie charts shows that the energy output of buildings with different materials in Hongkong is almost the same but a little unequal due to the insulation property of the materials. According to the data of district heating, interal lighting and internal equipment energy, the use of 3 materials are all the same. When it comes to district cooling, there are tiny differences between the 3 different materials.

2.2 EXPERIMENTAL RESULT —— CONSTRUCTIONS

HONGKNG

1KBtu ≈1 00 cf ≈2.83 m^3

Base Surface Constructions

Construction	Net Area (ft^2)	Surface Count	R Value (ft^2*h*R/Btu)
ASHRAE 189.1-2009 ExtRoof IEAD ClimateZone 2-5	3,444	9	24.73
ASHRAE 189.1-2009 ExtWall brick ClimateZone 4	6,872	32	12.83

base surface constraction-brick

Base Surface Constructions

Construction	Net Area (ft^2)	Surface Count	R Value (ft^2*h*R/Btu)
ASHRAE 189.1-2009 ExtRoof IEAD ClimateZone 2-5	3,444	9	24.73
ASHRAE 189.1-2009 ExtWall concrete ClimateZone 4	6,872	32	7.70

base surface constraction-concrete

Base Surface Constructions

Construction	Net Area (ft^2)	Surface Count	R Value (ft^2*h*R/Btu)
ASHRAE 189.1-2009 ExtRoof IEAD ClimateZone 2-5	3,444	9	24.73
ASHRAE 189.1-2009 ExtWall Mass ClimateZone 4	6,872	32	9.17

base surface constraction-wood

From the above data, we can see that, in Hongkong, due to the different constraction of the buildings, the thermal resistance are different. The brick exterior wall has 12.83m^2*K/W thermal resistance, while the value of concrete exterial wall is has 7.70m^2*K/W, and the wood one is 9.17m^2*K/W.

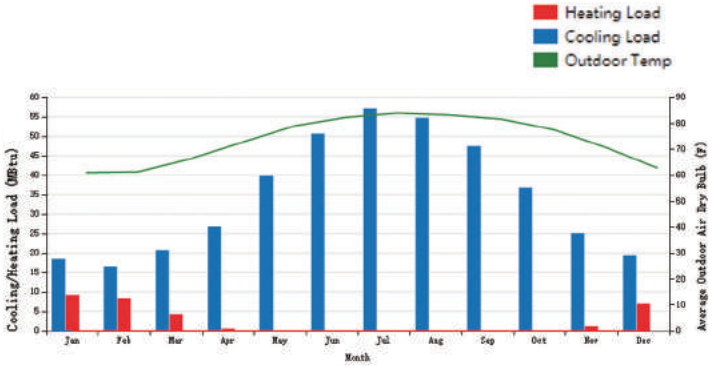
2.2 EXPERIMENTAL RESULT——HVAC load

1MBtu ≈1 000 cf ≈28.3 m³

HONGKNG

Monthly Load Profiles - view table

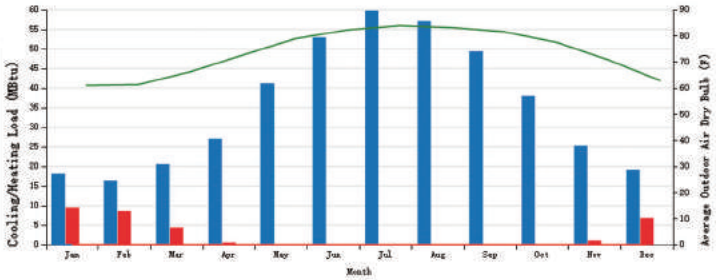
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Outdoor Air Dry Bulb (F)	61.0	61.3	66.3	72.7	78.9	82.2	83.9	83.2	81.6	77.6	70.8	62.8
Cooling Load (MBtu)	18.38	16.46	20.64	26.68	39.76	50.58	57.12	54.62	47.38	36.77	25.01	19.26
Heating Load (MBtu)	9.14	8.31	4.21	0.52	0.0	0.0	0.0	0.0	0.0	0.0	1.12	6.81



Monthly load profiles (brick)

Monthly Load Profiles - view table

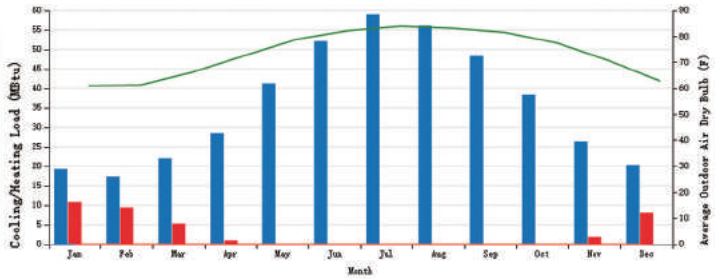
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Outdoor Air Dry Bulb (F)	61.0	61.3	66.3	72.7	78.9	82.2	83.9	83.2	81.6	77.6	70.8	62.8
Cooling Load (MBtu)	18.15	16.27	20.5	27.0	41.07	52.86	59.71	56.99	49.3	37.92	25.17	19.06
Heating Load (MBtu)	9.43	8.51	4.25	0.43	0.0	0.0	0.0	0.0	0.0	0.0	0.96	6.79



Monthly load profiles (concrete)

Monthly Load Profiles - view table

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Outdoor Air Dry Bulb (F)	61.0	61.3	66.3	72.7	78.9	82.2	83.9	83.2	81.6	77.6	70.8	62.8
Cooling Load (MBtu)	19.2	17.33	21.98	28.53	41.21	52.03	58.94	56.0	48.32	38.32	26.27	20.28
Heating Load (MBtu)	10.73	9.36	5.21	0.95	0.03	0.0	0.0	0.0	0.0	0.04	1.78	8.08



Monthly load profiles (wood)

From the data of monthly load profiles about three buildings with different mateals and constraction, we could find that the heating and cooling load of HVAC is almost the same, and the cosumption of heating load is higher in winter while cooling machine is used more in summer.

2.2 EXPERIMENTAL RESULT——Zone Condition

HONGKNG

Temperature (Table values represent hours spent in each temperature range)

Zone	Unmet Htg (hr)	Unmet Htg - Occ (hr)	< 56 (F)	56-61 (F)	61-66 (F)	66-68 (F)	68-70 (F)	70-72 (F)	72-74 (F)	74-76 (F)	76-78 (F)	78-83 (F)	83-88 (F)	>= 88 (F)	Unmet Clg (hr)	Unmet Clg - Occ (hr)	Mean Temp (F)
THERMAL ZONE 1	0	0	0	0	0	0	2176	627	830	4927	0	0	0	0	0	0	73.2 (F)
THERMAL ZONE 2	0	0	0	0	0	0	2158	973	1253	4376	0	0	0	0	0	0	73.0 (F)
THERMAL ZONE 3	0	0	0	0	0	0	2654	589	539	4978	0	0	0	0	0	0	73.1 (F)
THERMAL ZONE 4	0	0	0	0	0	0	278	605	1005	6872	0	0	0	0	0	0	74.5 (F)

brick

Humidity (Table values represent hours spent in each Humidity range)

Zone	< 30 (%)	30-35 (%)	35-40 (%)	40-45 (%)	45-50 (%)	50-55 (%)	55-60 (%)	60-65 (%)	65-70 (%)	70-75 (%)	75-80 (%)	>= 80 (%)	Mean Relative Humidity (%)
THERMAL ZONE 1	141	106	152	203	389	548	575	1330	1096	1037	1002	2161	68.8 (%)
THERMAL ZONE 2	180	143	179	2743	379	530	386	485	410	336	391	2598	63.5 (%)
THERMAL ZONE 3	142	107	159	176	356	469	416	627	534	649	1060	4065	74.0 (%)
THERMAL ZONE 4	192	131	199	396	935	1144	1555	1878	974	705	438	213	58.5 (%)

brick

Temperature (Table values represent hours spent in each temperature range)

Zone	Unmet Htg (hr)	Unmet Htg - Occ (hr)	< 56 (F)	56-61 (F)	61-66 (F)	66-68 (F)	68-70 (F)	70-72 (F)	72-74 (F)	74-76 (F)	76-78 (F)	78-83 (F)	83-88 (F)	>= 88 (F)	Unmet Clg (hr)	Unmet Clg - Occ (hr)	Mean Temp (F)
THERMAL ZONE 1	0	0	0	0	0	0	2176	822	775	4987	0	0	0	0	0	0	73.2 (F)
THERMAL ZONE 2	0	0	0	0	0	0	2006	755	1138	4851	0	0	0	0	0	0	73.3 (F)
THERMAL ZONE 3	0	0	0	0	0	0	2640	590	534	4996	0	0	0	0	0	0	73.1 (F)
THERMAL ZONE 4	0	0	0	0	0	0	324	644	986	6806	0	0	0	0	0	0	74.4 (F)

concrete

Humidity (Table values represent hours spent in each Humidity range)

Zone	< 30 (%)	30-35 (%)	35-40 (%)	40-45 (%)	45-50 (%)	50-55 (%)	55-60 (%)	60-65 (%)	65-70 (%)	70-75 (%)	75-80 (%)	>= 80 (%)	Mean Relative Humidity (%)
THERMAL ZONE 1	140	97	150	195	390	558	615	1419	1358	1252	876	1710	67.5 (%)
THERMAL ZONE 2	180	141	181	2746	396	525	407	511	433	427	500	2313	62.3 (%)
THERMAL ZONE 3	140	108	158	171	360	466	422	624	548	642	1132	3989	73.7 (%)
THERMAL ZONE 4	187	130	195	389	957	1363	1584	1760	1054	705	298	128	57.9 (%)

concrete

Temperature (Table values represent hours spent in each temperature range)

Zone	Unmet Htg (hr)	Unmet Htg - Occ (hr)	< 56 (F)	56-61 (F)	61-66 (F)	66-68 (F)	68-70 (F)	70-72 (F)	72-74 (F)	74-76 (F)	76-78 (F)	78-83 (F)	83-88 (F)	>= 88 (F)	Unmet Clg (hr)	Unmet Clg - Occ (hr)	Mean Temp (F)
THERMAL ZONE 1	0	0	0	0	0	0	2196	774	846	4942	0	0	0	0	0	0	73.2 (F)
THERMAL ZONE 2	0	0	0	0	0	0	2327	937	1143	4353	0	0	0	0	0	0	73.0 (F)
THERMAL ZONE 3	0	0	0	0	0	0	2611	590	571	4988	0	0	0	0	0	0	73.1 (F)
THERMAL ZONE 4	0	0	0	0	0	0	482	700	845	6733	0	0	0	0	0	0	74.3 (F)

wood

Humidity (Table values represent hours spent in each Humidity range)

Zone	< 30 (%)	30-35 (%)	35-40 (%)	40-45 (%)	45-50 (%)	50-55 (%)	55-60 (%)	60-65 (%)	65-70 (%)	70-75 (%)	75-80 (%)	>= 80 (%)	Mean Relative Humidity (%)
THERMAL ZONE 1	147	109	159	219	477	705	808	1248	987	800	784	2317	68.3 (%)
THERMAL ZONE 2	179	146	177	2739	485	472	442	474	411	367	351	2517	63.1 (%)
THERMAL ZONE 3	148	105	164	179	370	474	404	644	566	763	1036	3907	73.8 (%)
THERMAL ZONE 4	196	116	189	436	1081	1430	1315	1574	906	718	509	290	58.4 (%)

wood

From the above data, we can see that, due to the three different construction the value of temperature and humidity is closer to each other.

2.2 EXPERIMENTAL RESULT

HONGKNG

1KBtu ≈1 00 cf ≈2.83 m³

Site and Source Energy

	Total Energy (kBtu)	Energy Per Total Building Area (kBtu/ft^2)	Energy Per Conditioned Building Area (kBtu/ft^2)
Total Site Energy	756291.7	146.4	146.4
Net Site Energy	756291.7	146.4	146.4
Total Source Energy	1091127.0	211.2	211.2
Net Source Energy	1091127.0	211.2	211.2

Site and Source Energy (brick)

Site and Source Energy

	Total Energy (kBtu)	Energy Per Total Building Area (kBtu/ft^2)	Energy Per Conditioned Building Area (kBtu/ft^2)
Total Site Energy	767912.0	148.6	148.6
Net Site Energy	767912.0	148.6	148.6
Total Source Energy	1104093.2	213.7	213.7
Net Source Energy	1104093.2	213.7	213.7

Site and Source Energy (concrete)

Site and Source Energy

	Total Energy (kBtu)	Energy Per Total Building Area (kBtu/ft^2)	Energy Per Conditioned Building Area (kBtu/ft^2)
Total Site Energy	778101.0	150.6	150.6
Net Site Energy	778101.0	150.6	150.6
Total Source Energy	1129665.3	218.6	218.6
Net Source Energy	1129665.3	218.6	218.6

Site and Source Energy (wood)

From the table of Site and Source Energy, we could find that the wood building has the highest site and source energy(1129665.3(kBtu) total source energy), while the brick building has the low-est(1091127.0(kBtu) total source energy).

FINAL RESULTS

ENERGY PERFORMANCE COMPARISON OF A BUILDING IN THREE DIFFERENT LOCATIONS (PIACENZA, HELSINKI, HONG KONG)
ENERGY PERFORMANCE COMPARISON OF A BUILDING IN THREE DIFFERENT CASES OF THE FACADE WALL (BRICK, CONCRETE, WOOD)

ENERGY PERFORMANCE COMPARISON OF A BUILDING IN THREE DIFFERENT LOCATIONS (PIACENZA, HELSINKI, HONG KONG)

	PIACENZA (kBtu)	HONG KONG (kBtu)	HELSINKI (kBtu)
QUANTITY OF ENERGY FOR HEATING	290,079	30,103	506,523
QUANTITY OF ENERGY FOR COOLING	235,485	412,651	192,729

ENERGY PERFORMANCE COMPARISON OF A BUILDING IN THREE DIFFERENT CASES OF THE FACADE WALL (BRICK, CONCRETE, WOOD)

	PIACENZA (kBtu)	HONG KONG (kBtu)	HELSINKI (kBtu)
QUANTITY OF ENERGY FOR HEATING (BRICKS)	290,079	30,103	506,523
QUANTITY OF ENERGY FOR COOLING (BRICKS)	235,485	412,651	192,729
QUANTITY OF ENERGY FOR HEATING (CONCRETE)	307,443	30,378	543,469
QUANTITY OF ENERGY FOR COOLING (CONCRETE)	233,362	423,997	187,649
QUANTITY OF ENERGY FOR HEATING (WOOD)	313,945	36,169	540,246
QUANTITY OF ENERGY FOR COOLING (WOOD)	246,698	428,394	198,416

Regarding the energy performance of the building with different construction methods, we understand that in most of the cases the one using WOOD is the most expensive, both for the quantity of heating and cooling (except the comparison of quantity of energy for heating in Helsinki, where at the first place there is the building in concrete).
For the energy consumption for heating, for sure the best solution is to use BRICK walls for the facade, in order to diminish the dispersion and save energy and money.
If we analyze the energy consumption for cooling, the best option is to use CONCRETE, but is not too far from the results obtained for BRICK buildings.
So in conlusion, the best construction methods for energy saving of cooling and heating are in most of the cases to use BRICK or CONCRETE.