IBPSA SF – Designing With Climate Change
Thermal Comfort Modeling

INTEGRAL
Revolutionary Engineering
imagine | perform | accelerate | sustain
Highrise Apartment Building, 2015

Schematic Design Feedback
Oakland, CA

With operable windows and air movement could the mechanical air conditioning system be removed?
Site Orientation
Future Climate – Peak day in Current and Predicted Weather Data

Oakland Intl AP Climate Data - Peak Annual Temperature

Dry-Bulb Temperature (°F)

Time

0:00 2:00 4:00 6:00 8:00 10:00 12:00 14:00 16:00 18:00 20:00 22:00

ASHRAE 50 year design extreme

2000 2020 2050 2080
Oakland Intl AP Dry Bulb Temperature – 2000

- **Min:** 32°F
- **Max:** 93°F
- **Mean:** 57°F
- **Median:** 57°F
Oakland Intl AP Dry Bulb Temperature – 2020

- **Min:** 32°F
- **Max:** 98°F
- **Mean:** 59°F
- **Median:** 59°F
Oakland Intl AP Dry Bulb Temperature – 2050

Min: 34°F
Max: 106°F
Mean: 61°F
Median: 61°F
Oakland Intl AP Dry Bulb Temperature – 2080

Min: 36°F
Max: 111°F
Mean: 63°F
Median: 64°F
Thermal Comfort Modeling Inputs

Modeling Inputs

Site:
Oakland International Airport TMY3 Weather Data

4" concrete slab included in ceiling and floor assemblies

Curtain Wall Assembly – R-6

Ceiling Fans:
Automatically activated via thermostat
100 fpm airflow capable

Concept of the modeled geometry
Thermal Comfort Modeling Inputs

Modeling Inputs

Glazing:

**Base Glazing:**
Window to Wall Ratio: 60%
SolarBan 70XL on clear
Specs – U-0.4; SHGC-0.28; Vis-64%

**High Performance Glazing:**
Window to Wall Ratio: 50%
SolarBan R100 SolarBlue on clear
Specs – U-0.4; SHGC-0.20; Vis-26%

Window Operability – 5% area (4” side hung window)

Concept of the modeled geometry
Adaptive Thermal Comfort in Buildings

- Thermal Comfort depends on local climate and operative temperature

**Chart:**
- Monthly High Temperature
- Monthly Low Temperature
- 90% of People Comfortable
- 80% of People Comfortable

**Graph:**
- Operative temperature:
  - 60% acceptability limits
    - L Status
    - 73.9 to 86.5°F
    - Operative temperature: 73.9 to 86.5°F
    - Comfortable
  - 90% acceptability limits
    - L Status
    - 75.7 to 84.7°F
    - Operative temperature: 75.7 to 84.7°F
    - Comfortable

**Adaptive Chart:**
- Prevailing Mean Outdoor Temperature [°F]
- Operative Temperature [°F]

**Note:** Method is applicable only for occupant-controlled naturally conditioned spaces that meet all of the following criteria: (a) There is no mechanical cooling system installed. No heating system is in operation; (b) Metabolic rates ranging from 1.0 to 1.3 met; and (c) Occupants are free to adapt their clothing to the indoor and/or outdoor thermal conditions within a range at least as wide as 0.5 to 1.0 die.
Façade Directions – Thermal Comfort Results

Typical Year

Peak Temperature

87°F 84°F

88°F 85°F

91°F 86°F

92°F 87°F

>80°F

>82°F

Number of Days

Base Glazing Performance Glazing

Number of Days

Base Glazing Performance Glazing

Number of Days

Base Glazing Performance Glazing

Number of Days

Base Glazing Performance Glazing
Façade Directions – Thermal Comfort Results

Peak Temperature

98°F 94°F
Base Glazing Performance Glazing

>80°F 82°F
Number of Days

99°F 94°F
Base Glazing Performance Glazing

95°F 92°F
Base Glazing Performance Glazing

Extreme Hot Year

97°F 92°F
Number of Days
Façade Directions – Thermal Comfort Results

Effect of Glazing Improvements – Southeast Façade

Number of Uncomfortable Days in an Extreme Hot Year

Peak Temperature:
- Base: 97°F
- Reduce WWR to 50%: 95°F
- Apply Tint SGHC-0.20: 93°F
- 50% WWR with Tint: 92°F
Future Climate – Indoor Operative Temperature Southeast Façade Corner

Indoor Operative Temperature - Peak Day TMY3 and 50 Yr Extreme

- Upper Adaptive Comfort Limit
- 50 Yr Extreme Indoor Adaptive Temperature
- TMY3 Indoor Operative Temperature
- Lower Adaptive Comfort Limit
Future Climate – Peak day in Current and Predicted Weather Data

Oakland Intl AP Climate Data - Peak Annual Temperature

- ASHRAE 50 year design extreme
- Lines represent data for different years: 2000, 2020, 2050, 2080