Effect of Corridor Design on Energy Consumption for School Buildings in the Cold Climate

- Presented by: Anxiao ZHANG  Ph.D. Candidate
  - School of Architecture, Tianjin University, China
  - Faculty of Architecture and the Built Environment, Delft University of Technology, Netherlands
Corridor: traffic and communication space in school buildings

Typical plan of school buildings

Classroom unit

Corridor space
Space types of corridor design

Type A: Double-sided corridor school building

Type B: One-sided enclosed corridor school building

Type C: One-sided open corridor school building
The cold climate in China:

**Dwa:**
Humid continental climate;
Cold and dry winter;
Hot and humid summer (warmest month average above 22°C)
Research questions:

• Which corridor design measures can influence the energy performance of school buildings in cold climates more effectively?

• To what extent would the combination of corridor strategies provide energy-saving?
School building models for three types of corridors

<table>
<thead>
<tr>
<th>Configuration.</th>
<th>Double-sided corridor (Type A)</th>
<th>One-sided enclosed corridor (Type B)</th>
<th>One-sided open corridor (Type C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floor plan.</td>
<td><img src="image1" alt="Diagram" /></td>
<td><img src="image2" alt="Diagram" /></td>
<td><img src="image3" alt="Diagram" /></td>
</tr>
</tbody>
</table>

Legend:
- 🏭 General Classroom
- 📚 Specialized Classroom
- 🔧 Bath/Water/Tech
- 🚶 Stairs
- 🔴 Corridor
## Characteristics of corridor space

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orientation (Spatial location)</td>
<td>0°*, 90°, 180°, 270°</td>
</tr>
<tr>
<td>Corridor width</td>
<td>1.5m*, 2.4m*, 3m*a</td>
</tr>
<tr>
<td>Temperature control</td>
<td>16°C-26°C*, 14°C-28°C, 12°C-30°C</td>
</tr>
<tr>
<td>Wall insulation</td>
<td>0.35*, 0.30, 0.25 b W/m²K</td>
</tr>
<tr>
<td>Roof insulation</td>
<td>0.49*, 0.35, 0.15 b W/m²K</td>
</tr>
<tr>
<td>Glazing type</td>
<td>Single glass, double glass*, triple glass, double low-e glass</td>
</tr>
<tr>
<td>Window to wall ratio of external surfaces</td>
<td>20%, 30%, 40%*</td>
</tr>
<tr>
<td>Mechanical ventilation</td>
<td>10, 19*, 30 m³/h•p</td>
</tr>
<tr>
<td>Infiltration</td>
<td>0.75, 1.0*, 1.5 ac/h</td>
</tr>
</tbody>
</table>

* The base case settings of the reference model.

a Mean value of different periods of school design in China from the 1980s to the present (Wang, 2007).

b Best practice building from Designbuilder (Designbuilder, 2014).
<table>
<thead>
<tr>
<th></th>
<th>Double-sided corridor (Type A)</th>
<th>One-sided enclosed corridor (Type B)</th>
<th>One-sided open corridor (Type C)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Orientation</strong></td>
<td>0°*, 90°, 180°, 270°</td>
<td>0°*, 90°, 180°, 270°</td>
<td>0°*, 90°, 180°, 270°</td>
</tr>
<tr>
<td><strong>Corridor width</strong></td>
<td>1.5m*, 2.4m*, 3m*</td>
<td>1.5m*, 2.4m*, 3m*</td>
<td>1.5m*, 2.4m*, 3m*</td>
</tr>
<tr>
<td><strong>Temperature control</strong></td>
<td>16°C-26°C*, 14°C-28°C, 12°C-30°C</td>
<td>16°C-26°C*, 14°C-28°C, 12°C-30°C</td>
<td>-</td>
</tr>
<tr>
<td><strong>Wall insulation.</strong></td>
<td>0.35*, 0.30, 0.25 b W/m²K</td>
<td>0.35*, 0.30, 0.25 b W/m²K</td>
<td>-</td>
</tr>
<tr>
<td><strong>Roof insulation.</strong></td>
<td>0.49*, 0.35, 0.15 b W/m²K</td>
<td>0.49*, 0.35, 0.15 b W/m²K</td>
<td>-</td>
</tr>
<tr>
<td><strong>Glazing type.</strong></td>
<td>Single glass, double glass*, triple glass, double low-e glass</td>
<td>Single glass, double glass*, triple glass, double low-e glass</td>
<td>Single glass, double glass*, triple glass, double low-e glass</td>
</tr>
<tr>
<td><strong>Window to wall ratio of external surfaces</strong></td>
<td>20%, 30%, 40%*</td>
<td>20%, 30%, 40%*</td>
<td>20%, 30%, 40%*</td>
</tr>
<tr>
<td><strong>Mechanical ventilation.</strong></td>
<td>10, 19*, 30 m³/h•p</td>
<td>10, 19*, 30 m³/h•p</td>
<td>-</td>
</tr>
<tr>
<td><strong>Infiltration.</strong></td>
<td>0.75, 1.0*, 1.5 ac/h</td>
<td>0.75, 1.0*, 1.5 ac/h</td>
<td>-</td>
</tr>
</tbody>
</table>
Annual energy consumption of school buildings for different forms and orientations

Annual energy demand of corridor space for different forms and orientations
Temperature control

Annual energy consumption of school buildings for different temperature control

Annual energy demand of corridor space for different temperature control
Annual energy consumption of school buildings for different opaque envelope designs

Annual energy demand of corridor space for different opaque envelope designs
Glazing

Annual energy consumption of school buildings for different glazing

Annual energy demand of corridor space for different glazing
Annual energy consumption of school buildings for different ventilation and infiltration

Annual energy demand of corridor space for different ventilation and infiltration
Sensitivity analysis
Integration of corridor design strategies

Comparative energy analyses of the optimized design and the base case design for school building models.
Conclusion

- **Type C** consumes the least energy annually while **Type B** has the highest energy demand.
- **Form and orientation of corridors** can significantly affect the total building energy consumption. Buildings with 0° and 180° rotation angle perform better than other orientations. **Narrow corridors** have the best performance for Type A and B while the effect is only marginal for Type C.
- Corridors equipped with a **20% WWR of low-e double glazing** results in the highest energy-savings for both Type A and B. For **Type C** a double glazing with a **40% WWR** has the lowest energy demand.
- The design with **the widest temperature range and the lowest ventilation and infiltration rates** can achieve the minimal building energy consumption.
- The design of **the opaque envelope component** for corridors has little effect on the energy demand.
Conclusion

- Finally, the integration of the corridor design solutions offers a saving in total energy by around 6% and 17% for Type A and B respectively. For Type C, the base case has the best energy performance.
Thanks for your attentions!

○ **Information**

**Presenter:** Anxiao ZHANG

**Student:** Ph.D. Candidate on low energy consumption building design, and outdoor thermal comfort

**E-mail:** zhanganxiao9012@gmail.com

**Institute:** School of Architecture, Tianjin University, Tianjin, China; Faculty of Architecture and the Built Environment, Delft University of Technology, Netherlands