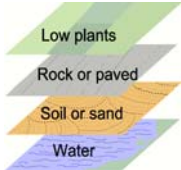







# LOCAL CLIMATE ZONE CLASSIFICATION SYSTEM

Stewart ID. 2011. *Redefining the urban heat island*. Unpublished doctoral dissertation. University of British Columbia, Vancouver, Canada. <https://circle.ubc.ca/handle/2429/38069>

## KEY TO DATASHEETS

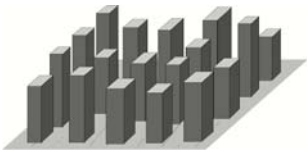
LCZ KEY	ZONE NAME	#
<b>ZONE DEFINITION</b>		
<p><b>Form:</b> Description of building morphology, land cover, construction materials, tree geometry, and human activity. <b>Function:</b> Land uses most likely associated with this zone. <b>Location:</b> Expected location of the zone (core, periphery; city, countryside). <b>Correspondence:</b> Comparable zones in the urban classification systems of Oke (2004) and Ellefsen (1990/91).</p>		
<b>ZONE ILLUSTRATION</b>		
<p><b>Land cover</b></p>  <p><b>Objects</b></p> <ul style="list-style-type: none"> <li> Buildings heavy materials</li> <li> Dwellings lightweight materials</li> <li> Trees/plants</li> </ul>	<p><b>High-angle photographs</b> (© Can Stock Photo Inc.)</p>  <p><b>Low-level photographs</b> (© Can Stock Photo Inc.)</p> 	
<b>ZONE PROPERTIES</b>		
<p><b>Sky view factor</b> <math>\psi_{sky}</math> 0 – 1</p> <p><b>Aspect ratio</b> H/W 0 – 3<sup>+</sup></p> <p><b>Mean building/tree height</b> <math>z_H</math> 0 – 50<sup>+</sup> m</p> <p><b>Terrain roughness class</b> 1 – 8</p> <p><b>Building surface fraction</b> <math>\lambda_b</math> 0 – 100 %</p> <p><b>Impervious surface fraction</b> <math>\lambda_i</math> 0 – 100 %</p> <p><b>Pervious surface fraction</b> <math>\lambda_v</math> 0 – 100 %</p> <p><b>Surface admittance</b> <math>\mu</math> 0 – 3,000<sup>+</sup> J m<sup>-2</sup> s<sup>1/2</sup> K<sup>-1</sup></p> <p><b>Albedo</b> <math>\alpha</math> 0 – 0.5</p> <p><b>Anthropogenic heat flux</b> <math>Q_F</math> 0 – 400<sup>+</sup> W m<sup>-2</sup></p>	<p>Fraction of sky hemisphere visible from ground level. Varies with height and spacing of buildings and trees. Affects surface radiational heating/cooling.</p> <p>Mean height-to-width ratio of street canyons (LCZ 1–7), building spacing (LCZ 8–10), and tree spacing (LCZ A–F). Affects surface airflow and radiational heating/cooling.</p> <p>Geometric average of building heights (LCZ 1–10) and tree/plant heights (LCZ A–F). Affects surface reflectivity, flow regimes, and heat dispersion above ground.</p> <p>Davenport et al. (2000) classification of effective terrain roughness (<math>z_0</math>) for city and country landscapes: 1–“sea” (<math>z_0 \sim 0.0002</math> m); 2–“smooth” (<math>z_0 \sim 0.005</math> m); 3–“open” (<math>z_0 \sim 0.03</math> m); 4–“roughly open” (<math>z_0 \sim 0.10</math> m); 5–“rough” (<math>z_0 \sim 0.25</math> m); 6–“very rough” (<math>z_0 \sim 0.5</math> m); 7–“skimming” (<math>z_0 \sim 1.0</math> m); 8–“chaotic” (<math>z_0 \sim 2</math> m). Affects surface reflectivity, flow regimes, and heat dispersion above ground.</p> <p>Proportion of ground surface with building cover. Affects surface reflectivity, flow regimes, and heat dispersion above ground.</p> <p>Proportion of ground surface with impervious cover (paved, rock). Affects surface reflectivity, moisture availability, and heating/cooling potential.</p> <p>Proportion of ground surface with pervious cover (bare soil, vegetation, water). Affects surface reflectivity, moisture availability, and heating/cooling potential.</p> <p>Ability of surface to accept or release heat. Affects surface heat storage and heating/cooling rates. Values give typical range for surfaces in each LCZ (e.g., buildings, roads, soils, water). Varies with soil wetness and material density.</p> <p>Surface reflectivity at local scale, under a clear midday sky. Affects surface radiational heating potential. Varies with surface wetness.</p> <p>Mean annual anthropogenic heat flux density at local scale. Heat sources include vehicle engines, industrial/domestic combustion processes, space cooling/heating, and human metabolism. Varies significantly with latitude, season, and population density.</p>	

## DEFINITION

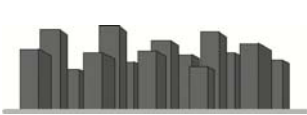
**Form:** Dense mix of tall buildings to tens of stories. Buildings free-standing, closely spaced. Sky view from street level significantly reduced. Buildings of steel, concrete, and glass construction. Land cover mostly paved; few or no trees. High space heating/cooling demand. Heavy traffic flow. **Function:** Commercial (office buildings, hotels); residential (apartment towers). **Location:** Core (downtown, central business district); periphery (highrise subcentre, highrise sprawl). **Correspondence:** UCZ1 (Oke 2004); Dc1 and Dc8 (Ellefsen 1990/91).

## ILLUSTRATION

*High angle*



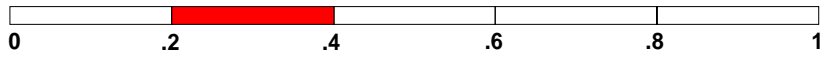
*Low level*



## PROPERTIES

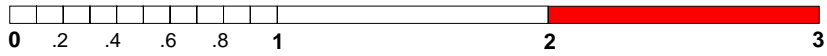
**Sky view factor**

0.2 – 0.4



**Canyon aspect ratio**

> 2



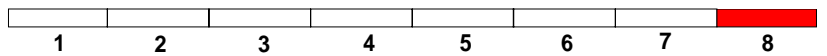
**Mean building height**

> 25 m



**Terrain roughness class**

8



**Building surface fraction**

40 – 60 %



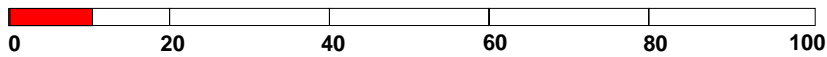
**Impervious surface fraction**

40 – 60 %



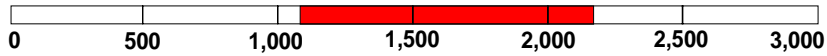
**Pervious surface fraction**

< 10 %



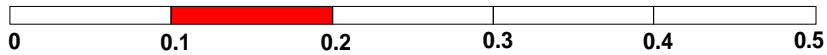
**Surface admittance**

1,100 – 2,200 J m<sup>-2</sup> s<sup>1/2</sup> K<sup>-1</sup>



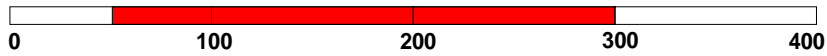
**Surface albedo**

0.10 – 0.20



**Anthropogenic heat flux**

50 – 300 W m<sup>-2</sup>

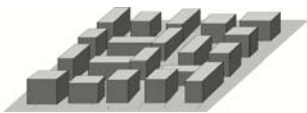


DEFINITION

**Form:** Attached or closely spaced buildings 3–9 stories tall. Buildings separated by narrow streets and inner courtyards. Buildings uniform in height. Sky view from street level significantly reduced. Heavy building materials (stone, concrete, brick, tile) and thick roofs and walls. Land cover mostly paved; few or no trees. Moderate space heating/cooling demand. Moderate to heavy traffic flow. **Function:** Residential (multi-unit housing; multistorey tenements); commercial (office buildings, hotels, retail shops); industrial (warehouses, factories). **Location:** Core (old city, old town; inner city, central business district); periphery (high-density sprawl). **Correspondence:** UCZ2 (Oke, 2004); A1, A2, A4, Dc2 (Ellefsen, 1990/91).

ILLUSTRATION

High angle



Low level



PROPERTIES

**Sky view factor**

0.3 – 0.6



**Canyon aspect ratio**

0.75 – 2



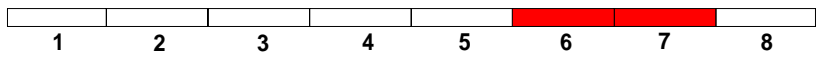
**Mean building height**

10 – 25 m



**Terrain roughness class**

6 – 7



**Building surface fraction**

40 – 70 %



**Impervious surface fraction**

30 – 50 %



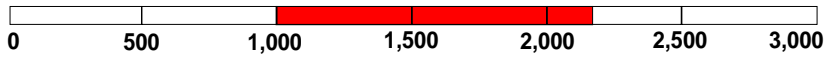
**Pervious surface fraction**

< 20 %



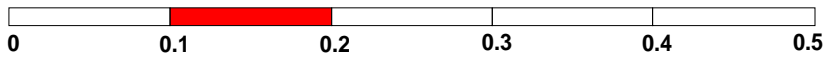
**Surface admittance**

1,000 – 2,200 J m<sup>-2</sup> s<sup>1/2</sup> K<sup>-1</sup>



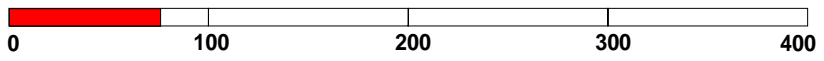
**Surface albedo**

0.10 – 0.20



**Anthropogenic heat flux**

< 75 W m<sup>-2</sup>

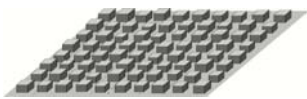


**DEFINITION**

**Form:** Attached or closely spaced buildings 1–3 stories tall. Buildings small and tightly packed along narrow streets, often without discernable alignment. Sky view from street level significantly reduced. Heavy building materials (stone, concrete, brick, tile) and thick roofs and walls. Land cover mostly paved; few or no trees. Moderate space heating/cooling demand. Low-moderate traffic flow. **Function:** Residential (single-unit housing, high-density terrace/row housing); commercial (small retail shops). **Location:** Old or densely populated cities, towns, villages. Core (central or inner city); periphery (high-density sprawl). **Correspondence:** UCZ3 (Oke, 2004); Dc3 (Ellefsen, 1990/91).

**ILLUSTRATION**

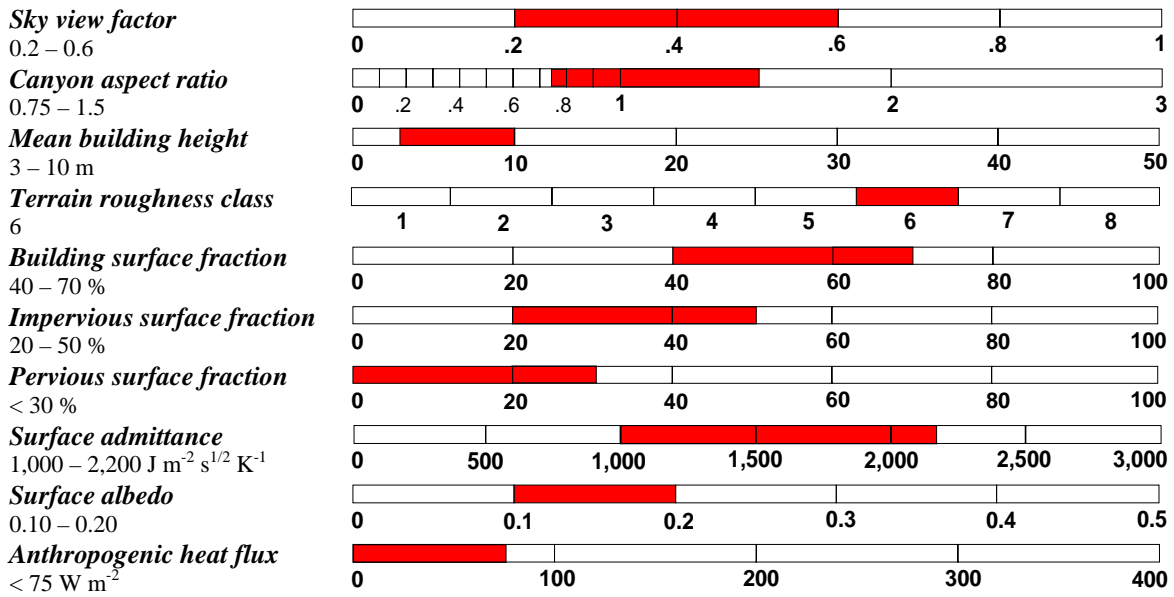
*High angle*



*Low level*



**PROPERTIES**



## DEFINITION

**Form:** Buildings tens of stories tall, set in open, geometric arrangement. Buildings uniform in height, width, and spacing. Sky view from ground level significantly reduced. Heavy building materials (concrete, steel, stone, glass) and thick roofs and walls. Roofs typically flat. Scattered trees and abundant plant cover. Moderate-low space heating/cooling demand. Moderate traffic flow. **Function:** Residential (apartment blocks, highrise housing estates, multistorey tenements). **Location:** Periphery. Densely populated cities. Socialist-style cities. **Correspondence:** Do2 (Ellefsen, 1990/91).

## ILLUSTRATION

*High angle*



*Low level*



## PROPERTIES

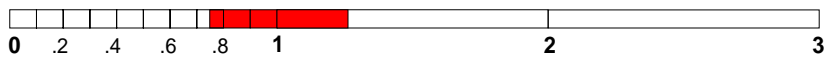
**Sky view factor**

0.5 – 0.7



**Canyon aspect ratio**

0.75 – 1.25



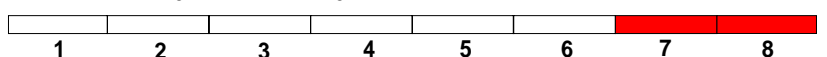
**Mean building height**

> 25 m



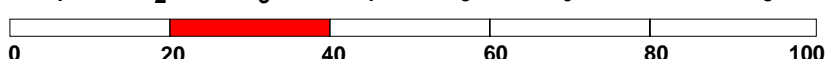
**Terrain roughness class**

7 – 8



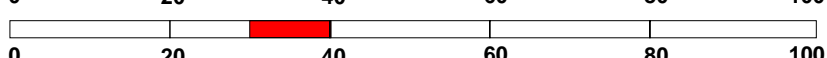
**Building surface fraction**

20 – 40 %



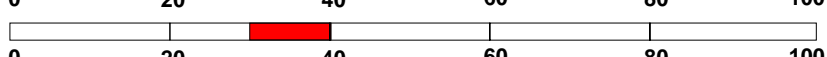
**Impervious surface fraction**

30 – 40 %



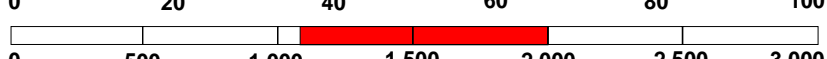
**Pervious surface fraction**

30 – 40 %



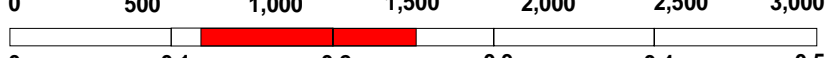
**Surface admittance**

1,100 – 2,000 J m<sup>-2</sup> s<sup>1/2</sup> K<sup>-1</sup>



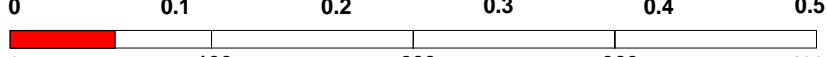
**Surface albedo**

0.12 – 0.25



**Anthropogenic heat flux**

< 50 W m<sup>-2</sup>



DEFINITION

**Form:** Open arrangement of buildings 3–9 stories tall. Sky view from street level slightly reduced. Heavy building materials (concrete, steel, stone, glass) and thick roofs and walls. Scattered trees and abundant plant cover. Low space heating/cooling demand. Low traffic flow. **Function:** Residential (multi-unit housing, multistorey tenements, apartment blocks); institutional (research/business parks, campuses); commercial (office buildings, hotels). **Location:** Periphery. **Correspondence:** UCZ6 (Oke, 2004); Do6 (Ellefsen, 1990/91).

ILLUSTRATION

High angle



Low level



PROPERTIES

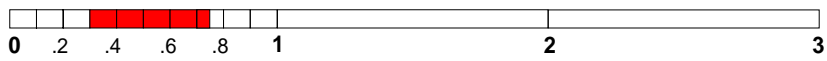
**Sky view factor**

0.5 – 0.8



**Canyon aspect ratio**

0.3 – 0.75



**Mean building height**

10 – 25 m



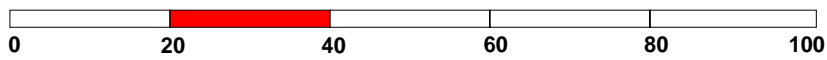
**Terrain roughness class**

5 – 6



**Building surface fraction**

20 – 40 %



**Impervious surface fraction**

30 – 50 %



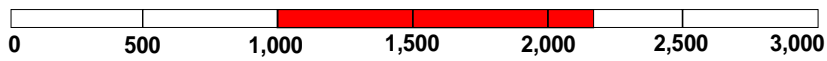
**Pervious surface fraction**

20 – 40 %



**Surface admittance**

1,000 – 2,200 J m<sup>-2</sup> s<sup>1/2</sup> K<sup>-1</sup>



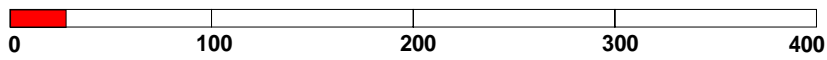
**Surface albedo**

0.12 – 0.25



**Anthropogenic heat flux**

< 25 W m<sup>-2</sup>

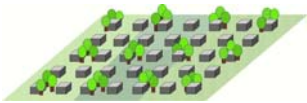


## DEFINITION

**Form:** Small buildings 1–3 stories tall; detached or attached in rows, often in grid pattern. Sky view from street level slightly reduced. Building materials vary (wood, brick, stone, tile). Scattered trees and abundant plant cover. Low space heating/cooling demand. Low traffic flow. **Function:** Residential (single or multi-unit housing, low density terrace/row housing); commercial (small retail shops). **Location:** City (medium density); periphery (suburbs). Commuter towns. Rural towns. **Correspondence:** UCZ5 (Oke 2004); Do3 (Ellefsen 1990/91).

## ILLUSTRATION

*High angle*



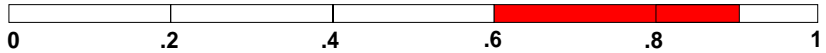
*Low level*



## PROPERTIES

**Sky view factor**

0.6 – 0.9



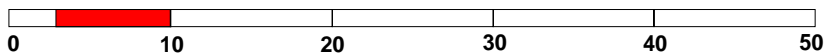
**Canyon aspect ratio**

0.3 – 0.75



**Mean building height**

3 – 10 m



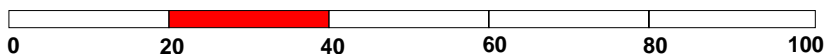
**Terrain roughness class**

5 – 6



**Building surface fraction**

20 – 40 %



**Impervious surface fraction**

20 – 50 %



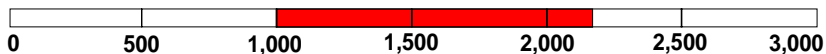
**Pervious surface fraction**

30 – 60 %



**Surface admittance**

1,000 – 2,200 J m<sup>-2</sup> s<sup>1/2</sup> K<sup>-1</sup>



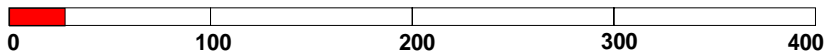
**Surface albedo**

0.12 – 0.25



**Anthropogenic heat flux**

< 25 W m<sup>-2</sup>

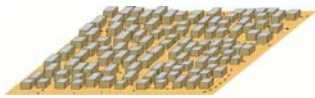


**DEFINITION**

**Form:** Single-story buildings set in compact (often formless) arrangement, attached or closely spaced. Buildings separated by narrow roads and alleys. Little or no consolidated infrastructure. Sky view from ground level significantly reduced. Lightweight building materials (thatch, wood, bamboo, corrugated metal); thin walls and flat roofs. Few or no trees. Land cover hard packed (bare soil, sand). Population density high. Space heating/cooling demand nil. Low traffic flow. **Function:** Residential (informal settlements, low-cost housing, shantytowns, squatter settlements, mobile housing); agricultural (small-holder lots). **Location:** Periphery of large, developing cities. Extended metropolitan regions. Inner city. Rural towns.

**ILLUSTRATION**

*High angle*



*Low level*



**PROPERTIES**

**Sky view factor**

0.2 – 0.5



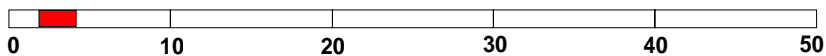
**Canyon aspect ratio**

1 – 2



**Mean building height**

2 – 4 m



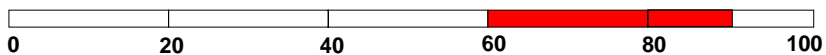
**Terrain roughness class**

4 – 5



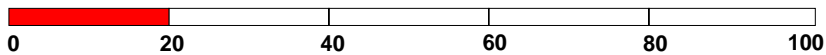
**Building surface fraction**

60 – 90 %



**Impervious surface fraction**

< 20 %



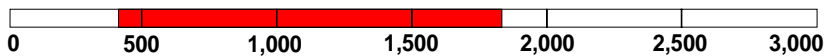
**Pervious surface fraction**

< 30 %



**Surface admittance**

400 – 1,800 J m<sup>-2</sup> s<sup>1/2</sup> K<sup>-1</sup>



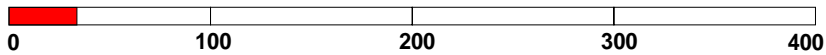
**Surface albedo**

0.15 – 0.35



**Anthropogenic heat flux**

< 35 W m<sup>-2</sup>





## DEFINITION

**Form:** Large, low buildings 1–3 stories tall, separated by extensive paved surfaces. Buildings extend outward not upward; roofs flat. Sky view from ground level slightly reduced. Building materials vary (steel, concrete, metal). Few or no trees; land cover mostly paved. Moderate-low space heating/cooling demand. Moderate-heavy traffic flow. **Function:** Light industrial (modern warehousing); commercial (shopping centres, storage facilities); transportation hub (air, rail, truck, ship). **Location:** Periphery. **Correspondence:** UCZ4 (Oke, 2004); Do1, Do4 (Ellefsen, 1990/91).

## ILLUSTRATION

*High angle*



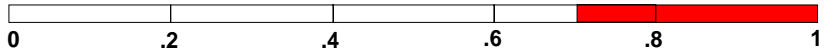
*Low level*



## PROPERTIES

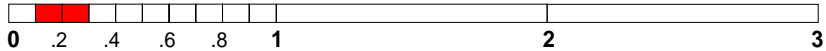
**Sky view factor**

> 0.7



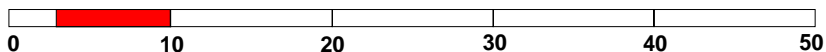
**Building aspect ratio**

0.1 – 0.3



**Mean building height**

3 – 10 m



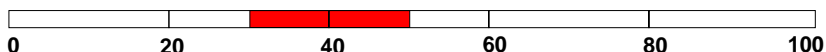
**Terrain roughness class**

5



**Building surface fraction**

30 – 50 %



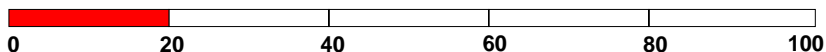
**Impervious surface fraction**

40 – 50 %



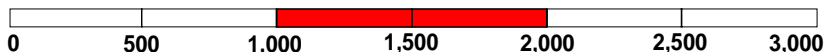
**Pervious surface fraction**

< 20 %



**Surface admittance**

1,000 – 2,000 J m<sup>-2</sup> s<sup>1/2</sup> K<sup>-1</sup>



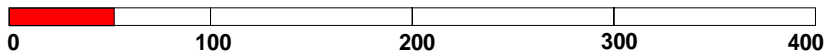
**Surface albedo**

0.15 – 0.25



**Anthropogenic heat flux**

< 50 W m<sup>-2</sup>



DEFINITION

**Form:** Small or medium-sized buildings widely spaced across natural landscape. Full sky view from ground level. Building materials vary. Scattered trees and abundant plant cover. Space heating/cooling demand negligible. Low traffic flow. **Function:** Residential (single or multi-unit housing); commercial (retail shops, office buildings); institutional (research/business parks, campuses); agricultural (farms, country estates). **Location:** Periphery (low-density suburbs). Extended metropolitan regions. Newly developed urban tracts. Rural towns. Lightly settled countryside. **Correspondence:** UCZ7 (Oke, 2004).

ILLUSTRATION

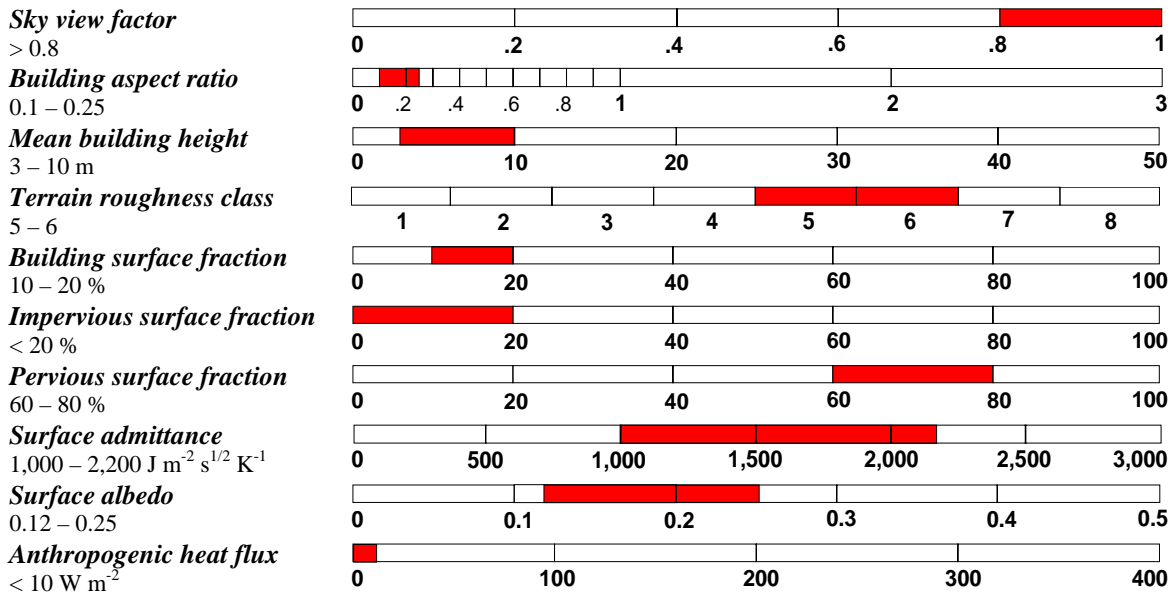
High angle



Low level



PROPERTIES



## DEFINITION

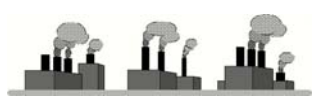
**Form:** Highly irregular mix of low and midrise industrial structures (tanks, towers, stacks). Structures openly spaced on hard-packed surfaces. Sky view from ground level slightly reduced. Building materials vary (steel, concrete, metal). Few or no trees. High demand for space heating/cooling. Large quantities of waste heat and atmospheric pollutants released from mechanical and chemical processing (smelting, pulping, distilling). Low traffic flow. **Function:** Industrial (factories, refineries, mills, plants). **Location:** City or country.

## ILLUSTRATION

*High angle*



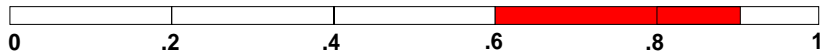
*Low level*



## PROPERTIES

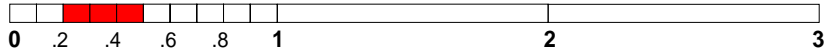
**Sky view factor**

0.6 – 0.9



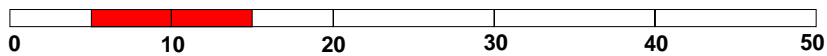
**Building aspect ratio**

0.2 – 0.5



**Mean building height**

5 – 15 m



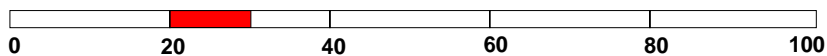
**Terrain roughness class**

5 – 6



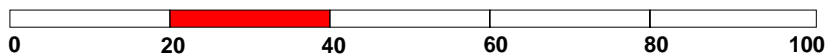
**Building surface fraction**

20 – 30 %



**Impervious surface fraction**

20 – 40 %



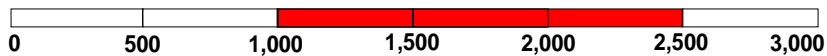
**Pervious surface fraction**

40 – 50 %



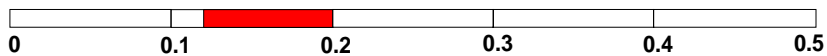
**Surface admittance**

1,000 – 2,500 J m<sup>-2</sup> s<sup>1/2</sup> K<sup>-1</sup>



**Surface albedo**

0.12 – 0.20



**Anthropogenic heat flux**

> 300 W m<sup>-2</sup>

