# Towards a global database on building architecture and construction materials for urban climate models

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**Abstract**

Due to regional climate change exacerbated by the Urban Heat Island (UHI) effect, the population of dense urban areas is vulnerable to heat stress. Accurate urban climate models are essential for quantifying UHI mitigation strategies and supporting climate adaptation efforts. These models require input data on urban form, materials, and function. However, existing frameworks, such as Local Climate Zones (LCZ) and Geoclimate, only provide urban morphological parameters and lack detailed information on building materials and Heating, Ventilation, and Air Conditioning (HVAC) systems.

To address these limitations, architects, engineers, urban climatologists and researchers in many countries have been contacted via a survey platform to provide information on building materials and HVAC systems. The survey has been translated into 11 languages to enable global coverage. This approach captures significant architectural and construction trends by collecting key data on building envelope characteristics (e.g., walls, roofs, windows, and insulation) and HVAC systems ~~and envelope characteristics (e.g., walls, roofs, windows, and insulation)~~.

The survey yielded 521 responses from 141 countries, demonstrating substantial global coverage. A multi-step imputation strategy was applied to create a comprehensive global database, and residential building typologies are defined for each country. Global homogeneous typologies are defined for non-residential buildings. The resulting datasets are freely available and can easily be combined with LCZ maps. These datasets provide a valuable resource for urban climate modeling and facilitate more accurate climate assessments on a global scale. Future work may enhance data granularity further, for instance, by providing typologies at the subnational level.

## 1 Introduction

In 2025, over half of the world's population will reside in urban areas, with projections reaching 70% by 2050 (United Nations, 2023). Understanding the interplay between cities and their environment is therefore crucial for climate resilience and adaptation. One of the most pressing challenges is ~~the~~ urban overheating (Martilli et al 2020, Nazarian et al 2022), which is more and more important due to climate change. Overheating in cities occur during day but also at night, due to the Urban Heat Island ~~island~~ (UHI) effect, wherein urban areas typically experience higher temperatures than their rural surroundings (Oke et al., 2017), posing significant threats to human thermal comfort and health.

Buildings, as key constituents of the urban landscape, influence the urban microclimate through heat release from heating, ventilation, and air-conditioning (HVAC) systems (Bueno et al., 2012; de Munck et al., 2012; Li et al., 2024), and due to their intrinsic design features and material compositions that impact heat storage capacity and exchange with the surrounding environment (Synnefa et al., 2008; Mirrahimi et al., 2012; Alghamdi et al., 2022). Indeed, the urban environment, and especially buildings, can absorb and retain significant amounts of heat during daytime, that is released during nighttime. Heat stored in buildings could also extend thermal discomfort after a heatwave (Van Oldenborgh et al., 2022). Therefore, accurate characterization of buildings is crucial for advanced urban climate models, enabling reliable predictions of UHI intensity and facilitating the development of effective mitigation strategies.

Sensitivity analyses have highlighted the impact of various building parameters on urban climate model outputs. Oleson et al. (2008) demonstrated that urban materials thermal parameters, such as thermal conductivity and heat capacity, can have a similar influence on sensible and storage heat flux than urban morphology parameters. Tornay et al. (2017) performed a sensitivity study focusing on French building archetypes and identified three highly influential characteristics crucial for accurate urban energy balance simulations: roof material albedo, the presence and thickness of insulation materials in walls and roofs, and the location of the insulation (interior or exterior). Schoetter et al. (2023) found that overlooking pitched roofs can significantly influence the simulated solar radiation budget, particularly at low solar elevation angles. These findings underscore the importance that input data of urban climate models precisely represent the morphological, thermal, and radiative properties of buildings to enhance model accuracy.

Thanks to recent research progress, data on~~Presently, data regarding~~ urban form~~s~~ is~~are~~ available in most countries. There exist multiple satellite-based global urban land cover datasets at hectometric or decametric resolution providing information on the presence of urban areas (Chakraborty et al., 2024). More detailed information on urban form like maps of plan area building density or building height required by urban climate models can be derived using two different approaches (Lean et al., 2024). The first approach is to use data on individual buildings (polygons, heights) from sources like OpenStreetMap or LIDAR data. The GlobalBuildingAtlas (Zhu et al., 2025) provides such building data on a global scale. Based on these data on individual buildings, maps of building height, density, and other geomorphological parameters can be computed (Bocher et al., 2021). Kamath et al. (2024) used this approach to derive maps on urban form at 1 km resolution for 1200 cities in the world. The second approach is to use satellite images to classify land cover in several urban classes like~~Land cover maps~~ the~~of~~ Local

Climate Zones (LCZ; Stewart and Oke, 2012) or Urban Atlas (EEA, 2026), and to use tables of attribution to link the urban form parameters with the urban land cover classes. The global LCZ map of Demuzere et al. (2022) is an example and it can provide information on building form, such as low-rise, mid-rise, high-rise and large low-rise buildings around the world.~~, (e.g. Demuzere et al., 2022). Additionally, detailed maps capturing building height, density, and other geomorphological parameters can be computed from building inventories (Bocher et al., 2021) or remote sensing instruments.~~

In contrast to urban form, ~~However,~~ there is a paucity of information regarding other building features required for refined urban climate modeling and a critical gap persists in the availability of national-level data on building construction materials, wall and roof albedo, window types, and HVAC systems. Existing databases, such as the Global Data Set of Urban and Building Properties developed by Jackson et al. (2010)~~, hereafter referred to as GDUBP,~~ describe building typologies considering 33 zones globally but lack country-level detail and comprehensive coverage of required parameters. The 1 km global U-Surf dataset of urban surface properties (Cheng et al., 2025) contains an update of the Jackson et al. (2010) ~~GDUBP~~ dataset. Roof radiative parameters have been derived from satellite data, which improves their effective spatial resolution compared to Jackson et al. (2010)~~GDUBP~~. However, given that the satellite images do not provide reliable information on the wall radiative parameters and the thermal parameters of roofs and walls, U-Surf still relies on the look-up tables for the 33 regions from Jackson et al. (2010)~~GDUBP~~. The Danube database (Tornay et al., 2017) offers more detailed information regarding spatial variability, but is limited to the French building stock. Other databases do not explicitly cater to urban climate models despite their potential utility in describing building typology at national level. Such are the Tabula Web Tool (IEE, 2012), which provides residential building typologies for 21 European countries aiming to estimate building energy consumption, and the World Housing Encyclopedia (World Housing Encyclopedia, n.d.), which describes specific residential buildings across 46 countries in the seismically active areas of the world.

Despite the available data on urban form and generic building types, crucial information regarding construction materials, wall and roof albedo, window types and HVAC systems remains scarce at national levels at a global scale. To bridge this gap, there is an urgent need for a comprehensive, global building typology database with country-level information that is accessible to the community in an open-source Geographical Information System (GIS) format. Such data should be integrable with other data describing urban morphological parameters, such as LCZ, to enable more accurate simulation of UHI effects, building energy consumption, and human thermal comfort.

To address this critical gap, this article introduces an open-source GIS database providing global building and material data for urban climate models, developed through a collaborative approach. It outlines the development process, starting with the overall methodology~~definition of objectives and complementarity with LCZ~~ (Sect. 2), the database design framework~~key variables~~ (Sect. 3), survey distribution and response overview (Sect. 4), and strategies for ensuring data quality and completeness (Sect. 5). Sect~~ion~~. 6 presents the resulting building typologies, by country for residential and globally for non-residential buildings. A~~, followed by a~~ discussion is made in Sect.~~, Section~~ ~~6~~7. Sect. 8 concludes with perspectives for future developments~~, and Sect. 7 provides access to the compiled data~~.

## 2 Overall Methodology~~Objectives~~

The goal of this paper is to complement the description of the urban fabric for climate studies by providing architectural information at country-scale for various types of buildings. ~~Land cover information dedicated to urban areas already exist, such as LCZ maps (e.g. Demuzere et al., 2019, 2022) and urban Atlas (EEA, 2026provided by Copernicus). ItThese land cover classes provides insight on the morphological structure of the neighborhoods (Stewart and Oke 2012), typically density and building form. These LCZ classifications can be applied to represent the diversity of the urban forms throughout the world.~~

Urban Canopy Models, in addition to urban form information (translated as building density and height, impervious surfaces fraction, wall surfaces or sky-view-factor, etc.), require separate input data on materials for roofs and walls (such as albedo, heat capacity, thermal conductivity, window share, etc…) and HVAC systems (to compute anthropogenic fluxes with a building energy Module) (Masson et al 2020, Lipson et al 2024). However, Stewart and Oke (2012) only provide ranges for broad ranges for 3 parameters for the materiality and use: surface admittance and albedo, and anthropogenic fluxes.

An issue with building materials, architectural practices, practices and HVAC systems is that they are much more variable from one place to another across the globe, as already shown by Jackson et al (2010). Two objectives are then followed here:

- To provide the needed information for urban canopy models of all complexity level (see Lipson et al 2024) on buildings materials and structure (roofs, walls, windows) and HVAC systems, for various types of buildings
- To take into account the spatial variability across the globe, aiming to reach the country scale.

In order to reach these, the methodology is first to identify and organize the necessary data (sSect~~ion~~. 3). A~~Then,~~ ~~a~~ dedicated survey is used to gather information from specialists across the world ~~using a dedicated survey~~ (~~see~~ Sect.~~ion~~ . ~~3 and~~ 4). Then, the information is treated in order to provide data for each type of building (low-rise, mid-rise, high-rise and large low rise) and use (residential or not) and each country to describe all the needed parameters. One should note that these data are not spatially localised within each country.

To create the spatial maps of the architectural and system parameters, it is necessary to cross the information of our new database with the urban form maps (e.g. from LCZ, Urban Atlas, or other) (Fig. 1). This database would then open promising perspectives for the urban climate research community, as it represents a global architectural typology dataset developed at the national scale specifically for urban climate studies.

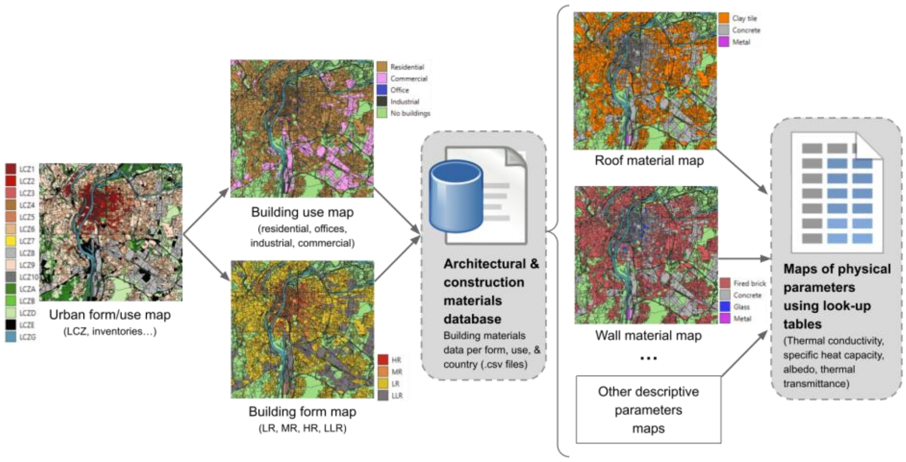


**Figure 1: Flowchart of the strategy to cross spatial information of existing urban form maps (e.g. LCZ, left) with the developed architectural & construction materials database (middle in gray) to produce maps of architectural characteristics and their corresponding maps of physical parameters (using look-up tables, right in gray). The examples of roof and wall materials are presented for Lyon, France.**

## 3 Database Design Framework~~Variable definition~~

This study assumes that architecture and construction materials depend on building form, use, geographical location, and construction period. Each plausible combination of these variables defines a unique building type with specific materials and architectural features. Tornay et al. (2017) employed this approach to define building types for France. Here, this approach is adapted to a global context such as to capture the diversity of factors influencing building practices across different countries.

The data framework ~~survey~~ was designed to characterise building typologies and gather data relevant to urban climate applications. The information is then grouped in wo main types~~ of information were collected~~: typological data, used to distinguish buildings, and descriptive data, which provides the characteristics of major building elements (Fig. 2).

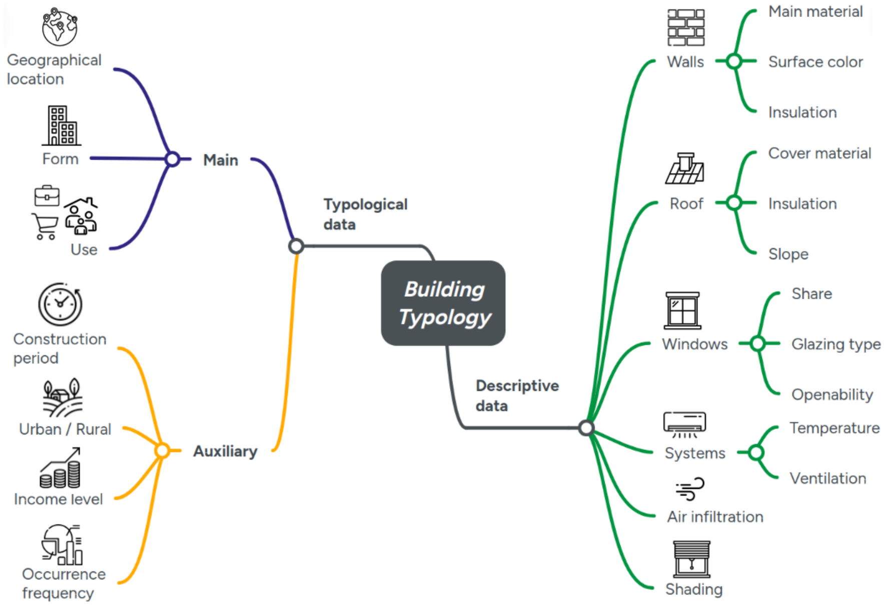


**Figure 2: Categories of building data~~ collected through the survey~~.**

In the descriptive data, ~~the survey collected information on ~~the characteristics of major building components that significantly influence the urban climate~~, which ~~are: external walls, roofs, windows, HVAC systems, solar shading elements, and air infiltration levels. For example, once a typical post-1950s urban single-family house in France linked to a middle-income level is defined, one needs to ~~respondents ~~provide detailed information on its materials and architectural characteristics.~~ To ensure comprehensive and consistent data across all categories, a series of multiple-choice questions was used to capture the key features of these elements.~~

~~To gather essential background information, the survey included an additional respondent data section. This section collected the respondent's field of experience (specialist or non-specialist in architecture/civil engineering), serving as a proxy for response reliability. It also gathered email contacts for potential follow-up clarifications. An open-ended comment section at the survey's conclusion captured unaddressed details, offering insights for data verification.~~

Sect.~~ion~~ 3~~2~~.1 details the typological variables, their categories, the reasoning behind their selection and their adaptation to a global context. Sect.~~ion~~ 3~~2~~.2 outlines the criteria for selecting building descriptive data, emphasizing their relevance to a typological approach and their impact on urban climate model results.

### 3.1 Building typological data

The building typology categories must capture key dimensions influencing building typologies across diverse international contexts. Their associated categories, therefore, must be broad enough to accommodate this global variation. The specific adaptations and reasoning behind the category choices are detailed below.

**Geographical location**

The aim of this study is to obtain building data for every country in the world. ~~Where national data are unavailable, information from neighboring countries may be used as a proxy, taking into account cultural and geographical similarities.~~

**Building use**

To optimise data collection, this study focuses on the most frequent building uses in urban and peri-urban areas, which are most relevant for urban climate applications. These are residential (Res), commercial (Com), office (Off), and industrial (Ind).

**Building form**

The building form is categorised according to the established Local Climate Zones (LCZs) to facilitate the combination of the results from this study with LCZ maps (e.g. Demuzere et al., 2019, 2022). The following building forms are considered in this study depending on the number of storeys and the surface of the building.

- Low-rise (LR) - 3 stories or less.
- Mid-rise (MR) - from 4 to 9 stories.
- High-rise (HR) - more than 9 stories.
- Large low-rise (LLR) - 3 stories or less and large building footprint area.

The choice of these four broad building forms allow to make the link with the Local Climate Zones (LCZ) and the Urban Atlas by enabling the development of a cross-reference table (Tab. ~~le~~ 1).

*Table 1: Correspondence between the building typologies and land cover classifications (LCZ and Urban Atlas).*

| Building typology | Associated LCZ classes | Associated Urban Atlas classes (Europe) | Associated CLMU (Oleson et al., 2010) |
|---|---|---|---|
| Low-rise residential | LCZ3: Dense low-rise<br>LCZ6: Open low-rise<br>LCZ9: Sparse low-rise | 1.1.2.3 Discontinuous Low Density Urban Fabric<br>1.1.2.4 Discontinuous Very Low Density Urban Fabric | Low Density<br>Medium Density |
| Mid-rise residential | LCZ2: Dense mid-rise<br>LCZ5: Open mid-rise | 1.1.1 Continuous Urban Fabric<br>1.1.2.1 Discontinuous Dense Urban Fabric<br>1.1.2.2 Discontinuous Medium Density | High Density |

| | | | |
|---|---|---|---|
| | | Urban Fabric | |
| High-rise residential | LCZ1: Dense high-rise<br>LCZ4: Open high-rise | No land cover class  is predominantly occupied by HR buildings in European cities | Tall Building District |
| Large low-rise non-residential | LCZ8: Large low rise | 1.2.1 Industrial, Commercial, Public, Military and Private Units | |
| Not covered in the present data | LCZ7: Informal settlements<br>LCZ10: Heavy industry | 1.2.3 Port Areas<br>1.2.4 Airports | |

Some land cover classes are not included in the database. For instance, Informal Settlements (LCZ7) are omitted. Accurately capturing these would require a more detailed classification of lower social strata, and global simplification is challenging due to the wide variation of materials used in informal settlements within and between countries. Heavy industry (LCZ10 or Urban Atlas Port classes) are not described, because the variability of the buildings presented in these classes is largely variable and dependent on the activity. However, these land cover classes do not cover in general a large surface at the scale of an agglomeration or city.

**Building construction period**

The relevance and specificities of construction periods as a variable for characterising building architecture and construction materials vary considerably across different countries. Each nation possesses unique construction traditions, historical trajectories, and regulatory frameworks that shape its building stock. For example, in France, rapid reconstruction was required after the World Wars (Abram, 2021), while the 1973 oil crisis spurred the development of the first building thermal regulations (Boesch, 2020). Other historical events, such as the Soviet era's impact on construction practices and material selection in former USSR countries (Van Assche, 2011; Saravan, 2024), must be considered. Similarly, in formerly colonized nations, construction practices can vary considerably across pre-colonial, colonial, and post-colonial periods (Lambert, 2017; James-Chakraborty, 2021). These and countless other regionally specific influences highlight the complex challenge of establishing construction periods that accurately reflect the diverse evolution of building practices worldwide.

Despite these variations, a broad international shift toward the Modern architecture movement, characterised by the widespread adoption of steel, concrete, and glass, emerged during~~in~~ the early 20th century in Europe and North America, ~~characterised by the widespread adoption of steel, concrete, and glass (Lucchi, 2023)~~ and proliferated globally (Lucchi, 2023). To account for the global impact of World War II and the rapid urbanisation of recent decades, the 20th century is divided into two periods. Buildings constructed before the 20th century are categorised to include vernacular architecture and local practices, which utilized regionally distinct materials and techniques. Finally, the 21st century is distinguished to capture contemporary concerns in architecture, such as sustainability and the revival of traditional practices. To encompass diverse historical and architectural contexts, the following broader construction period categories are selected:

- Before the 20th century.
- First half of the 20th century.
- Second half of the 20th century.
- 21st century.

These categories enable the inclusion of diverse architectural traditions while minimising the need for highly specialised local expertise from respondents. Although they are less specific to any single national context, they provide a pragmatic framework for comparative architectural analysis across different regions.

To account for potential changes in building envelope insulation levels, an *insulation thickness* variable has been introduced in the descriptive data for each decade starting from 1970, when increased attention started to be given to building thermal efficiency. ~~This strategy simplified the building construction period classification, making it easier for non-experts to respond to the survey, while allowing experts to provide more detailed input on insulation levels.~~

**Household income level**

Socio-economic factors could have a marked influence on building construction practices especially in countries with a low average income level. A study addressing multiple factors associated with housing material inequality in low and middle-income countries, revealed that factors such as wealth quintile (poorest, poorer, middle, richer and richest), and building environment (rural or urban) have an important influence on housing characteristics in most low and middle-income countries (Morakinyo, Fagbamigbe, Adebowale, 2022). Other studies reinforce significant differences in building characteristics according to household income level (Daly, 2021; Wells and Harris, 2007; Gooding, 2016). Therefore, household income level was incorporated as a variable ~~in the survey~~ for residential buildings. The three following categories, low, medium, and high income, specific to the country of the building under consideration, are distinguished.

**Building environment**

The building environment can significantly influence construction practices, impacting materials and building design. Strong differences in building characteristics for urban or rural environments have been found by Sun et al. (2023) and Wang et al. (2024). Rural areas, characterised by lower population densities, may use traditional, locally sourced materials and building construction practices can more strongly correlate with socioeconomic factors. Urban, high-density areas typically employ standardised, large-scale construction and adhere to modern building regulations. To account for these differences, the following building environment categories are included ~~in the survey~~: rural, urban or both.

**Building occurrence frequency**

Data on building frequency within a given location was collected to indicate the prevalence of specific building typologies. This helps to evaluate the representativeness and generalizability of those building typologies, reducing the risk of overgeneralization from atypical or uncommon buildings, which may be disproportionately recalled due to their distinctive nature. The variable is categorised into three groups: very common, somewhat common, uncommon.

### 3.2 Building descriptive data

Buildings exchange sensible heat with the environment through radiation, conduction, and convection. They also store sensible heat in their thermal mass. Anthropogenic heat, for example due to temperature control systems, electrical appliances, or cooking, is released inside buildings. Equation 1 shows the sensible heat balance of a single zone building (Senave, 2019; Fig. 3).

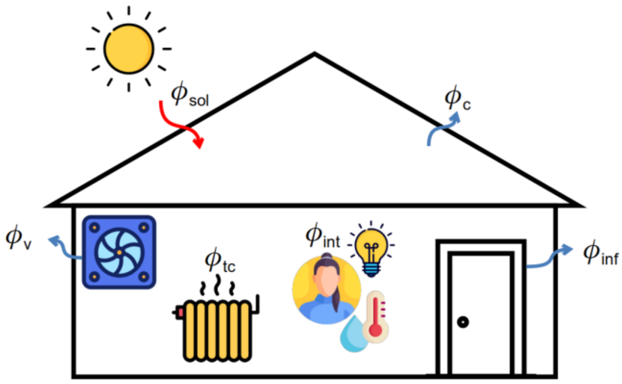


**Figure 3: Heat fluxes in single zone building heat balance.**

$$C \times \frac{\partial T}{\partial t} = \phi_{tc} + \phi_{int} + \phi_{sol} + \phi_{v} + \phi_{inf} + \phi_{c} \qquad (1)$$

Where:

− *T is the average interior temperature of the zone (K);*

− *C is the effective heat capacity of the zone thermal mass (J/K);*

− $\phi_{tc}$ *is the sensible heat flux from temperature control systems (W);*

− $\phi_{int}$ *is the internal heat gain (W);*

− $\phi_{sol}$ *is the solar heat gain (W);*

− $\phi_{v}$ *is the sensible heat flux due to ventilation (W);*

− $\phi_{inf}$ *is the sensible heat flux due to infiltration through the building envelope (W);*

− $\phi_{c}$ *is* the heat transfer due to conduction through the building envelope (W).

Tab.~~le~~ 2 shows how the parameters in Eq. 1 are related to the building materials and temperature control systems and how they have been translated into non-technical ~~survey~~ questions for the survey (~~presented in s~~Sect~~ion~~. 4). For example, wall and roof colour have been used as a proxy for the physical parameters albedo and emissivity.

Once identified, continuous variables, such as the wall and roof colour, insulation thickness, glazing ratio, and perceived air infiltration, are categorised into discrete ranges. This categorisation addresses the trade-off between data granularity and respondent accessibility. Although finer-grained data would have provided more detailed insights, it could have increased respondent burden and hindered data collection among non-specialists. Therefore, broader categories were chosen to optimise data collection. Another restriction of our database is that vegetated roofs and facades are not considered, because such green buildings are not representative buildings at city scale, and even more at country scale.

Table 2 - Conversion between physical parameters relevant to the building sensible heat balance and the building descriptive variables in the survey.

| **Heat balance parameter** | **Building typology related ?**<br><br>**If yes, which physical parameters are researched and what is their link with the UHI?** | **Adaptation to non-technical language style and associated survey questions** |
|---|---|---|
| C | The volumetric heat capacity of the building envelope depends on the roof and wall materials and their thickness. The storage of heat in the building materials during the daytime and its subsequent release during the nighttime is a crucial process for the UHI. | - Wall materials and thickness<br>- Roof materials and thickness<br>- Insulation materials and placement if any |
| $\phi_{tc}$ | The heat release from heating and air conditioning systems can be the dominant part of the anthropogenic heat flux. Depending on the season and city type, the anthropogenic heat flux can be an important contribution to the UHI. | - Presence of heating or cooling systems |
| $\phi_{int}$ | The internal heat gains are primarily driven by occupant behavior (e.g., appliance use, lighting). They are not directly related to the construction practices, but rather to building use. Therefore, these parameters are excluded from the survey. | Not included |
| $\phi_{sol}$ | The window solar gains can influence the heat storage in the building materials, and the anthropogenic heat release due to heating and air conditioning. | - Share of windows on the facade<br>- Presence and type of shading |
| $\phi_{v}$ | The ventilation flow rates can influence the anthropogenic heat release due to heating and air conditioning. | - Possibility of opening windows<br>- Presence of mechanical ventilation |

| | | |
|---|---|---|
| $\phi_{inf}$ | The air infiltration rate that is governed by the building's air tightness can influence the anthropogenic heat release due to heating and air conditioning. | - Perception of air drafts with closed windows and door |
| $\phi_c$ | The conductive heat flux through the building envelope depends on the solar reflectivity and terrestrial radiation emissivity of the wall and roof cover materials and the thermal resistance of the building envelope. | - Insulation presence<br>- Wall insulation thickness range<br>- Roof insulation thickness range<br>- Wall insulation evolution over time<br>- Roof insulation evolution over time<br>- Color tone of wall surfaces<br>- Wall main material<br>- Roof cover material<br>- Window glazing type |

## 4 Survey

### 4.1 Survey distribution

A dedicated survey was designed to gather the information on building archetypes and corresponding descriptive data (described in ~~s~~Sect.~~ion 3~~ 3 and Fig.~~figure~~ 2) for many countries in the world.

To maximise global reach and data quality, Zoho Forms was selected as the survey platform due to its global accessibility, multilingual support, ability to include photographs and to implement branching logic. These are crucial for ensuring broader comprehension among a diverse public. Branching logic streamlined the user experience by presenting only relevant questions and answer categories, optimising data collection efficiency and avoiding irrelevant inquiries. While questions related to the main building typology were mandatory for clear identification, the other questions were made optional. This strategy was intended to prevent respondent discouragement due to questions for which they do not know the answer, leading to higher completion rates, even with some incomplete data for certain questions.

The survey was translated from English into ten languages (Arabic, Chinese, French, German, Indonesian, Japanese, Portuguese, Russian, Spanish, and Swahili), with native speaker verification for each. These languages were strategically chosen for maximum global accessibility, considering the number of speakers and the number of countries in which they are official languages. Photographs were also included to enhance comprehension, particularly for non-native speakers. The English version of the survey is detailed in Tab.~~le~~ A1, Appendix A.

The survey dissemination relied on multiple complementary channels to ensure broad international coverage while engaging qualified respondents. The following actions were implemented to promote participation:

- **Distribution via the Météo-France mailing list**: the survey was shared through the mailing list of Météo-France, targeting a local network of researchers and employees.
- **Distribution to participants of the International Meeting on Statistical Climatology (IMSC)**: the survey was shared with international attendees of the IMSC, held at Météo-France.
- **Distribution via the International Association for Urban Climate (IAUC) mailing list**: the survey was disseminated through the mailing list of the IAUC. This initiative aimed to reach a global community of researchers and professionals engaged in urban climate studies.
- **International network outreach**: the survey was disseminated through the first author's international academic and professional networks, using a direct and personalized outreach. This approach expanded geographic coverage and integrated valuable local knowledge from nationals in diverse countries. While accessible to a wide audience, this strategy primarily targeted individuals with postgraduate education.
- **Targeted LinkedIn outreach for underrepresented regions** (2024-11-15): this strategy complemented the outreach by identifying countries with no responses and directly contacting architects and civil engineers from leading universities in those regions. This approach engaged qualified professionals in underrepresented areas, improving both the global coverage and quality of the survey data.

The largest share of responses resulted from international network outreach (38%), which facilitated geographically diverse participation and incorporated local knowledge from nationals across multiple countries. Targeted outreach via LinkedIn (28%) further addressed geographic gaps by identifying countries with no initial responses and directly contacting architects and civil engineers affiliated with leading universities, thereby improving representation in underrepresented regions. Dissemination through the mailing lists of the IAUC (22%), Météo-France (4.2%), and participants of the IMSC (1.9%) primarily reached researchers and professionals specialized in climate-related fields. Overall, the survey predominantly attracted respondents with higher education and technical expertise, supporting informed assessments of architecture, engineering, and climate-sensitive building characteristics, yet its design and accessibility also enabled non-experts to provide meaningful contributions.

### 4.2 Overview of the responses

The survey was conducted from August 6, 2024, to May 24, 2025. During this period, the survey page received 2,933 visits, resulting in 521 responses from 141 countries. Of these, 272 responses came from participants with backgrounds in architecture, civil engineering, or climatology, representing 100 countries. Fig.~~ure~~ 4 shows some pictures of described building typologies in different countries and Fig. 5 shows the percentage of described buildings per continent.


**Figure 4: Example of described buildings in different countries: a) LR in the Republic of the Congo (photo by Rolains Elenga), b) LR in Australia (photo by Henrique Rossi), c) HR in China (photo by Sun Rui Ze), d) LR in Belgium (photo by Sara Top), e) LR in Kenya (photo by Valéry Masson), f) LR in Canada (photo by Nubia Rezende), g) HR in Tajikistan (photo by Osim Jon), h) MR in Argentina (photo by Natalia Vergara), i) LR in Luxembourg (photo by Robert Schoetter), j) LR in Finland (photo by Minttu Havu), k) LR in Brazil (photo by Ana Luíza Araujo).**

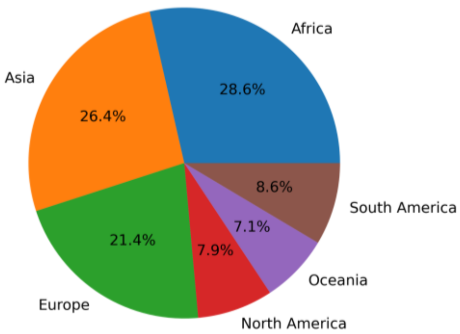


**Figure 5: Percentage of survey responses per continent.**

The distribution of survey responses across building use and form was uneven, with some combinations well represented and others lacking sufficient data. Tab.~~le~~ 3 shows the total number of responses per building use and form. From the total number of responses, 80% concern buildings of residential use, and 20% all other building uses combined: commercial, industrial and offices.

*Table 3 - Number of survey responses per building use and form.*

| Building use \ form | Low-rise | Mid-rise | High-rise | Large low-rise | Total |
|---|---|---|---|---|---|
| **Commercial** | 0 | 17 | 12 | 26 | 55 |
| **Industrial** | 0 | 0 | 0 | 14 | 14 |
| **Offices** | 0 | 19 | 11 | 4 | 34 |
| **Residential** | 236 | 128 | 54 | 0 | 418 |
| **Total** | 236 | 164 | 77 | 44 | 521 |

Figs.~~ures~~ 6 and 7 illustrate respectively the number of survey responses for residential and for combined non-residential buildings. The collected data yielded substantial global coverage for residential building typologies, particularly for LR forms. However, even by combining all non-residential building uses, sufficient global coverage was not achieved. These findings prompted the provision of country-level data for residential buildings, while offering global typologies for non-residential typologies.

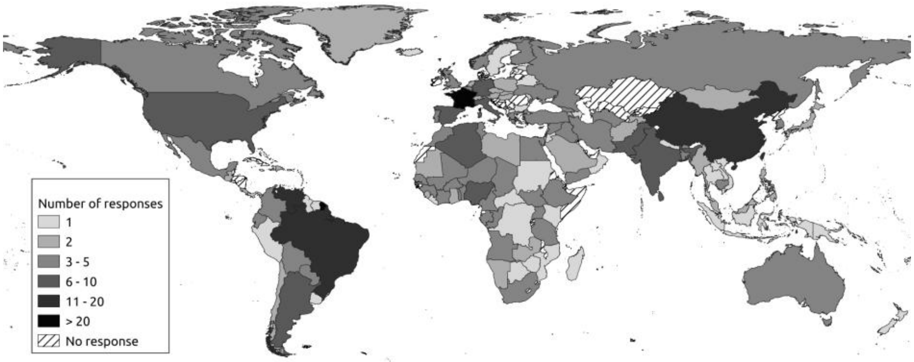


**Figure 6: Number of survey responses for residential buildings per country.**

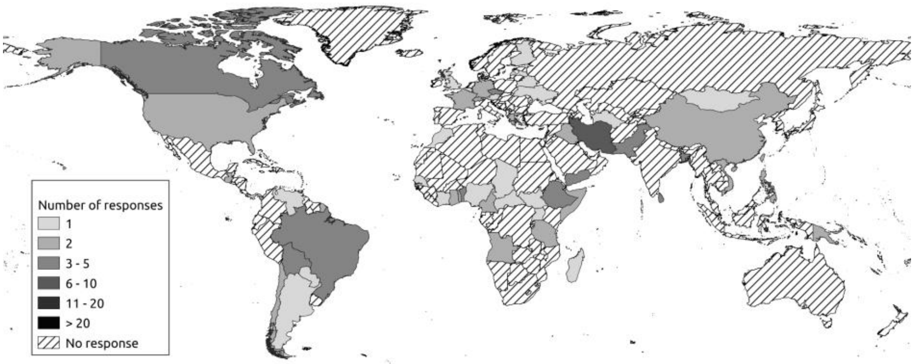


**Figure 7: Number of responses for non-residential buildings per country.**

Tab. 4 demonstrates the substantial expansion of the geographical evidence base achieved by the present survey compared with Jackson et al (2010). While Jackson et al. (2010) provides particularly detailed coverage for North America, its representation is more limited across several other continents. This analysis considers the standard continent definition, where Central America is part of North America. The present survey broadens this coverage substantially, with data available for 115 territories for low-rise (LR) buildings and 76 for mid-rise (MR) buildings, distributed across all continents. The expansion is especially pronounced in Africa and Asia, where the survey provides LR data for 38 and 28 territories, respectively, compared with 5 and 7 territories represented in Jackson et al., and also contributes substantially to MR coverage. Additional values are provided for South America and Oceania, further improving the geographical balance of the database. For high-rise (HR) buildings, coverage remains more limited, with survey data available for 28 territories, reflecting the greater scarcity of detailed information for this building form.

*Table 4 - Number of territories per continent with survey data by building form, and number of territories with data in Jackson et al. (2010).*

| *Continent* | *Territories with one or more survey response, by building form* | | | *Territories in Jackson et al. (2010)* |
|---|---|---|---|---|
| | *LR* | *MR* | *HR* | |
| *Africa* | *38* | *13* | *4* | *5* |
| *Asia* | *28* | *23* | *13* | *7* |
| *Europe* | *19* | *26* | *5* | *5* |
| *South America* | *11* | *7* | *5* | *3* |
| *North America* | *10* | *6* | *1* | *11* |
| *Oceania* | *9* | *1* | *0* | *2* |
| *Total* | *115* | *76* | *28* | *33* |

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## 5 Data quality and completion

This section outlines the process of transforming survey data into a uniform database, aiming for a consistent level of information across the countries. It begins with analyzing survey response agreement and correcting descriptive variables where necessary (Sect. 45.1). Then, a unique description is selected for each building typology with multiple responses (Sect. 45.2), followed by a comparison of this unique description with external databases (Sect. 54.3). Finally, gaps in country-level information are addressed using additional data sources and assumptions (Sect. 54.4). These methodological steps, specifically applied to residential buildings, are elaborated upon in the subsequent sections.

### 5.1 Agreement and correction of responses

In cases where multiple responses were submitted for the same building typology, the consistency of descriptive variables across respondents was assessed. Specifically, survey responses corresponding to the same set of typological variables were examined to determine whether they produced similar outcomes. Cohen's Kappa (for two responses) and Fleiss' Kappa (for more than two) are used to assess the reliability of agreement among survey responses. Both measures quantify the extent to which ~~whether the degree of~~ agreement between survey responses ~~is in~~ exce~~s~~eds ~~over that which~~ what would be expected by chance (~~, according to the~~ Eq. 2, ~~(~~Landis & Koch, 1977)~~:~~.

$$k = \frac{Po - Pe}{1 - Pe} \tag{2}$$

Where Po represents the observed agreement and Pe represents the expected agreement if random judgment. Tab.~~le~~ 4 presents the results of these measures of agreement, where N is the number of typologies analysed with more than one response and non-null values for the analysed variable.

*Table 4 - Cohen's and Fleiss' kappa measures of agreement among responses.*

| *Variable* | *Cohen's kappa* | | *Fleiss kappa* | |
|---|---|---|---|---|
| | *N* | *k* | *N* | *k* |
| *Wall material* | *51* | *0.46* | *28* | *0.44* |
| *Roof material* | *53* | *0.62* | *27* | *0.47* |
| *Window share* | *51* | *0.51* | *25* | *0.22* |

All agreement levels exceed what would be expected by chance, with most variables showing moderate agreement according to Landis and Koch (1977). Fleiss' Kappa for window share is lower, likely due to a higher probability of chance agreement stemming from the concentration of responses in the "Many windows" category (survey variable categories are presented in Appendix A), which accounts for 69% of responses for this variable. The strict requirement for exact matches, despite the ordinal nature of the variable, also contributes to this score. These findings suggest that responses are not random, supporting the reliability of the survey while also reflecting natural variation in architectural practices across similar typologies.

A thorough plausibility check of the survey responses led to the removal of unreliable entries and the correction of others. These checks addressed inconsistencies such as the use of modern materials in pre-industrial buildings, HVAC systems or insulation not aligned with climate zones (based on the Köppen-Geiger classification), and mismatches between roof materials and slopes. Window and glazing data were revised based on open-ended responses and visual verification when necessary. Additionally, general comments submitted by respondents informed targeted corrections to variables. Details on the plausibility checks and on the calculation of agreement levels are available in the intermediate data files of the data repository (de Carvalho Araujo et al., 2025).

### 5.2 Choice of a representative typology per building form and use

In order to integrate the collected data into a GIS database, it is essential to ensure consistency in the quantity and regularity of the data across different countries. In some countries, multiple responses were obtained for a given building typology. For instance, in France, 25 responses were recorded for LR and MR buildings, whereas in other countries, only a single survey response was available for LR buildings. To maintain a uniform level of information across countries, a single representative set of descriptive variables was selected for each building typology .

To select one description for a building typology for a specific country, form, and use, selection criteria prioritised the majority categories of each variable and the level of representativeness of each individual survey response. When no clear majority existed, representativeness was evaluated through a combination of variables, favouring buildings described as *very common* over those described in the survey as *uncommon*. Additional criteria guided the decision process for the least representative categories, in descending order of influence: subnational data scale, high social level, rural buildings and period of construction predating the 20th century. If these criteria were still equivalent, the respondent's professional background in architecture or civil engineering was considered, as 33% of participants reported such expertise, assumed to indicate higher data quality. Finally, if equivalence persisted, responses with fewer empty columns were favoured, and in cases of complete parity, the earliest submitted response was chosen.

In some instances, the available descriptions did not fully reflect the broader building stock. For example, responses might describe only modern buildings with thermal performance superior to the national average or an atypical building. In such cases, a review of the literature was conducted to adjust specific variable values and improve alignment with the typical characteristics of the building stock, and a flag was specified for these cases as manual corrections (Sect. 5.4)~~.~~.

### 5.3 Comparison with external databases

Data from the Tabula and World Housing Encyclopedia external data sources at the country level are used to compare the residential building typologies provided by the survey. The Tabula database describes different building typologies for twenty-one European countries and is dedicated to improving the estimation of energy consumption in the European building stock (IEE, 2012). In each country, the building typologies are classified according to period of construction and form. The period classes can vary according to the construction specificities in each country.

The Earthquake Engineering Research Institute (EERI) World Housing Encyclopedia (WHE) served as another external data source. Developed as part of the United States Geological Survey Prompt Assessment of Global Earthquakes for Response (USGS PAGER) project (2007-2011), WHE is an initiative designed to enhance the understanding and classification of global construction types (Greene & D'Ayala, 2010). It describes residential buildings across 46 countries in the seismically active areas of the world. In the context of the present work it is used to derive wall and roof cover materials based on the report's descriptions and window share based on the report's pictures. However this database does not provide parameters on building thermal properties, such as the envelope insulation characteristics.

The analysis focused on three variables available in all datasets: exterior wall material, roof cover material, and window share. For each building typology, the value of these variables was compared between the survey and the external database. This required compiling relevant information from representative Tabula and WHE reports into a comparative table, which was then evaluated against the survey data.

WHE reports often provide comprehensive information on materials but may lack clear specifications regarding representativeness. Furthermore, the database's emphasis on earthquake-vulnerable buildings may not align with a country's most representative building typologies. To address this, selection criteria consistent with those used for the survey responses were applied. Reports explicitly indicated as common to the entire country or those not designated as at subnational scale or in rural areas were prioritised. In cases where multiple rural or subnational reports presented consistent values (e.g., in accompanying charts), all such reports were retained. Any reports not meeting these criteria were excluded. Following this selection, materials specified for walls and roofs were examined. If multiple options were presented, all were included in the comparison. In instances where only "masonry" was specified for walls without further detail, "brick" was assumed as the material. Window share was deduced from the provided report photographs.

For Tabula, no filtering of reports was required, as their typologies are already considered representative. Given Tabula's objective of estimating energy consumption, it provides information on insulation (e.g., U-value, insulation thickness) and heating systems. While material information is often indicated, it is not consistently present. For walls, if the material was not explicitly stated, attempts were made to identify exposed brick from accompanying photographs. If information remained unavailable or indiscernible from images, that variable was then excluded from the comparison. For roofs, since the database mainly provides structural rather than covering materials, images were used to identify roof coverings based on color, form, and texture. For flat roofs, "gravel" and "concrete" were assumed as potential materials. For sloped roofs, color and texture guided identification: red roofs were associated with tiles, while darker roofs, depending on texture, were categorised as asphalt, slate, or metal. If identification was not possible through this examination, the roof cover material variable was excluded from the analysis.

The results of the comparisons with both external databases are presented in Tab.~~le~~ 5. All the compared variables showed an agreement of at least 50% with most of them ranging above 70%. The degree of agreement is satisfactory, especially given the differing purposes of the external databases and the present database. However, these results should be interpreted with caution, as the external databases were not developed for the purpose of urban climate modelling. The WHE database focuses mainly on seismic risk whereas Tabula focuses on residential building energy consumption. Therefore, a mismatch between our database and these external databases can be expected. ~~other objectives and likely contain non-exhaustive building lists focused on typologies relevant to their original contexts.~~ Despite these limitations, the methodology intended to maximize the use of the available information.

*Table 5 - Agreement levels between external databases and the survey data.*

| Building form | External database | Exterior wall material agreement | Roof cover material agreement | Window share agreement |
|---|---|---|---|---|
| LR | Tabula | 73 % | 75 % | 67 % |
| | WHE | 67 % | 50 % | 71 % |
| MR | Tabula | 67 % | 73 % | 100 % |
| | WHE | 77 % | 85 % | 92 % |

To assess data coverage, the availability of Tabula and WHE data alongside the survey data is presented in ~~the~~ Appendix B for LR (Tab. B1) and MR (Tab. B2) buildings for WHE and Tab. B5 for Tabula. Locations where both the external database and the survey data were available were used in the above comparison. For locations where external database data were available but survey data were missing, the external data were used to fill the gaps. The following section outlines the methodology used to complete the missing data.

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**5.4 Filling missing data**

To avoid overgeneralization based on too-sparse survey responses, some variables are not included in the database. For example, variables describing insulation details, such as the position of the insulation and the evolution of wall and roof insulation thickness over time, exhibit response rates below 10%.

Other variables are excluded because it is assumed that the survey questions may have been misunderstood or that the responses are not consistent. For example, survey responses related to air infiltration are difficult to analyse, as they likely reflect respondents' perceptions rather than objective measurements. Another example concerns the reported presence of mechanical ventilation systems, defined here as central systems designed to regulate air exchange with the external environment, did not follow expected patterns and may have been misinterpreted by respondents. In several countries where air tightness is not a regulatory priority, the formulation of the question and the respondents' prior knowledge may have led to confusion between mechanical ventilation systems and simpler devices such as individual fans. As a result, responses related to air tightness and mechanical ventilation were excluded from the analysis.

All descriptive variables, excluding those previously mentioned, are retained in the final data, with missing data completed as described in this section. Different actions were taken to complete the data based on their nature and the availability of information. Preserving the original survey data was a priority; however, modifications were made when the original data appeared clearly implausible.

Variables are classified by nature—structural, fenestration ~~lighting~~, or thermal—to tailor missing data completion strategies to relevant data sources. Structural variables include the main wall material, its exterior color (which may be inherent to the material if no paint is applied), the roof slope and cover material. Fenestration~~Lighting~~ variables comprise the window share and the types of solar shading used. Thermal variables encompass the presence of insulation, the thickness of wall and roof insulation, the temperature control system and the window glazing type.

The Tabula and WHE data sources provide country-level information and are used to fill in missing values. Tabula often provides information on all variable categories, either through building descriptions or accompanying images. For insulation characteristics derived from Tabula, buildings constructed in the 1990s are used as the reference. WHE data is primarily used to obtain structural variables from report descriptions and fenestration ~~lighting~~ variables from report images, as thermal variables are generally not covered in WHE reports.

For variables with low variability in survey responses, a default-value imputation method was applied. This was particularly the case for HR buildings, which exhibited less diversity in structural variables across the survey responses. Consequently, a default combination, concrete walls in light tones and a flat concrete roof, was defined for all HR buildings. For fenestration~~lighting~~ variables, both HR and MR buildings are assumed by default to have "many windows," as this was by far the most frequently selected category in the survey responses.

In general, thermal variables are linked to a building's location and a country's thermal regulations. For this reason, if information for a thermal variable was available for one building form (e.g., LR) within a country but missing for another (e.g., MR or HR), the available data was imputed to the missing forms.

A key step in defining the thermal variables was completing the "presence of insulation" variable, which guided the assignment of other variables. In this endeavor, the World Map of Köppen-Geiger Climate zones (Peel, Finlayson, and Mcmahon, 2007) is used as a reference for climate zones. The 'BWk', 'Dfa', 'Dfb', 'Dfc', 'Dfd', 'Dsa', 'Dsb', 'Dsc', 'Dsd', 'Dwa', 'Dwb', 'Dwc', 'Dwd', 'EF', and 'ET' zones are assumed to represent cold climates, whereas the 'Af', 'Am', 'As', and 'Aw' are assumed to represent hot climates. It was then assumed that buildings without any data in cold climate countries are insulated, while those in hot climate countries are not. Following the delineation of insulation zones, buildings in insulated areas are assumed to have heating systems and double-glazed windows, whereas those in non-insulated zones are presumed to have single-glazed windows and no heating system.

Regarding insulation characteristics, two additional variables, representing the evolution of insulation thickness over time (insulation period) for walls and roofs, are not included in the final dataset but were used to complete missing data. For records lacking wall or roof insulation thickness, values were imputed based on available data for insulation periods, with priority given to insulation levels from the 1990s, followed by the 2000s, and then the

1970s–1980s. This approach is grounded in survey observations showing that general wall insulation thickness and its temporal evolution correspond most closely to values from the 1990s, making these values a reasonable approximation for overall wall insulation levels.

A last step of missing data completion was to attribute values from another country in the same region. This involves two main aspects: defining the region limits and choosing an appropriate neighboring country with available data. Initially, the regions considered are based on the Jackson et al. (2010) ~~GDUBP~~ database regions, which were defined to describe similar building typologies and practices. In case no data is available within the region, other neighboring countries are considered, this could be especially important for large countries that are the only country in a Jackson et al. (2010) ~~GDUBP~~ database region.

A data provenance flag is provided ~~defined~~ to highlight the sources used to complete the database information:

- **S: Survey** - The data was obtained from the corrected and aggregated survey responses.
- **V: Inferred from another variable** - Data completed using other related variables from the same survey response. This strategy was applied to temperature control systems and insulation thickness.
- **T: Tabula** - Data sourced from the Tabula database. This imputation strategy was applied uniformly across all variables.
- **W: WHE** - Data sourced from the World Housing Encyclopedia. This imputation strategy was applied to structural and fenestration~~lighting~~ variables, as no thermal variables were provided.
- **D: Default** - The data has been completed using default values. This strategy was applied to ~~window share in~~ MR buildings (when no other imputation method was successful the most frequent value was attributed) and to structural and fenestration variables~~fenestrationlighting variables~~ in HR buildings (see Appendix E).
- **F: Urban Form** - The data has been derived from buildings with other forms (LR, MR, HR) within the same country where survey data was available. This strategy has been applied to complete missing thermal variables across all building forms and window share only in HR buildings.
- **C: Climate** - The data has been completed using assumptions based on the climate zone. This strategy has been applied specifically for the variable presence of insulation.
- **I: Insulated** - Thermal variables have been completed with default values according to the building's final insulation status.
- **R: Region** - Missing data was filled using values from a neighboring country within the same region (Jackson et al. (2010)~~GDUBP~~ or climatic). This approach was applied to most variables.
- **M: Manual corrections** - In cases where gaps remained after all previous treatments, or when a value required adjustment, manual corrections were applied punctually.

The specific treatment given to each group of variables is documented in the *Detailed methodology for completing data*, included in the intermediate data of the data repository (de Carvalho Araujo et al., 2025). Details on the share of each variable per percentage of countries and population are presented in Appendix E. Fig.~~ure~~ 8 illustrates the diverse data sources and methodologies used to complete information on temperature control systems, with each color representing a different strategy for handling missing data.

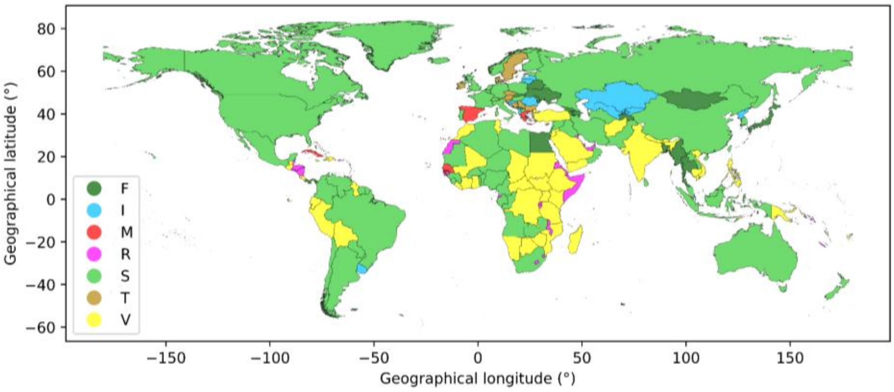



**Figure 8 - Flag of data sources for temperature control systems in low-rise residential buildings.**

In some countries across all continents, survey data (S) is available. Much of Africa, India, Southeast Asia, and parts of South America rely on inferred values estimated from the presence of other related variables (V). Specifically for the temperature control system, it was noted that no respondent selected the 'None' category. However, many answered preceding questions on air tightness and mechanical ventilation, indicating they were engaged with the survey but likely did not consider the temperature system relevant, as it is uncommon in their region. In these cases, the temperature system was assumed to be 'None' despite the missing response.

In some countries across Europe, Asia, and Africa, temperature control system data is derived through form-based extrapolations (F), using information from similar building types within the same country. Some European countries benefit from localised data sourced from the Tabula building database (T). In areas like Central Asia and scattered regions elsewhere, default values are assigned based on insulation presence (I). Small regions apply regional estimates (R) by borrowing data from neighboring countries with similar climates, this extrapolation may be less reliable given the potential differences between countries even within similar climate zones. Finally, only a few countries required manual corrections (M). This reflects disparities in data source, which can influence the reliability of the provided information. The maps of data source flags for all variables are available in the data repository (de Carvalho Araujo et al., 2025).

**6 Building typologies**

Following the completion of all variables for residential building typologies, a geographical analysis has been conducted to study their spatial distribution across the globe. These analyses for all residential building forms, variables are provided in the Appendix C (Figs. C1 to C3) and in the data repository (de Carvalho Araujo et al., 2025), where the corresponding tabular and GIS data can also be found. Selected geographical maps of residential buildings variables are presented in Sect. ~~5~~6.1 and Sect. ~~5~~6.2. Sect.~~ion~~ ~~5~~6.3 shows the global typologies for non-residential buildings. The proposed relationships between selected ~~certain~~ variable categories and physical parameters are presented in Appendix D (Tabs. D1 to D5).

**6.1 Structural variables in residential buildings**

Figs.~~ures~~ 9 to 12 display the global distribution of principal wall and roof materials for LR and MR buildings. The results for HR buildings are not displayed since their construction materials are considered homogeneous.

Fig.~~ure~~ 9 illustrates the global distribution of exterior wall materials in LR buildings. Fired brick and concrete are the most common materials, accounting for 52% and 32% of all countries, respectively. Fired brick is widely distributed worldwide, while concrete is notably prevalent in North Africa, parts of Sub-Saharan Africa, Central Asia, and various European countries. Wood predominates in forested, colder regions, accounting for 8% of countries. Earth construction is concentrated in arid or traditionally built environments, representing 7% of countries. Conversely, metal and stone are rarely identified as the primary wall material in any country.

The prevalence of concrete in African low-rise buildings should be interpreted in the context of the database's focus on urban typologies. While traditional and vernacular construction often relies on earth, stone, and other locally available materials, rapid urbanization has increased the use of concrete in African urban centres. The results therefore primarily reflect contemporary urban building typologies rather than the full diversity of rural and traditional construction

Fig.~~ure~~ 10 shows the geographical distribution of roof cover materials. It appears to be significantly influenced by local climate, material availability, traditional construction practices, and Gross Domestic Product (GDP). Metal, concrete, and clay tiles emerge as the most widespread roof cover materials globally, accounting for 31%, 27%, and 23% of countries, respectively.

A high prevalence of concrete is particularly noticeable in North Africa and the Middle East. Asbestos, in both its natural and colored forms, remains a common building material in several countries, primarily in Southeast Asia, Central America, and isolated areas of West Africa, collectively representing 13% of all countries. Asphalt shingles are predominantly found in colder climate countries, constituting 4% of the total. Thatched roofs, accounting for 2% of countries, are prevalent in regions with traditional building practices or where rural typologies are considered dominant, specifically in certain African nations. Earth and slate were not frequently identified as the majority roof cover material in surveyed countries.

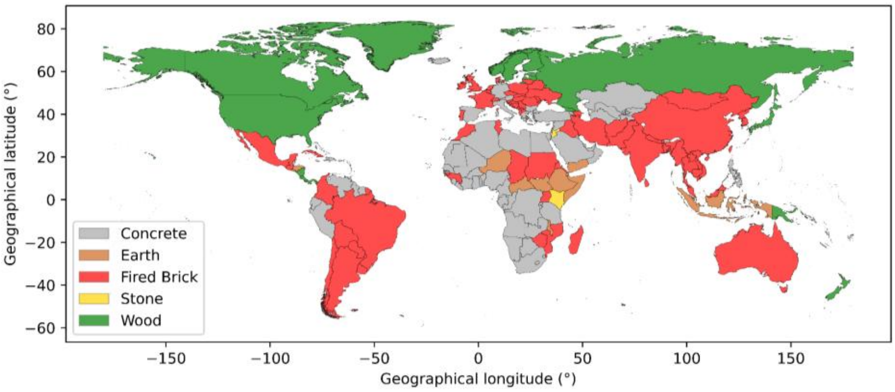



**Figure 9 - Wall material in low-rise residential buildings.**

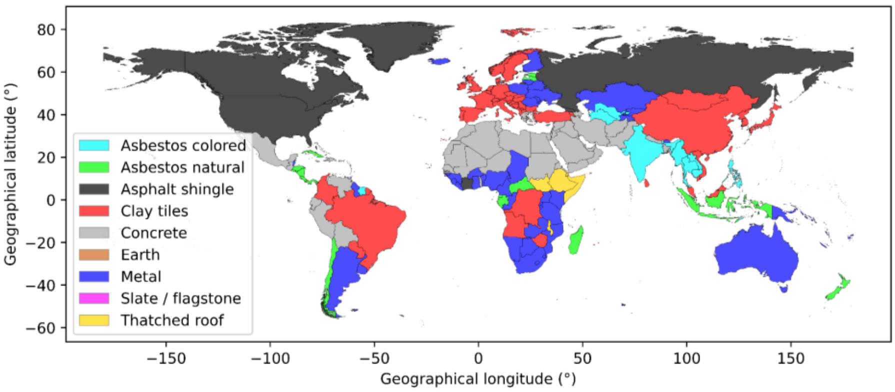
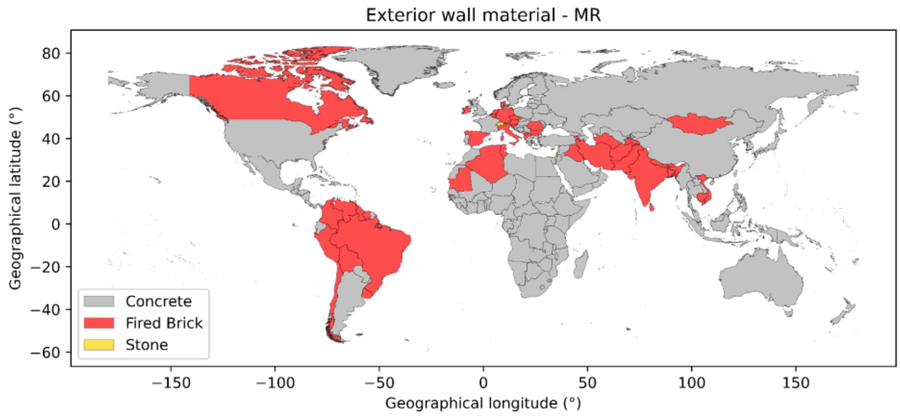



**Figure 10 - Roof cover material in low-rise residential buildings.**

Fig.~~ure~~ 11 indicates that MR buildings exhibit less variability in wall materials than LR buildings, primarily utilising concrete (71%) and fired brick (28%). This is likely because MR buildings require stronger, more uniform materials to support greater loads and meet stricter codes. Fig.~~ure~~ 12 shows a similar pattern for roof materials, with MR buildings presenting less variability than LR buildings. Concrete is the predominant roof cover material for MR buildings globally, accounting for 78% of countries. It is distantly followed by metal at 9% and clay tiles at 8%.

Colored asbestos is primarily observed in African countries, a pattern potentially influenced by the regional data completion methodology and the lower abundance of MR building data compared to LR buildings in those regions. Additionally, it appears sporadically in other areas, with all forms of asbestos combined representing only 4% of countries. Other roof cover materials are present in negligible amounts on a global scale for MR buildings.



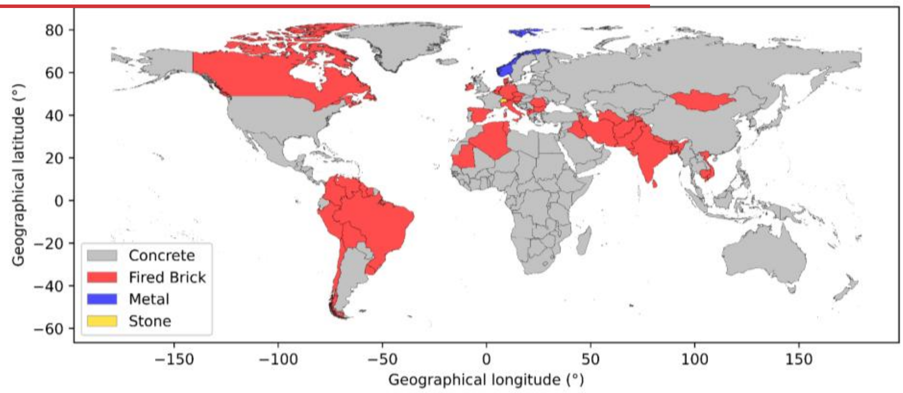
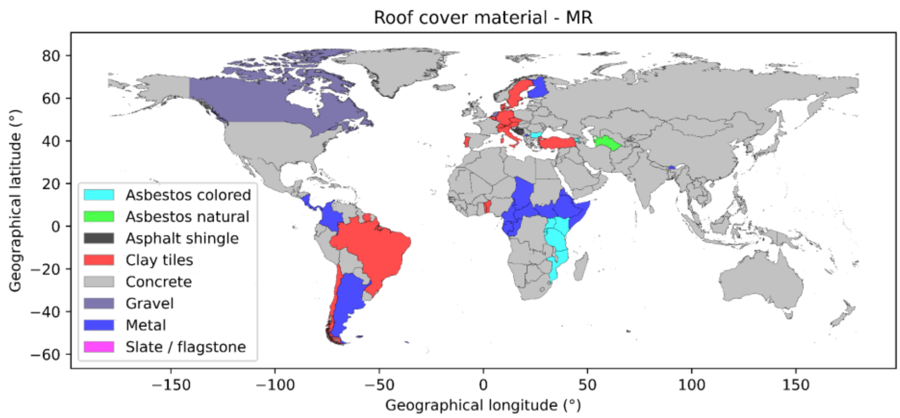




**Figure 11 - Wall material in mid-rise residential buildings.**



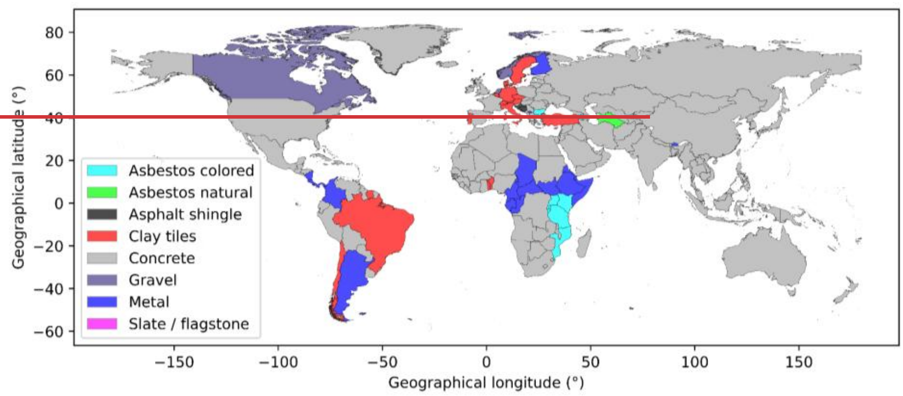



**Figure 12 - Roof cover material in mid-rise residential buildings.**

A specific verification in Tunisia, using data from Mhedhbi (2019), confirmed the findings of this research; both LR and MR buildings in Tunisia are predominantly constructed with fired brick for their walls. Regarding exterior wall color, Mhedhbi (2019) reports that both LR and MR buildings are white, whereas in the present data, LR buildings are also white, but MR buildings are described as having light tones.

### 6.2 Thermal and fenestration~~lighting~~ variables in residential buildings

Figs.~~ures~~ 13 to 16 display the global distribution of selected thermal and fenestration ~~lighting~~ variables in LR buildings.

Fig.~~ure~~ 13 illustrates the global distribution of temperature control systems in LR residential buildings, along with the presence of insulation, revealing clear climate-driven patterns. As expected, heating systems dominate in colder regions, while air conditioning~~cooling~~ systems are prevalent in warmer tropical and subtropical areas, patterns that partly reflect the assumptions made in the data completion strategies.

Temperate climate zones are frequently characterised by the presence of both heating and air ~~cooling~~ conditioning, reflecting seasonal temperature variability. Similarly, some partially tropical countries with mountainous regions exhibit heating or mixed systems due to local cooler climates. Regions without any formal temperature control systems are found in parts of Africa, Asia, and Central and South America, likely reflecting either mild climates or limited technological access. It is important to recognise that the presence or absence of temperature control systems goes beyond building typology, reflecting a complex interplay of climate conditions, cultural norms, and economic factors. While this figure offers a useful general overview, significant variation may also occur within a single country, particularly where altitude or regional climates diverge from national averages.

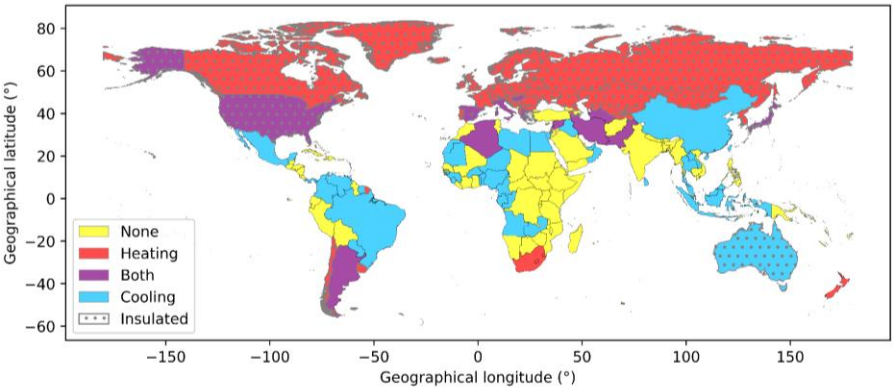



**Figure 13 - Temperature control systems and insulation presence in low-rise residential buildings.**

Fig.~~ure~~ 14 shows the global distribution of window glazing types in LR residential buildings. Double glazing dominates colder regions, while single glazing is more common in moderate and warm climates. In hot, arid parts of central Africa, areas without glazing appear, likely for ventilation purposes. The observed alignment between insulated buildings and double-glazed windows is partly influenced by the data completion methodology: where glazing data was missing, double glazing was assigned to insulated countries and single glazing to non-insulated ones, based on typical patterns from surveyed regions. While this approach supports existing climate-based patterns, it also means that part of the observed distribution reflects the imputation strategy itself.

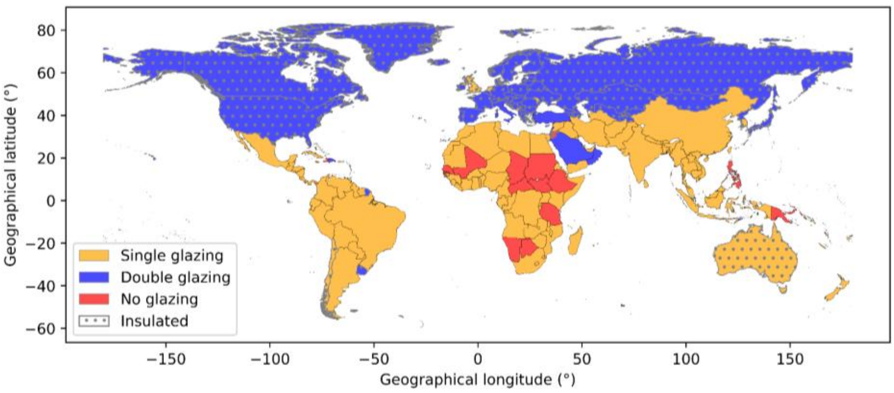



**Figure 14 - Window glazing type and insulation presence in low-rise residential buildings.**

Fig.~~ure~~ 15 shows window share in LR buildings globally, with "*many windows*" dominating Global North countries, while "*few windows*" is common across much of Africa and parts of Asia. "*Bay/large windows*" appear in specific regions like parts of India and the Middle East. It is generally observed that building design patterns, particularly concerning the amount of glazing, are influenced by a combination of economic development, climate considerations, and prevailing architectural traditions. For instance, there's a tendency for more extensive glazing to be favored in wealthier, temperate regions, often to maximize natural light. Conversely, in hotter climates or developing areas, fewer windows may be preferred, likely due to concerns for thermal comfort and cost-effectiveness.

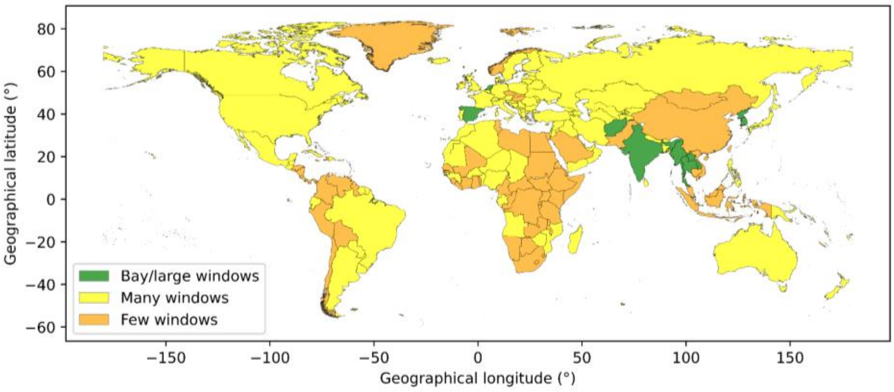



**Figure 15 - Window share in low-rise residential buildings.**

Fig.~~ure~~ 16 illustrates the types of shading device utilized across the globe, reflecting strategies to manage solar radiation for thermal comfort and daylighting. While some nuanced regional variations exist, a general tendency can be observed, with exterior shading appearing somewhat more prevalent in hotter climates, and interior shading showing a higher presence in cooler, higher latitude regions. This distribution aligns with the inherent thermal performance of each shading type. Exterior shading devices intercept solar radiation before it reaches the glazing surface, preventing it from entering the building. In contrast, interior shading allows solar radiation to penetrate the glass and convert into heat inside the space before it can be blocked, making it less efficient for thermal control. Therefore, the greater efficiency of exterior devices makes their use in global areas where controlling solar heat gains is crucial a logical architectural response.

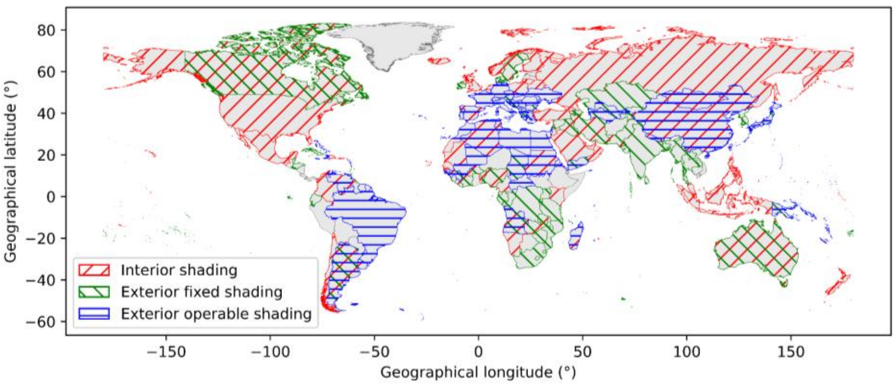



**Figure 16 - Shading devices in low-rise residential buildings.**

### 6.3 Structural variables in non-residential buildings

For non-residential buildings, global typologies are defined by grouping responses according to building use and form combinations. Structural variables are then assigned based on the most frequently reported values within each group. This approach resulted in one to three representative typologies per combination. To ensure global applicability, thermal and fenestration~~lighting~~ variables are excluded, as they are climate-dependent and thus considered country-specific. The resulting non-residential building typologies are presented in Tab.~~le~~ 6.

*Table 6 - Wall and roof characteristics of global typologies.*

| Form | Use | Wall material | Wall color | Roof slope | Roof material |
|---|---|---|---|---|---|
| HR | Commercial | Concrete | White tones | Flat | Concrete |
| HR | Commercial | Glass | N/A | Flat | Concrete |
| LLR | Commercial | Concrete | Light tones | Flat | Concrete |
| LLR | Commercial | Fired Brick | Light tones | Flat | Concrete |
| LLR | Commercial | Metal | Medium tones | Flat | Metal |
| MR | Commercial | Concrete | Medium tones | Flat | Concrete |
| MR | Commercial | Glass | N/A | Flat | Concrete |
| LLR | Industrial | Concrete | Medium tones | Flat | Concrete |
| LLR | Industrial | Metal | Dark tones | Moderately sloped | Metal |
| HR | Offices | Concrete | Medium tones | Flat | Concrete |
| HR | Offices | Glass | N/A | Flat | Concrete |
| LLR | Offices | Concrete | Light tones | Flat | Concrete |
| MR | Offices | Concrete | Light tones | Flat | Concrete |
| MR | Offices | Fired Brick | Light tones | Flat | Concrete |
| MR | Offices | Glass | N/A | Flat | Concrete |
| HR | Residential | Concrete | Light tones | Flat | Concrete |

## 7~~6.4~~ Discussion

This study led to the development of a global architectural database at the country scale, specifically tailored to urban climate contexts. While this represents a significant advancement, the methodological framework inevitably involves certain compromises and limitations must be acknowledged. One key constraint lies in the simplified typological approach adopted, which, while necessary for global-scale analysis, does not fully capture the diversity and variability of national building stocks. This may limit the applicability of the findings, particularly in regions with highly heterogeneous architectural characteristics.

Another important limitation concerns the granularity of the data. Initially, the objective was to provide more detailed typological information by considering the main typological variables (form, use, and geographical location) and the auxiliary ~~all~~ typological variables (construction period, income level, occurrence frequency, and degree of urbanisation). However, ~~due to the uneven availability of~~ not sufficient information on the auxiliary typological variables was available from the survey. ~~results across these variables,~~Therefore, ~~only~~ the main typological variables ~~(*country*, *use* and *form*)~~ were prioritised over the auxiliary ones ~~(Fig. 1)~~.

Distinguishing between urban and rural LR building forms would be important, as settlement type significantly influences construction materials and practices. Ideally, both would be included, but due to the lack of comprehensive data covering both contexts, providing separate datasets was not feasible. When both urban and rural survey responses existed, urban typologies were generally prioritised, reflecting the study's focus on urban climate modeling and phenomena like the UHI effect. However, in countries where rural buildings constitute a large share of LR structures, rural typologies were considered more representative. This was the case for~~of~~ some African nations. As a result, the final dataset does not explicitly differentiate urban and rural contexts, representing a practical compromise within the study's objectives and constraints.

Still within the set of main typological variables retained for defining building types, the level of available information varied considerably. A substantial amount of data was available for LR buildings, and to a lesser extent for MR buildings, allowing for geographically robust results for these categories. In contrast, data on HR and non-residential buildings were more limited. Due to the scarcity of survey responses for these typologies, a simplified approach was necessary, leading to the adoption of less detailed global categories (T~~t~~ab.~~le~~ 6), even if it was possible to derive country-specific information for thermal and fenestration~~lighting~~ variables for HR residential buildings. No information has been gathered for informal settlements, which would be linked to LCZ7. This could be a focus of future studies since such settlements frequently concentrate the most vulnerable population.

Despite these limitations, a relatively high level of information was available for LR and MR buildings, which enabled good global coverage for these categories. The amount of available survey data was also sufficient to analyse major trends within the reported variable categories, allowing for cross-analysis with other factors such as climate, region, and the interactions between typological characteristics. This supported a satisfactory approach to filling missing data, relying on logical assumptions based on the nature and behavior of the variables. For the remaining data gaps, a regional extrapolation approach was applied, an assumption with higher uncertainty, but still reasonable, based on the hypothesis that neighboring countries are more likely to share similar construction practices. Together, these strategies make the country-level geographical granularity particularly robust for LR and MR typologies, offering a solid foundation for large-scale applications.

In terms of application, this database represents a significant advancement for urban climate modeling at multiple scales, from city to continental and global scale. This data expands the analytical capabilities of urban research teams worldwide. It enables comparisons of UHI across cities and countries and supports simulations in contexts where researchers have limited data. At the regional and global scales, it facilitates simulations that account for the distinct architectural characteristics of each country. For instance, it complements the European (Demuzere et al., 2019) and global (Demuzere et al., 2022) LCZ maps that provide information on urban form and function with information on construction materials and HVAC systems. This can enhance the realism of urban climate model simulations. Beyond its application in urban climate modeling, this resource can also contribute to assessments of building energy consumption, offering valuable insights to inform building-scale climate mitigation and adaptation strategies in the face of climate change.

## 8~~6~~ Conclusion and outlook

This study presents a first step towards a global architectural database at the country level tailored for urban climate modeling. This database ~~should~~ addresses a crucial data gap in the materials description needed by urban canopy models and should further help in the understanding, the quantification and the mitigation possibilities of UHI. By leveraging a collaborative expert based survey rooted in a typological framework, the project collected detailed information on building form, use, materials, HVAC~~thermal~~ systems, and shading.

The survey yielded 521 responses across 141 countries, with strong coverage of residential buildings which compose the majority of the building stock. Due to limited data for non-residential typologies, global typologies are defined based on predominant wall materials and other shared characteristics, while omitting climate-sensitive variables to maintain broader applicability.

To ensure data reliability, several verification steps were undertaken: statistical assessments of response agreement (Cohen's and Fleiss' Kappa), plausibility checks across variables, and literature reviews where survey responses appeared unrepresentative. A methodology was implemented to select one representative building per typology, prioritising descriptions marked as "common" and balancing socio-economic, temporal, and spatial representativeness. Cross-checks with external sources such as Tabula and the World Housing Encyclopedia showed good alignment for key variables, increasing the confidence of the database.

To ensure a full world coverage and to provide the widest possible uses of the database, a multi-step imputation strategy has then been applied to fill gaps, using a hierarchy of sources and assumptions based on variable type and climatic logic. Each value is flagged for transparency. The final residential dataset reveals clear global patterns shaped by climate, resource availability, and socio-economic factors.

This database is known to present some approximations linked to an insufficient amount of data for some countries or typologies. As a consequence, it required the use of simplified typologies, and reduced details for non-residential and HR buildings. But despite these limitations, it represents a major step towards a complete harmonized materials database at the country level.

Future work should aim to improve data granularity. At first, the database should be completely filled at the country level by additional expert answers. Refining sub-national typologies to enhance reliability at the city level would be a second great aim, especially for countries where the urban form and construction are diverse. Nevertheless, such detailed disaggregation may not be feasible on a global scale due to the complexity of the task.

To further develop this database an important future direction is to make it evolvable through time. A contribution link is provided in the data repository (de Carvalho Araujo et al., 2025), allowing users and readers to suggest additions or corrections. If significant new data becomes available, future updates could enhance the global database.

A key outlook for this work is its application in comparative studies and practical urban climate modeling worldwide. This database can already be used in applied research, enabling direct testing of how finer building detail influences simulation outcomes. By incorporating this enhanced dataset into modeling exercises, researchers can better assess the impact of architectural variations on urban climate dynamics, providing valuable insights into the role of building form and materials in shaping local thermal environments. In the meantime, the use and the spreading in the community of this database could benefit to its development by collecting the improvements from the modelers. A positive feedback loop is expected to improve the database and make it more robust.

~~This database was developed through an innovative methodological process, including the selection of targeted variables, collection of specialist knowledge, survey data verification, filtering of representative typologies, multi-step imputation, and transparent flagging of data sources. Despite some limitations, this approach aimed to produce the most precise, reliable and usable database as possible, to fulfill the needs of the urban climate research community.~~

~~Overall, this work represents a step toward closing the global data gap in urban climate modeling. It delivers an open-source GIS database of representative building typologies worldwide. By providing detailed, globally distributed information on building characteristics, theis UCAD databaseUCAD strengthens the capacity to estimate and forecast UHI intensity, energy consumption, and thermal comfort. It offers researchers and policymakers a practical, scalable resource to support the design of more resilient and sustainable cities in the context of climate change and urbanisation. Nevertheless, there is still additional work necessary to make the database more complete and robust and this work opens the way to get these improvements.~~

## Appendix

### A Survey content

Table A1 - Survey questions and options.

| Element type | Content |
|---|---|
| Introduction title | Join our Global Effort: Describe Building Types for a Sustainable Future! |
| Introduction description | We are building a global database to understand how buildings affect our climate. Your knowledge of local building types will greatly improve urban weather and climate models. Why Participate? Climate Impact: Understand how different buildings affect our environment and urban heat. Weather Forecast: Contribute to more accurate weather forecasts in cities. Your Task: Help us by describing various building types from your country. Each submission should focus on one specific building type. You can describe as many building types as you want. Together let's build a more sustainable future! |
| **Page name** | **Building type** |
| Page description | Think of a type of building that is frequent in your country: homes, shops, offices , industries. Buildings of a same type often share a similar design and materials. Let's describe this type of building by answering some questions!<br>(When several options are possible for a question, focus on the most common feature.) |
| Question | Country (Required) |
| Choices | [List of countries] |
| Question | What is the main use of the building you are going to describe? |
| Choices | Residential; Commercial; Offices; Industrial |
| Question hint | In case of mixed use consider the main one. For example a residential building with a commercial ground floor is considered as residential. |
| Question | What is the shape of this building? (Required) |
| Choices | Individual houses or low-rise building (1 to 3 storeys); Mid-rise building (4 to 9 storeys); High-rise building (more than 9 storeys); Large low-rise building (1 to 3 storeys) |
| Question | During which time periods would this type of building typically be constructed? (Select all that apply if this type of building was built in several of these periods.) (Required) |
| Choices | Before the 20th century; First half of the 20th century; Second half of the 20th century; 21st century; All periods |
| Question | Is this type of building characteristic of urban or rural areas? |
| Choices | Both; Urban; Rural |
| Question | Is this type of building associated with a certain social level? |
| Choices | No; Low income; Medium income; High income |

| | |
|---|---|
| Question | Where can you find this type of building in your country? (Required) |
| Choices | In the whole country; In some specific regions |
| Question | Where is it commonly found? (Many options can be selected) |
| Choices | [List of the regions] |
| Question | How common is this type of building? |
| Choices | Very Common; Somewhat common; Uncommon; I don't know |
| **Page name** | **Exterior walls and roof** |
| Section header | In the following questions please describe the exterior walls of this building type. |
| Question | What is the main wall material? |
| Choices | Fired Brick; Concrete; Stone; Wood; Earth (e.g. Adobe Cob Daub); Metal (e.g. corrugated metal metal panels); Glass (in case of glass buildings) |
| Question | What is the predominant color tone of the exterior wall surfaces? |
| Choices | White tones (e.g. pure white off-white); Light tones (e.g. beige cream light yellow); Medium tones (e.g. green red blue other bright colors); Dark tones (e.g. dark brown black dark gray) |
| Question | Does this building type have thermal insulation? |
| Choices | Yes; No; I don't know |
| Question | Where is usually placed the insulation on the wall? |
| Choices | Inside; Outside; Uniformly distributed throughout the wall; I don't know |
| Question | Estimate the thickness of the wall insulation: |
| Choices | < 5 cm (< 2 in); 5 - 15 cm (2 - 6 in); 16 - 25 cm (6 - 10 in); > 25 cm (> 10 in); It depends on the date it was insulated; I don't know |
| Section header | In the following questions please describe the roof of this building type. |
| Question | Is the roof usually flat or sloped? |

| | |
|---|---|
| Choices | Flat; Moderately sloped; Steeply sloped (> 45°) |
| Question | What is usually the roof cover? |
| Choices | Asphalt shingle; Asbestos cement roofing - coloured; Asbestos cement roofing - natural color; Clay tiles; Concrete; Gravel; Green roofing; Metal (zinc aluminium steel etc); Slate / flagstone; Thatched roof; Wood |
| Question | Estimate the thickness of the roof insulation: |
| Choices | < 5 cm (< 2 in); 5 - 15 cm (2 - 6 in); 16 - 25 cm (6 - 10 in); > 25 cm (> 10 in); It depends on the date it was insulated; I don't know |
| **Page name** | **Window, ventilation, temperature control and shading** |
| Section header | For the following questions focus on the most common building features. |
| Question | How much of the exterior wall is covered by windows? |
| Choices | No windows; Few windows; Many windows; Bay windows / Large windows; Glass building |
| Question | What type of glazing is found in this type of building? |
| Choices | No glazing (windows without a glass panel); Single glazing; Double glazing; Triple glazing; Other (Please specify) |
| Question hint | Glazing refers to the number of glass panels in a window. |
| Question | In this type of building can some windows be opened? |
| Choices | Yes; No |
| Question | Assuming all windows and doors are closed can you feel air drafts coming from outside (air infiltration)? |
| Choices | Not noticeable; Slightly; Strongly; I don't know |
| Question | Does this type of building usually have a mechanical ventilation system? |
| Choices | Yes; No; I don't know |
| Question | Does the building have a heating or a cooling system? |
| Choices | Heating; Cooling; Both; None |

| | |
|---|---|
| Question | Which types of solar shading are commonly used for this type of building? |
| Choices | Overhangs: roof overhang balcony overhang arcades etc; Fixed exterior window shading: window overhangs louvers fins egg-crate shading etc.; Operable exterior window shading: shutters rolling shades retractable awnings etc.; Interior window shading: curtains blinds etc.; None of the above; I don't know |
| **Page name** | **Leave your mark** |
| Question | Would you mind sharing your email? |
| Choices | [Open field element] |
| Question | Would you like to share a picture of this building type? |
| Choices | [upload element] |
| Question | Have you ever been involved in the field of Architecture or Civil Engineering through study or work? |
| Choices | Yes; No |
| Matrix question | Match the wall insulation thickness with the following periods for this type of building:(Please select maximum one choice for each period) |
| Matrix rows | Before 70's; 70's and 80's; 90's; 2000's; 2010's; 2020's |
| Matrix columns | I don't know; No insulation; < 5 cm (< 2 in); 5 - 15 cm (2 - 6 in); 16 - 25 cm (6 - 10 in); > 25 cm (> 10 in) |
| Matrix question | Match the roof insulation thickness with the following periods for this type of building:(Please select maximum one choice for each period) |
| Matrix rows | Before 70's; 70's and 80's; 90's; 2000's; 2010's; 2020's |
| Matrix columns | I don't know; No insulation; < 5 cm (< 2 in); 5 - 15 cm (2 - 6 in); 16 - 25 cm (6 - 10 in); > 25 cm (> 10 in) |
| Question | If any, to which architectural style does this building type correspond? |
| Choices | [Open field element] |
| Question | Do you have any further comments? |
| Choices | [Open field element] |

| | |
|---|---|
| Final message | Your responses are incredibly valuable as describing the different types of buildings helps us better understand the urban climate worldwide. Thank you again for submitting this form. We would greatly appreciate it if you could take the time to answer the survey for another type of building in your country. |

**B Coverage of external databases**

Figs.~~ures~~ B1 and B2 illustrate the geographic coverage of survey data alongside that from the external databases (Tabula and WHE). Where both data sources were available (countries highlighted in green and marked with circles), a comparative analysis was conducted. Conversely, in regions where only external database data was present (countries shown in grey and with circles), this information was utilized to complete missing survey data.

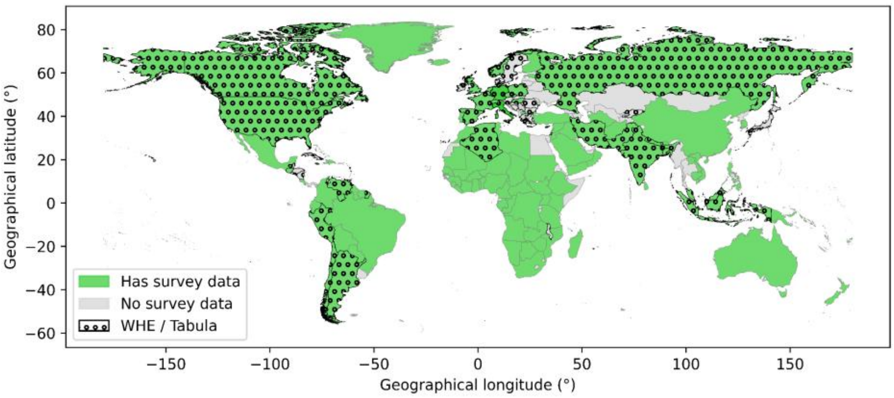



**Figure B1: Presence of data in external databases and in the survey for LR buildings.**

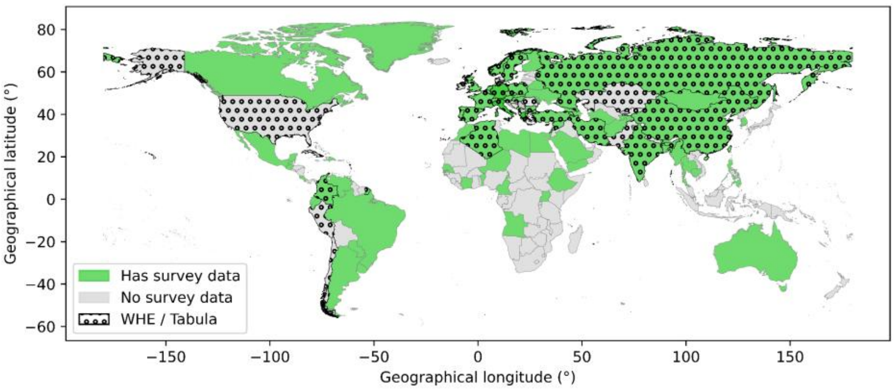



**Figure B2: Presence of data in external databases and in the survey for MR buildings.**

The following tables present a comparative analysis of building characteristics, specifically focusing on the agreement regarding wall and roof materials and window share in different global contexts. Tabs.~~les~~ B1 and B2, derived from the WHE project, categorise low-rise and mid-rise buildings, respectively, based on whether the reported characteristics for these elements align with survey data. It should be noted that in some WHE cases, the absence of clear photographic evidence impeded the precise definition of window share levels. For the WHE data, every report used is precisely cited for each country. Tabs.~~les~~ B3 and B4 show the reports used to complete the missing data with WHE. Tab.~~le~~ B5, based on the TABULA project, applies this comparison to various European countries for both low-rise and mid-rise structures. This table additionally indicates instances of data "completion" where information for one of the building forms was not directly available in the survey data, and also highlights cases where wall and roof materials were not explicitly described in the TABULA descriptions. All TABULA data was sourced directly from its website.

*Table B1: WHE - Agreement between our database and WHE external database for countries covered by WHE ~~coveredcompared cases with agreement~~ for wall and roof materials and window share for low-rise buildings.*

| | **Agreement for Low-Rise buildings** | | | **Analysed report number (#) and references** |
|---|---|---|---|---|
| **Country** | **Wall material** | **Roof material** | **Window share** | |
| Algeria | no | yes | yes | #103 (Farsi & Lazzali, 2003). |
| Argentina | yes | no | no | #1 (Rodriguez et al., 2002a),<br>#2 (Rodriguez et al., 2002c),<br>#70 (Rodriguez et al., 2002b),<br>#89 (Rodriguez et al., 2003),<br>#152 (Graciela & Tornello, 2008). |
| Bangladesh | yes | no | yes | #91 (Ansary, 2003),<br>#143 (Das et al., 2007). |
| Canada | yes | no | yes | # 82 (Ventura & Kharrazi, 2002). |
| Chile | yes | yes | no | #5 (Moroni et al., 2002c). |
| Guatemala | no | no | no | #161 (Velasquez Jofre et al., 2011),<br>#144 (Lang et al., 2007),<br>#136 (French, 2007a). |
| India | yes | yes | no | #18 (Brzev et al., 2002),<br>#20 (Khan & Moin, 2002),<br>#21 (Sinha & Brzev, 2002),<br>#22 (Kumar, 2002a), |

| | | | | |
|---|---|---|---|---|
| | | | | #23 (Kumar, 2002b),<br>#72 (Choudhary et al., 2002),<br>#80 (Sinha & Ambati, 2002),<br>#116 (Kumar & Pundit, 2005),<br>#146 (Hicyilmaz et al., 2008),<br>#147 (Khan, 2008),<br>#154 (Kaushik, 2009),<br>#170 (Rahul et al., 2013),<br>#171 (Sood et al., 2012),<br>#172 (Sood et al., 2013). |
| Indonesia | no | yes | yes | #24 (Wijanto, 2002). |
| Iran | yes | no | yes | #27 (Hashemi et al., 2002)<br>#104 (Mehrain & Naeim, 2004),<br>#114 (Ahari & Azarbakht, 2005),<br>#118 (Bekloo, 2007). |
| Italy | no | no | yes | #28 (D'Ayala & Speranza, 2002),<br>#29 (D'Ayala et al., 2002),<br>#31 (Goretti et al., 2002). |
| Jamaica | yes | no | no data | #207 (Webber & Abrahamczyk, 2020). |
| Malaysia | yes | yes | no | #44 (Adnan et al., 2002). |
| Nepal | yes | yes | yes | #47 (Parajuli et al., 2002a),<br>#74 (Parajuli et al., 2002b),<br>#145 (Bilas Marhatta et al., 2007). |
| Pakistan | yes | yes | yes | #112 (Ali, 2006),<br>#116 (Kumar & Pundit, 2005),<br>#138 (Ali & Muhammad, 2007),<br>#146 (Hicyilmaz et al., 2008),<br>#166 (Lodi et al., 2012),<br>#173 (Lodi et al., 2013),<br>#174 (Parajuli et al., 2012). |
| Peru | no | yes | yes | #51 (Loaiza & Blondet, 2002b),<br>#52 (Loaiza et al., 2002),<br>#107(Charleson, 2009) |

| | | | | |
|---|---|---|---|---|
| Russia | yes | no | yes | #56 (Klyachko et al., 2002a), #57(Klyachko et al., 2002b), #53(Klyachko et al., 2002d). |
| Switzerland | no | no | yes | #108 (Bostenaru, 2004). |
| United States | yes | yes | yes | #65 (Arnold, 2002). |

*Table B2: Agreement between our database and WHE external database for countries covered by WHE ~~WHE - compared cases with agreement~~ for wall and roof materials and window share for mid-rise buildings.*

| | Agreement for Mid-Rise buildings | | | Analysed report number (#) and references |
|---|---|---|---|---|
| **country** | **Wall material** | **Roof material** | **Window share** | |
| Algeria | yes | yes | yes | #75 (Farsi et al., 2002), #103 (Farsi & Lazzali, 2003). |
| Armenia | no | no | no | #202 (Martin, s. d.a), #203 (Martin, s. d.b), #204 (Martin, s. d.c). |
| China | no | yes | yes | #9 (Zhou et al., 2002). |
| Colombia | yes | yes | no data | #11 (Mejia, 2002b), #12 (Mejia, 2002a), #175 (Hackmayer, et al., 2013). |
| Cyprus | no | yes | yes | #13 (Levtchitch, 2002). |
| Greece | yes | yes | yes | #15 (Tassios & Syrmakezis, 2002). |
| India | yes | yes | yes | #19 (Jaiswal et al., 2002), #150 (Rautela et al., 2008). |
| Iran | yes | yes | yes | #25 (Alimoradi, 2002), #26 (Hashemi & Ashtiany, 2002), #27 (Hashemi et al., 2002). |
| Italy | yes | yes | yes | #30 (Leggeri et al., 2002), #113 (Sassu & Cei, 2005), #120 (Vetturini et al., 2007b), #121 (Vetturini et al., 2007a). |
| Russia | yes | yes | yes | #53 (Klyachko et al., 2002d), #54 (Klyachko et al., 2002c), #55 (Klyachko et al., 2002e). |
| Switzerland | yes | yes | yes | #108 (Bostenaru, 2004), #119 (Lang & Bachmann, 2007). |
| Syria | yes | yes | yes | #59 (Awad et al., 2002b), #60 (Awad et al., 2002a). |
| Turkey | yes | no | yes | #64 (Gulkan et al., 2002), #101 (Yakut & Gulkan, 2003). |

*Table B3: Data from WHE database that are used in case of lack of survey data (data provenance flag set to W)~~WHE - completed cases~~ for low-rise buildings with detailed used reports.*

| **Country** | **Analysed report number (#) and references** |
|---|---|
| Belize | #164 (Redmond and DesRoches, 2012) |
| Cuba | #183 (Morejón Blanco et al., 2016a) |
| El Salvador | #14 (Lopez M. et al., 2002) |
| Greece | #17 (Koumousis, 2002) |
| Honduras | #134 (French, 2007b) |
| Japan | #86 (Maki and Tanaka, 2002) |
| Kyrgyzstan | #36 (Begaliev and Uranova, 2002) |
| Malawi | #45 (Sassu and Ngoma, 2002) |
| Malawi | #45 (Sassu and Ngoma, 2002a)<br>#46 (Sassu and Ngoma, 2002a) |
| Nicaragua | #148 (Lang et al., 2008) |
| Palestine | #49 (Al Dabbeek and Al-Jawhari, 2002b) |
| Romania | #84 (Bostenaru and Sandu, 2002a)<br>#85 (Bostenaru and Sandu, 2002b) |
| Serbia | #69 (Muravljov and Dimitrijevic, 2002) |
| Slovenia | #88 (Lutman and Tomazevic, 2002a) |
| Trinidad and Tobago | #156 (Clarke and Ramnath, 2009) |

*Table B4: Data from WHE database that are used in case of lack of survey data (data provenance flag set to W)~~WHE - completed cases~~ for mid-rise buildings with detailed used reports.*

| **Country** | **Analysed report number (#) and references** |
|---|---|
| Albania | #208 (Charleson, 2020) |
| Chile | #7 (Moroni et al., 2002b)<br>#8 (Moroni et al., 2002a) |
| Cuba | #186 (Morejón Blanco et al., 2016b) |
| Kazakhstan | #32 (Itskov et al., 2002) |
| Kyrgyzstan | #39 (Uranova and Begaliev, 2002) |
| Nepal | #145 (Marhatta et al., 2007) |
| Pakistan | #167 (Lodi et al., 2013) |
| Palestine | #48 (Al Dabbeek and Al-Jawhari, 2002a) |
| Peru | #50 (Loaiza F. and Blondet, 2002a) |
| Romania | #71 (Bostenaru and Sandu, 2002c)<br>#96 (Bostenaru, 2003) |
| Serbia | #68 (Dimitrijevic, 2002) |
| Slovenia | #73 (Lutman and Tomazevic, 2002b) |
| USA | #111 (Faison et al., 2004) |

*Table B5: Agreement (yes/no) between our database and Tabula external database for countries covered by Tabula - and data from Tabula database that are used in case of lack of survey data (completion; data provenance flag set to T)~~compared and completed cases with agreement~~ for wall and roof materials and window share for low-rise and mid-rise buildings.*

| Country | Agreement | | | | | |
|---|---|---|---|---|---|---|
| | MR | | | LR | | |
| | **Wall material** | **Roof material** | **Window share** | **Wall material** | **Roof material** | **Window share** |
| Austria | yes | yes | yes | completion | completion | completion |
| Belgium | yes | no | yes | yes | no | yes |
| Bulgaria | yes | no | yes | completion | completion | completion |
| Cyprus | no | yes | yes | no | yes | yes |
| Czech Republic | yes | yes | yes | yes | yes | no |
| France | no data | yes | yes | no data | yes | yes |
| Germany | yes | yes | yes | yes | yes | yes |
| Greece | yes | yes | yes | completion | completion | completion |
| Hungary | no | yes | yes | yes | yes | no |
| Italy | yes | yes | yes | no | no | yes |
| Netherlands | no data | no | yes | yes | yes | no |
| Norway | no | no | yes | yes | yes | no |
| Poland | yes | yes | yes | yes | no | yes |
| Spain | no data | yes | yes | no | yes | yes |
| Sweden | no data | no data | yes | completion | completion | completion |
| United Kingdom | no | yes | yes | yes | yes | yes |

**C Maps of all descriptive variables**

The ~~three next f~~Fig. ~~ures (~~C1~~, C2,~~ to C3~~)~~ present all the parameters of the database for the Low-Rise, Mid-Rise and High-Rise buildings, respectively.

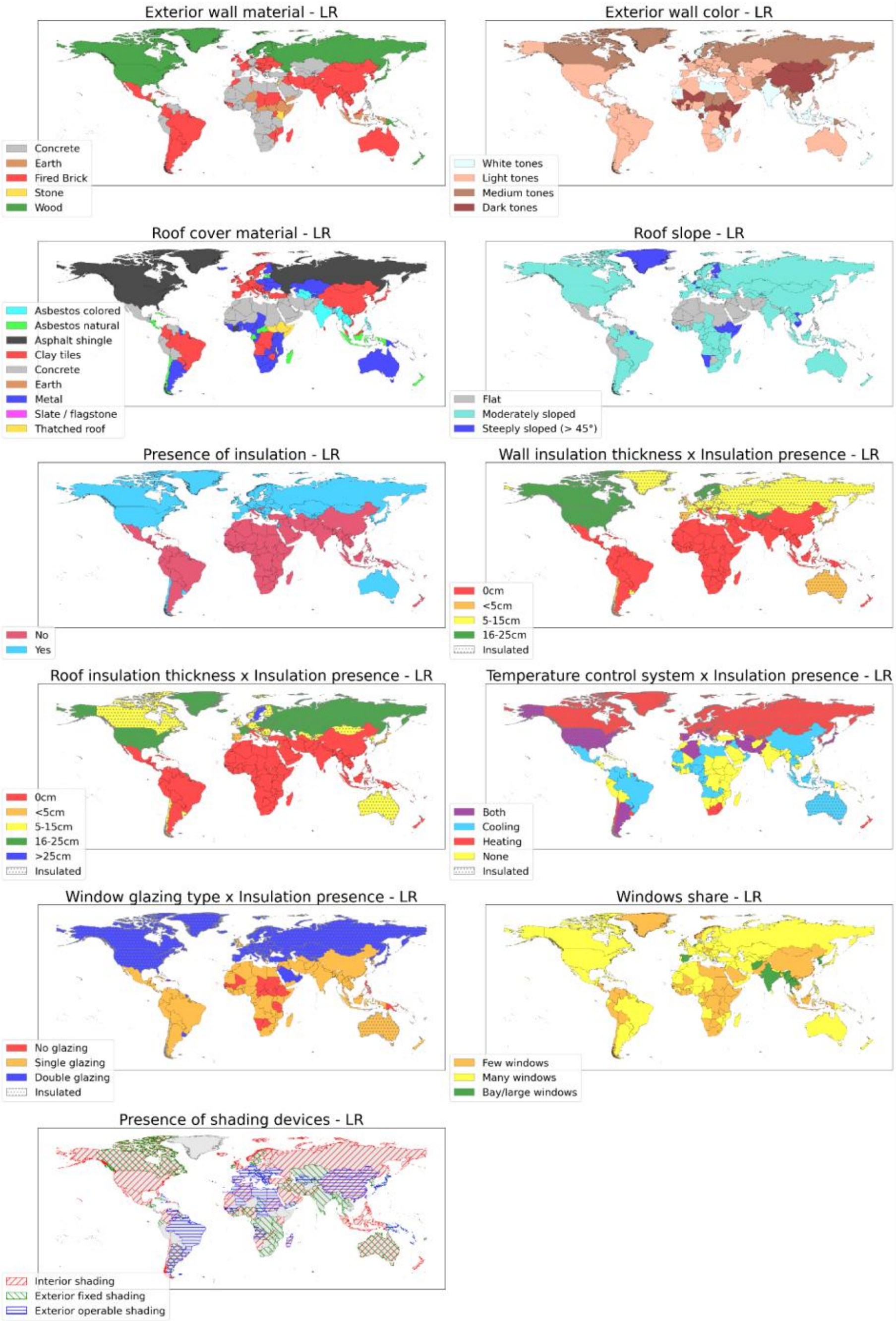
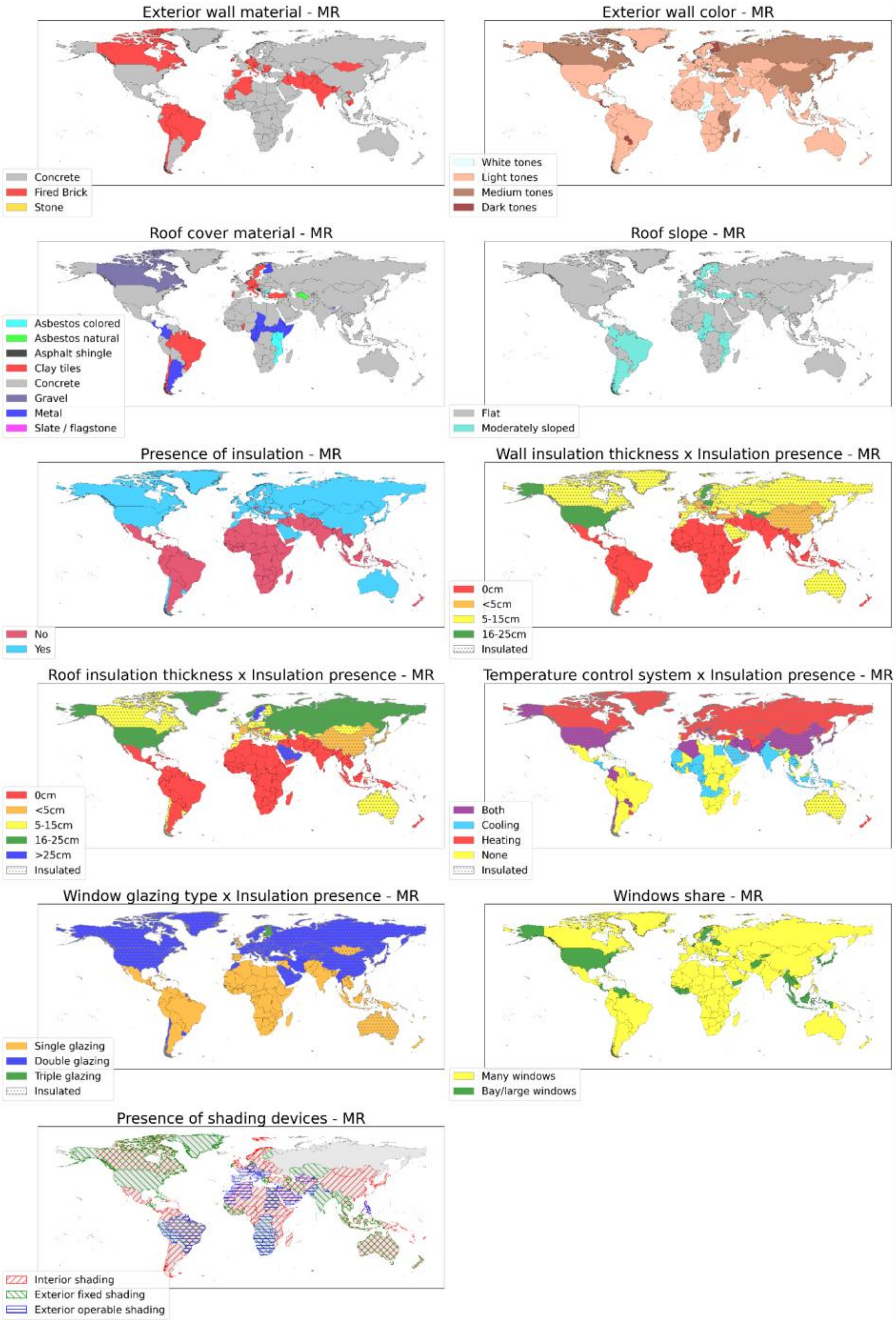



**Figure C1: Descriptive variables for low-rise buildings.**


Exterior wall material - MR
Concrete
Fired Brick
Stone
Exterior wall color - MR
White tones
Light tones
Medium tones
Dark tones
Roof cover material - MR
Asbestos colored
Asbestos natural
Asphalt shingle
Clay tiles
Concrete
Gravel
Metal
Slate / flagstone
Roof slope - MR
Flat
Moderately sloped
Presence of insulation - MR
No
Yes
Wall insulation thickness x Insulation presence - MR
0cm
<5cm
5-15cm
16-25cm
Insulated
Roof insulation thickness x Insulation presence - MR
0cm
<5cm
5-15cm
16-25cm
>25cm
Insulated
Temperature control system x Insulation presence - MR
Both
Cooling
Heating
None
Insulated
Window glazing type x Insulation presence - MR
Single glazing
Double glazing
Triple glazing
Insulated
Windows share - MR
Many windows
Bay/large windows
Presence of shading devices - MR
Interior shading
Exterior fixed shading
Exterior operable shading

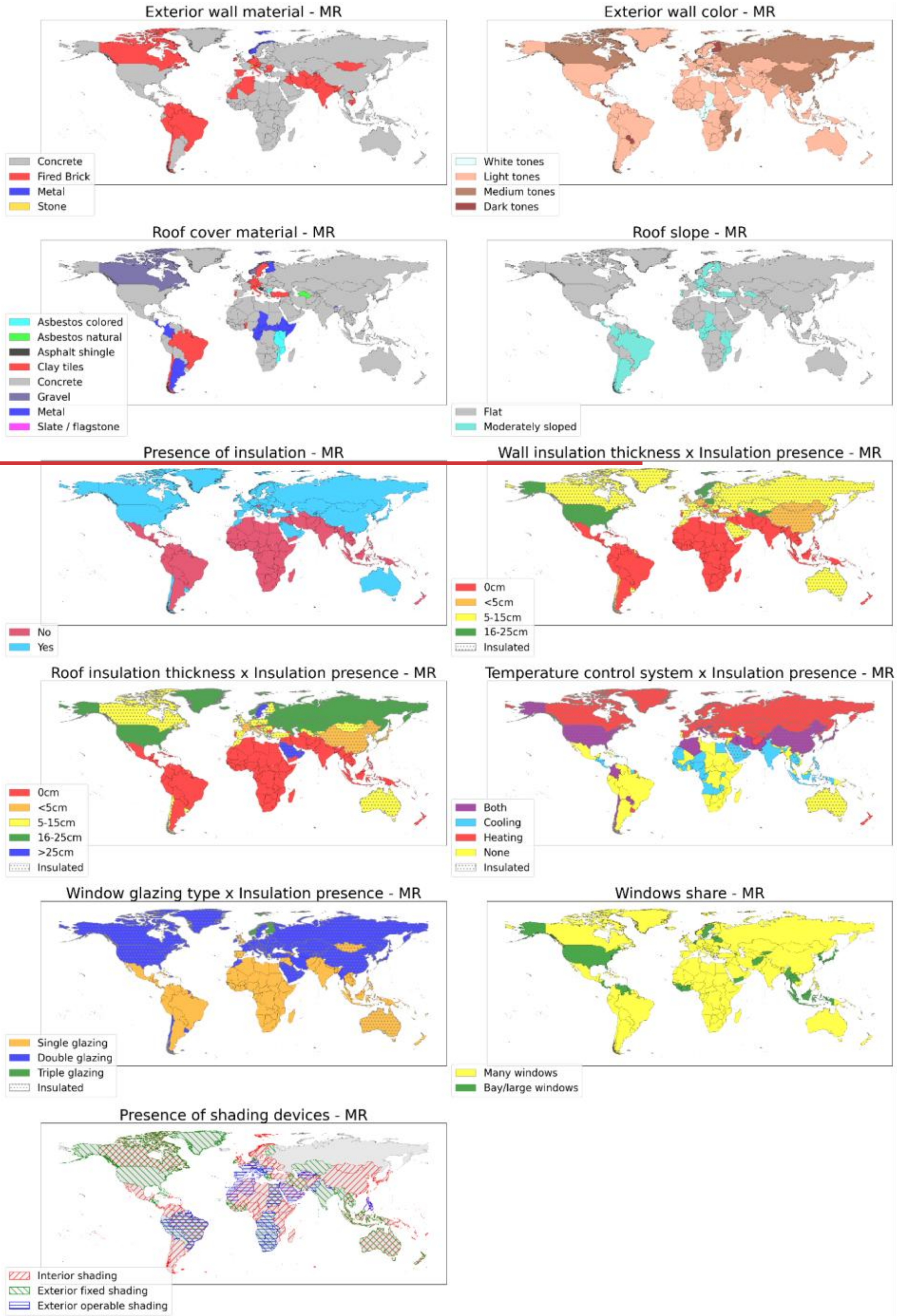



**Figure C2: Descriptive variables for mid-rise buildings.**

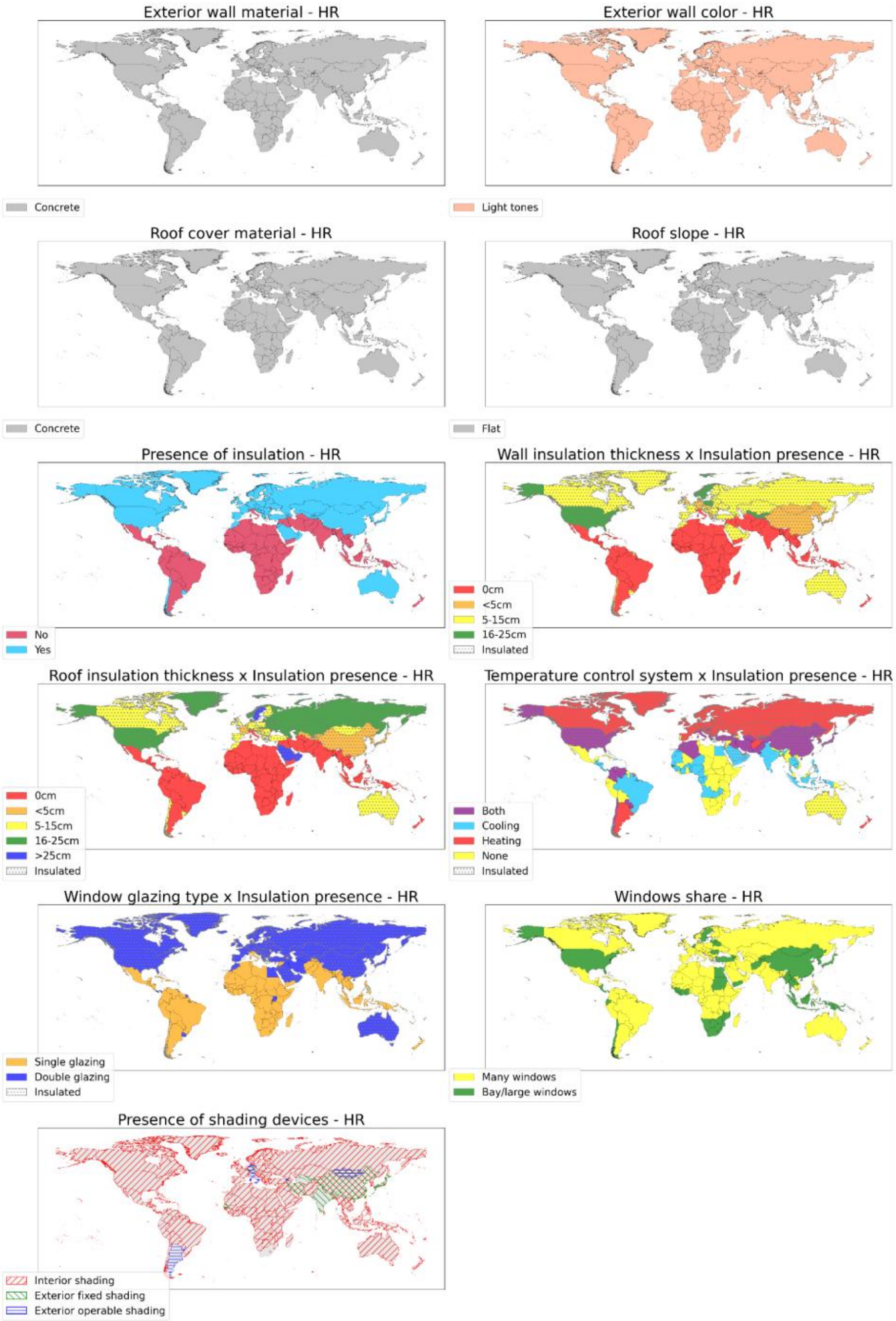



**Figure C3: Descriptive variables for high-rise buildings.**

**D Look-up tables for physical parameters**

This section provides an association between the database categories for each variable and their corresponding physical parameters, which are to be applied in urban climate modeling. These associations are provided for the following variables: wall materials (Tab. ~~le~~ D1), roof cover material (Tab. ~~le~~ D2), wall color (Tab. ~~le~~ D3), window glazing type (Tab. ~~le~~ D4), and window share (Tab. ~~le~~ D5). Other descriptive variables do not require conversion.

*Table D1: Associated physical parameters for wall materials. References: Gb92: Geotti-Bianchini and Lohrengel (1992); Ki03: Kikegawa et al. (2003); Ol08: Oleson et al. (2008); Gr11: Grimmond et al. (2011); HR11: Haldi and Robinson (2011); Ro11: Roetzel et al. (2011); Pi14: Pigeon et al. (2014); Gi19: Giuffrida et al. (2019). Typical values for thickness have been taken from the Danube dataset (Dan).*

| Wall material | Volumetric heat capacity [J.m$^{-3}$.K$^{-1}$] | Thermal conductivity [W.m$^{-1}$.K$^{-1}$] | Thickness [m] |
|---|---|---|---|
| Concrete | 1.0 x $10^6$ [Ol08]; 1.525 x $10^6$ [Gr11]; 2.11 x $10^6$ [Ol08]; 2.592 x $10^6$ [HR11] | 0.67[Ol08]; 0.87[Gr11]; 1.39[Ki03]; 1.51[Ol08]; 1.8[HR11] | 0.2-0.4[Dan] |
| Earth | 8.7 x $10^5$ [Gi19] - 3.9 x $10^6$ [Gi19] | ~~0.6~~0.19-1.35[Gi19] | 0.7[Dan] |
| Fired Brick | 1.26 x $10^6$ [Gr11]; 1.71 x $10^6$ [Ro11] | 0.415[Ro11]; 0.71[Gr11] | 0.4[Dan] |
| Glass | 1.9 x $10^6$ [Gr11] | 1.01-1.03[Gb92] ~~1.0~~ | 0.02-0.03[Dan] |
| Metal | 8.73 x $10^6$ [Gr11] | 72[Gr11] | 0.01-0.02[Dan] |
| Stone | 1.54 x $10^6$ [Ol08]; 2.2 x $10^6$ [Pi14] | 0.88[Ol08]; 1.7[Pi14] | 0.4-0.8[Dan] |
| Wood | 1.12 x $10^6$ [HR11]; 1.05 x $10^6$ [Gr11]; 1.58 x $10^6$ [Gr11] | 0.14[HR11; Gr11]; 0.23[Gr11] | 0.5[Dan] |

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*Table D2: Associated physical parameters for roof cover materials. Sources: Ki03: Kikegawa et al. (2003); Ol08: Oleson et al. (2008); Gr11: Grimmond et al. (2011); Ko14: Kotthaus et al. (2014); Pi14: Pigeon et al. (2014); Gi19: Giuffrida et al. (2019); La20: Labus et al. (2020); Si22: Simpson (2022); Ar: https://www.archingreen.com/en/materials/straw/, last accessed on August 21 2026. Typical values for thickness have been taken from the Danube dataset (Dan). In the case no reference is provided, the value is a best guess.*

| **Roof cover material** | **Volumetric heat capacity [J.m$^{-3}$.K$^{-1}$]** | **Thermal conductivity [W.m$^{-1}$.K$^{-1}$]** | **Thickness [m]** | **Albedo** | **Emissivity** |
|---|---|---|---|---|---|
| Asbestos colored | 1.8 x $10^6$ [Gr11] | 0.55[Gr11] | 0.008[Gr11] | 0.10 - 0.40 | 0.9-0.95 |
| Asbestos natural color | 1.8 x $10^6$ [Gr11] | 0.55[Gr11] | 0.008[Gr11] | 0.20 - 0.40 | 0.9-0.95 |
| Asphalt shingle | 1.76 x $10^6$ [Ol08] | 0.2[Ol08] | 0.0185[Ol08] | 0.07[Ko14] | 0.93[Ko14] |
| Clay tiles | 1.6 x $10^6$ [Pi14] | 1.0[Pi14] | 0.02[Dan] | 0.12-0.31[Ko14] | 0.92-0.95[Ko14] |
| Concrete | 1.53 x $10^6$ [Gr11]; 2.11 x $10^6$ [Ol08] | 1.1[Gr11]; 1.39[Ki03]; 1.51[Ol08] | 0.2[Dan] | 0.21-0.42[Ko14] | 0.92-0.95[Ko14] |
| Earth | 8.7 x $10^5$ [Gi19] - 3.9 x $10^6$ [Gi19] | 0.19-1.35[Gi19] | 0.05-0.2 | 0.20 - 0.25 | 0.9-0.95 |
| Gravel | 1.76 x $10^6$ [Ol08]; 1.8 x $10^6$ [Pi14] | 1.4[Ol08]; 2.0[Pi14] | 0.05-0.10[Dan] | 0.4[Pi14] | 0.9[Pi14] |
| Metal | 2.73 x $10^6$ [Pi14]; 8.73 x $10^6$ [Gr11] | 72[Gr11]; 110[Pi14] | 0.008-0.2[Dan] | 0.05-0.45[Ko14] | 0.16-0.97[Ko14] |
| Slate / flagstone | 8.1 x $10^5$ [La20]-3.0 x $10^7$ [La20] | 1.43-3.92[La20] | 0.02[Dan] | 0.09-0.14[Ko14] | 0.9-0.93[Ko14] |
| Thatched roof | 2.2 x $10^5$-3.42 x $10^5$ [Ar] | 0.04 - 0.1[Si22] | 0.3 | 0.20 - 0.40 | 0.9-0.95 |

~~*Table D2: Associated physical parameters for roof cover materials.*~~

*Table D3: Associated albedos for exterior wall color. For emissivity, values between 0.9-0.95 can be assumed, except for metal for which emissivity might range between 0.16 and 0.97 (Kotthaus et al., 2014).*

.

| **Wall color** | **Albedo** |
|---|---|
| White tones | 0.5 |
| Light tones | 0.3 |
| Medium tones | 0.2 |
| Dark tones | 0.15 |

*Table D4: Associated physical parameters for window glazing types. Sources: Pi14: Pigeon et al. (2014); Ba23: Bartko and Durica (2023).*

| **Window glazing type** | **Thermal transmittance [W.m$^{-2}$.K$^{-1}$]** |
|---|---|
| No glazing | *adapt the model with high ventilation rates |
| Single glazing | 4.95[Pi14]; 4.8 - 5.8 |
| Double glazing | 1.95[Pi14]; 2.4[Pi14]; 1.1 - 3.0 |
| Triple glazing | 0.52~~ - 0.8~~0.96[Ba23] |

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*Table D5: Associated window facade percentage for window share.*

| ***Window share*** | ***Percentage of windows in the facade [%]*** |
|---|---|
| *No windows* | *0* |
| *Few windows* | *10* |
| *Many windows* | *20* |
| *Bay/large windows* | *40* |
| *Glass building* | *90* |

## E Percentage of country and population per data source

The following figures show, for each variable in the building typology (rows), the proportion of data points attributed to each data source (columns): as a percentage of the number of countries in the sample (Fig. E1, E3 and E5, respectively for LR, MR and HR), and as a percentage of total sampled population (Fig. E2, E4, E6, respectively for LR, MR and HR). The population-weighted analysis was based on the total population indicator for 2025 (World Bank, 2026). A total of 215 countries and territories were included in the analysis. Thirty-five territories were excluded because no 2025 population value was available for them in the World Bank database. The excluded entities consisted predominantly of small overseas dependencies and other territories rather than countries. Cell values are percentages; color intensity follows the same 0–100% scale across figures to allow direct visual comparison.

Data sources are: Survey (filtered and aggregated survey responses), Region (imputed from a neighboring country within the same region), Insulated (imputed from the building's final insulation status), Tabula (imputed from the Tabula database), WHE (imputed from the World Housing Encyclopedia), Inferred from another variable (imputed from a related survey variable), Urban Form (imputed from other building forms, such as mid- or high-rise, within the same country), Climate (imputed from climate-zone assumptions), Manual corrections (individually adjusted post-imputation), and Default (completed using default values). Blank cells indicate that the data source was not applicable to that variable.

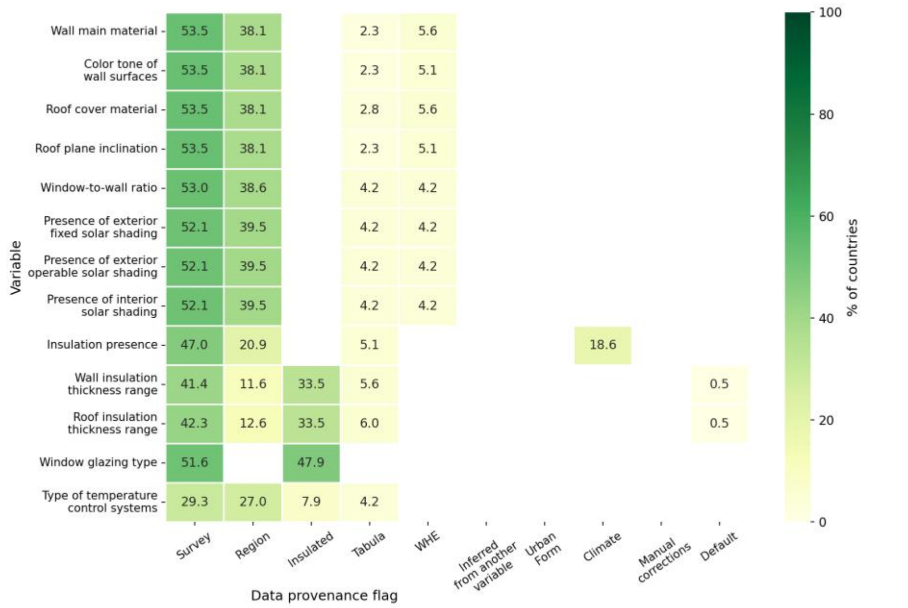


**Figure E1: Data provenance flag of LR building typology variables, weighted by share of countries.**

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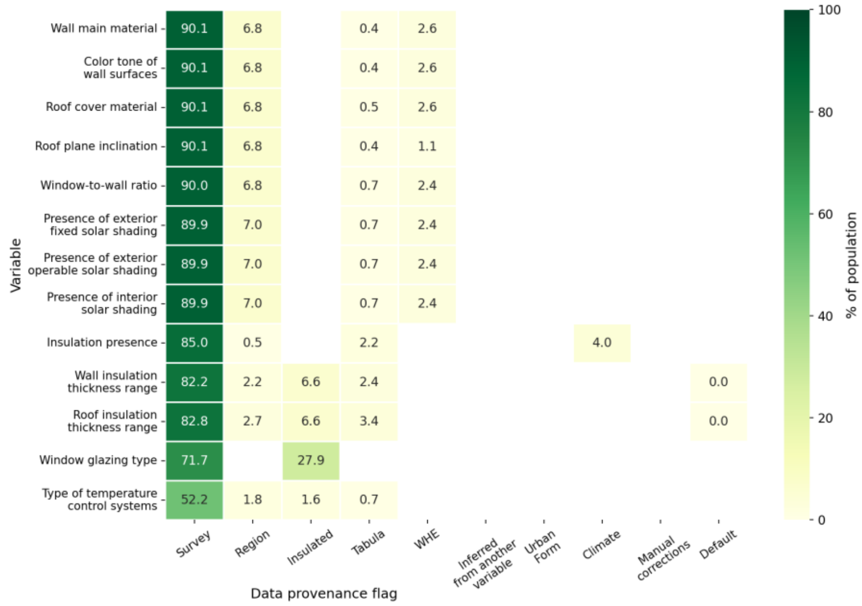


**Figure E2: Data provenance flag of LR building typology variables, weighted by share of population.**

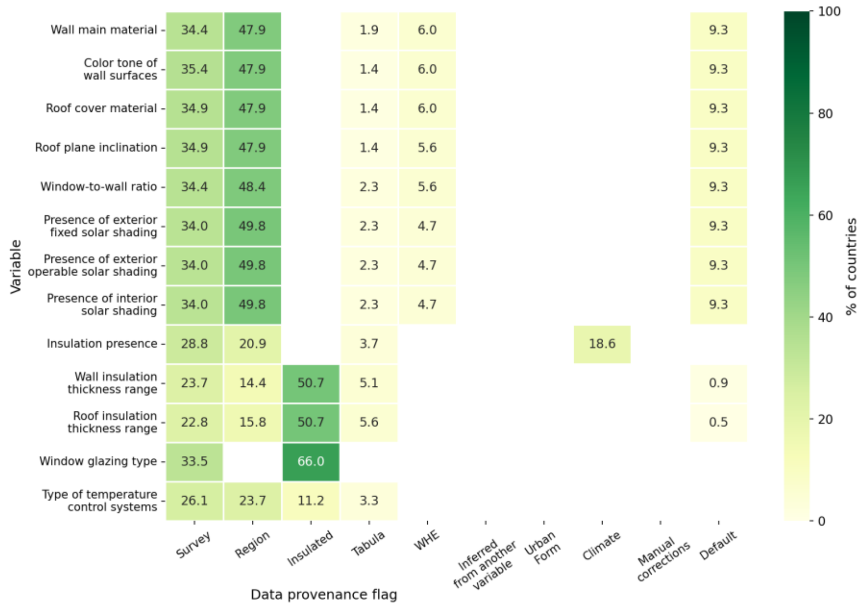


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Figure E3: Data provenance flag of MR building typology variables, weighted by share of countries.


Figure E4: Data provenance flag of MR building typology variables, weighted by share of population.

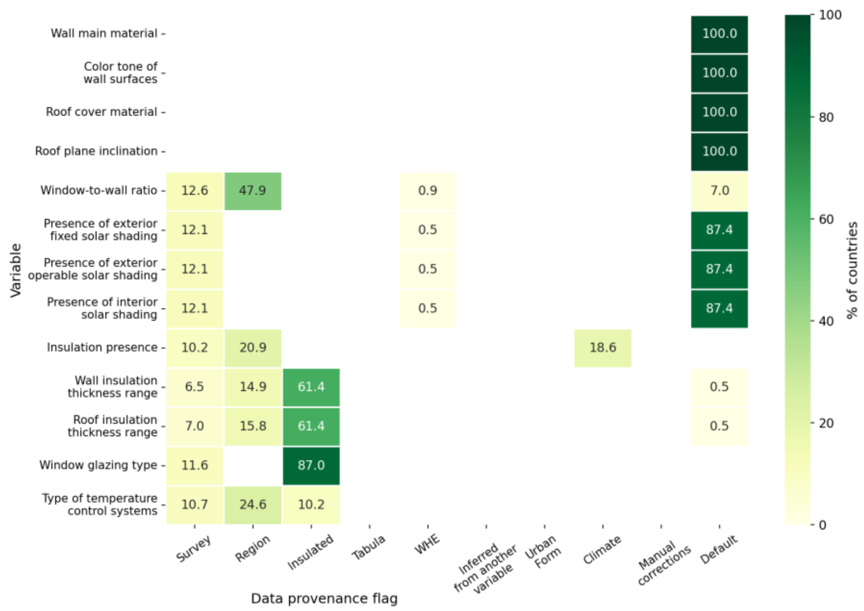


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Figure E5: Data provenance flag of HR building typology variables, weighted by share of countries.

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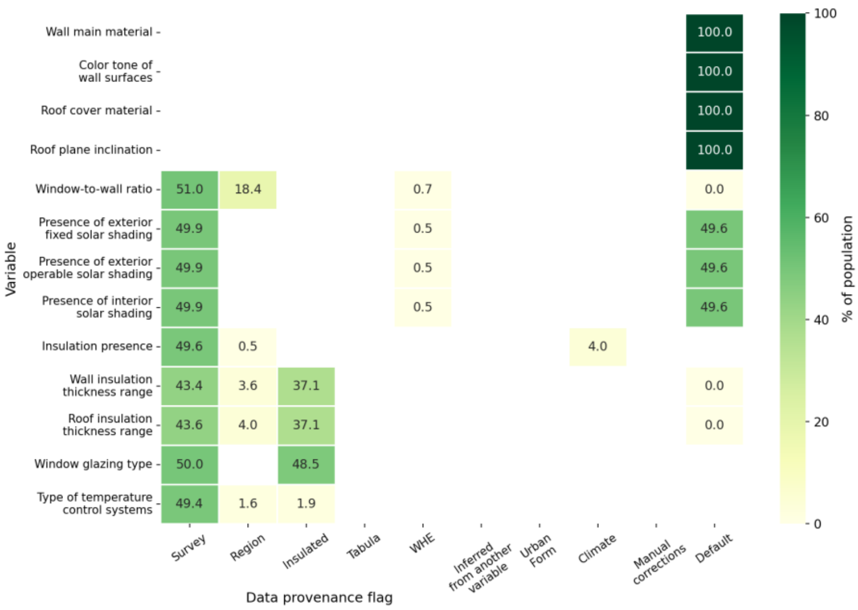


Figure E6: Data provenance flag of HR building typology variables, weighted by share of population.

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Comparison of Figs. E1 and E2 shows that countries with survey data tend to be among the most populous in the sample; consequently, survey-based data account for close to 90% of the total population represented in the analysis, despite covering approximately half of the countries.

Compared with LR buildings, data availability is lower for MR buildings (Figs. E3 and E4). Nevertheless, survey data still cover countries which account for the majority of the global population.

Data availability is more limited for HR buildings. Some building-envelope variables were therefore assigned default values (a concrete envelope, a flat roof, and a light-colored wall exterior) because the available survey responses showed a strong convergence toward these characteristics. For variables that are not assigned default values across all countries, survey data still account for approximately half of the available information for HR buildings when weighted by population.

Variables related to building systems and envelope insulation were also imputed based on climate conditions, insulation presence and, on information available for other urban forms (LR and MR).

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**Data availability**

The original survey results and the final maps and datasets of building typologies can be downloaded at https://doi.org/10.5281/zenodo.16096963 (de Carvalho Araujo et al., 2025).

**Author contributions**

Lorena de Carvalho Araujo: Conceptualization, data curation, formal analysis, investigation, methodology, project administration, software, validation, visualization, writing – original draft, writing – review & editing.

Valéry Masson: Conceptualization, funding acquisition, investigation, methodology, project administration, resources, supervision, writing – review & editing.

Robert Schoetter: Conceptualization, investigation, methodology, supervision, writing – review & editing.

Jean Wurtz: Conceptualization, investigation, methodology, supervision, writing – review & editing.

Anouk Le Bihan: Data curation, formal analysis, methodology.

Marion Bonhomme: Conceptualization, methodology, writing – review & editing.

**Competing interests**

The authors declare that they have no conflict of interest.

**Acknowledgements**

We deeply appreciate the valuable contributions of the following individuals, whose careful review and linguistic support were essential in verifying and refining the survey translations. Their help greatly enhanced the clarity of the final version: Clara Paez, Gemma Bamugyeya, Marbella Treins, Marianna Ercole, Mikhail Varentsov, Paul Darciaux, Rita Tabchoury, Sun Rui Ze, Thairo Abdias Pinheiro Rocha.

We wish to thank Nathalie Tornay and Serge Faraut for their interest and participation in the initial discussions of this project.

We sincerely thank all those who responded to the survey, making the data collection possible. We received 521 responses from participants around the world and their contributions were essential to the success of this research. Thank you for advancing research through your participation.

Finally, we acknowledge the use of free icons in Figs. 1 and 2, designed using resources from Flaticon.com. The utilized icons were created by the following authors: Freepik, srip, surang, Payungkead, Kiranshastry, kerismaker, Fir3Ghost, yut1655, Icongeek26, Icon home, mj, Fahrul Saputra, redempticon and Nikita Golubev.

**Financial support**

We gratefully acknowledge the support and funding from the FPCUP U-CLIMADAPT Project, which was instrumental in the successful completion of this research. Partial funding was received from Agence Nationale de la Recherche grant no. ANR-21-CE46-0013.

**Bibliography**


Abram, J.: Modernity and housing production in France after WWII, Docomomo Journal, Iss. 65, 2021.

Adnan, A. B., Chik, T. N. T., and Baharudin, B.: Reinforced concrete frame building with timber roof, Housing Report No. 44, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100076.pdf, 2002.

Ahari, M. N. and Azarbakht, A.: Stonework building with wooden timber roof, Housing Report No. 114, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100111.pdf, 2005.

Al Dabbeek, J. N. and Al-Jawhari, A. H. W.: Reinforced concrete frame with infill walls designed for gravity loading, Housing Report No. 48, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100032.pdf, 2002a.

Al Dabbeek, J. N. and Al-Jawhari, A. H. W.: Unreinforced concrete and masonry bearing wall construction (designed for gravity loads only), Housing Report No. 49, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100023.pdf, 2002b.

Alghamdi, S., Tang, W., Kanjanabootra, S., and Alterman, D.: Effect of architectural building design parameters on thermal comfort and energy consumption in higher education buildings, Buildings, 12, 329, https://doi.org/10.3390/buildings12030329, 2022.

Ali, Q. and Muhammad, T.: Stone masonry residential buildings, Housing Report No. 138, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100145.pdf, 2007.

Ali, Q.: Unreinforced brick masonry residential building, Housing Report No. 112, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100109.pdf, 2006.

Alimoradi, A.: Steel frame with semi-rigid "Khorjini" connections and jack arch roof "Taagh-e-Zarbi", Housing Report No. 25, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100058.pdf, 2002.

Ansary, M.: Single-storey brick masonry house (EMSB1), Housing Report No. 91, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100098.pdf, 2003.

Arnold, C.: Wood frame single family house, Housing Report No. 65, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100034.pdf, 2002.

Awad, A., Bassam, H., and Talal, I.: Moment resisting frame designed for gravity loads only, Housing Report No. 60, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100027.pdf, 2002a.

Awad, A., Bassam, H., and Talal, I.: Reinforced concrete frame with concrete shear walls - dual system, Housing Report No. 59, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100026.pdf, 2002b.

Bartko, M. and Durica, P.: Experimental analysis of thermo-technical parameters of windows glazing in the pavilion laboratory, Buildings, 13, 1026, https://doi.org/10.3390/buildings13041026, 2023.

Begaliev, U. T. and Uranova, S.: Single-family brick masonry house, Housing Report No. 36, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100069.pdf, 2002.

Bekloo, N. T.: Earring system (Shekanj) in dome-roof structures with unreinforced brick and adobe materials, Housing Report No. 118, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100142.pdf, 2007.

Bocher, E., Bernard, J., Le Saux Wiederhold, E., Leconte, F., and Petit, G.: GeoClimate: a geospatial processing toolbox for environmental and climate studies, J. Open Source Softw., 6, 3541, https://doi.org/10.21105/joss.03541, 2021.

Boesch, O.: RT20XX. La réglementation thermique des bâtiments : une histoire compliquée, Tous urbains, 30-31, 36–38, https://doi.org/10.3917/tu.030.0036, 2020.

Bostenaru, M. D. and Sandu, I.: A single-family, two-storey house with brick walls and timber floors, Housing Report No. 84, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100092.pdf, 2002a.

Bostenaru, M. D. and Sandu, I.: One family one storey house, also called "wagon house", Housing Report No. 85, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100093.pdf, 2002b.

Bostenaru, M. D. and Sandu, I.: Reinforced concrete frame structure with diagonal bracing and brick infill walls, Housing Report No. 71, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100077.pdf, 2002c.

Bostenaru, M. D.: Early RC frame condominium building with masonry infill walls designed for gravity loads only, Housing Report No. 96, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100101.pdf, 2003.

Bostenaru, M. D.: Half-timbered house in the "border triangle" (Fachwerkhaus im Dreiländereck), Housing Report No. 108, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100106.pdf, 2004.

Brzev, S. N., Greene, M., and Sinha, R.: Rubble stone masonry walls with timber frame and timber roof, Housing Report No. 18, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100051.pdf, 2002.

Bueno, B., Norford, L., Pigeon, G., and Britter, R.: A resistance-capacitance network model for the analysis of the interactions between the energy performance of buildings and the urban climate, Build. Environ., 54, 116–125, 2012.

Chakraborty, T. C., Venter, Z. S., Demuzere, M., Zhan, W., Gao, J., Zhao, L., and Qian, Y.: Large disagreements in estimates of urban land across scales and their implications, Nat. Commun., 15, 9165, https://doi.org/10.1038/s41467-024-52241-5, 2024.

Charleson, A. W.: Reinforced Adobe, Housing Report No. 107, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100139.pdf, 2009.

Charleson, A.: Reinforced concrete frame and brick infill multi-storey apartment building, Housing Report No. 208, World Housing Encyclopedia, https://www.world-housing.net/wp-content/uploads/2024/09/record_208.pdf, 2020.

Cheng, Y., Zhao, L., Chakraborty, T. C., Oleson, K., Demuzere, M., Liu, X., Che, Y., Liao, W., Zhou, Y., and Li, X. C.: U-Surf: a global 1 km spatially continuous urban surface property dataset for kilometer-scale urban-resolving Earth system modeling, Earth Syst. Sci. Data, 17, 2147–2174, https://doi.org/10.5194/essd-17-2147-2025, 2025.

Choudhary, M., Jaiswal, K. S., and Sinha, R.: Traditional rural house in Kutch region of India (bhonga), Housing Report No. 72, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100080.pdf, 2002.

Clarke, R. P. and Ramnath, R.: Typical Single-Story Residential Construction Practices in Trinidad and Tobago, Housing Report No. 156, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100174.pdf, 2009.

D'Ayala, D. and Speranza, E.: Single-family stone masonry house, Housing Report No. 28, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100061.pdf, 2002.

D'Ayala, D., Speranza, E., and D'Ercole, F.: Single-family historic brick masonry house (Casa unifamiliare in centro storico, Centro Italia), Housing Report No. 29, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100062.pdf, 2002.

Daly, D., Harada, T., Tibbs, M., Cooper, P., Waitt, G., and Tartarini, F.: Indoor temperatures and energy use in NSW social housing, Energ. Buildings, 249, 111240, https://doi.org/10.1016/j.enbuild.2021.111240, 2021.

Das, A., Islam, M. S., Alam, D. M. J., and Hoque, N.: Mud House of Bangladesh, Housing Report No. 143, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100161.pdf, 2007.

de Carvalho Araujo, L., Masson, V., Schoetter, R., Wurtz, J., Le Bihan, A., and Bonhomme, M.: A global database on building architecture and construction materials for urban climate models, Zenodo [data set], https://doi.org/10.5281/zenodo.16096963, 2025.

de Munck, C., Pigeon, G., Masson, V., Meunier, F., Bousquet, P., Tréméac, B., Merchat, M., Poeuf, P., and Marchadier, C.: How much can air conditioning increase air temperatures for a city like Paris, France, Int. J. Climatol., https://doi.org/10.1002/joc.3415, 2012.

Demuzere, M., Bechtel, B., Middel, A., and Mills, G.: Mapping Europe into local climate zones, PLoS ONE, 14, e0214474, https://doi.org/10.1371/journal.pone.0214474, 2019.

Demuzere, M., Kittner, J., Martilli, A., Mills, G., Moede, C., Stewart, I. D., van Vliet, J., and Bechtel, B.: A global map of local climate zones to support earth system modelling and urban-scale environmental science, Earth Syst. Sci. Data, 14, 3835–3873, https://doi.org/10.5194/essd-14-3835-2022, 2022.

Dimitrijevic, R.: Precast, prestressed concrete frame structure with concrete shear walls, Housing Report No. 68, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100043.pdf, 2002.

European Environment Agency (EEA) and Copernicus Land Monitoring Service: Urban Atlas 2021 – Product User Manual version 1.0.2, 41 pp., https://library.land.copernicus.eu/products/Urban_Atlas_CLMS_UA2021_LULC_PUM_v1.pdf, 2026.

Faison, H., Comartin, C. D., and Elwood, K.: Reinforced Concrete Moment Frame Building without Seismic Details, Housing Report No. 111, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100108.pdf, 2004.

Farsi, M. and Lazzali, F.: Single-family reinforced concrete frame houses, Housing Report No. 103, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100105.pdf, 2003.

Farsi, M., Lazzali, F., and Ait-M, Y.: Stone masonry apartment building, Housing Report No. 75, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100084.pdf, 2002.

French, M. A.: Adobe with sawn timber roof framing and corrugated iron sheeting, Housing Report No. 136, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100149.pdf, 2007a.

French, M. A.: Adobe with timber and clay tile roof, Housing Report No. 134, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100147.pdf, 2007b.

Geotti-Bianchini, F. and Lohrengel, J.: Thermal conductivity of float glass at room temperature, Glastech. Ber., 66, 25–29, 1992.

Giuffrida, G., Caponetto, R., and Nocera, R.: Hygrothermal properties of raw earth materials: a literature review, Sustainability, 11, 5342, https://doi.org/10.3390/su11195342, 2019.

Gooding, T.: Low-income housing provision in Mauritius: improving social justice and place quality, Habitat Int., 53, 502–516, https://doi.org/10.1016/j.habitatint.2015.12.018, 2016.

Goretti, A., Malvolti, D., and Papa, S.: Brick masonry farmhouse with a "dead door", Housing Report No. 31, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100064.pdf, 2002.

Greene, M. and D'Ayala, D.: Final technical report: providing building data in support of PAGER, Earthquake Engineering Research Institute, https://world-housing.net/wp-content/uploads/pager/2009/06/FINAL_REPORT_BDLG_DATA_IN_SUPPORT_OF_PAGER.pdf, 2010.

Grimmond, C. S. B. et al.: Initial results from Phase 2 of the international urban energy balance model comparison, Int. J. Climatol., 31, 244–272, https://doi.org/10.1002/joc.2227, 2011.

Gulkan, P., Aschheim, M., and Spence, R.: Reinforced concrete frame building with masonry infills, Housing Report No. 64, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100031.pdf, 2002.

Hackmayer, L. C., Abrahamczyk, L., and Schwarz, J.: Reinforced Clay Brick Masonry Building, Housing Report No. 175, World Housing Encyclopedia, https://www.world-housing.net/wp-content/uploads/2013/12/Report_175_letter.pdf, 2013.

Haldi, F. and Robinson, D.: The impact of occupants' behaviour on building energy demand, J. Build. Perform. Simu., 4, 323–338, https://doi.org/10.1080/19401493.2011.558213, 2011.

Hashemi, B. H. and Ashtiany, M. G.: Semi-rigid steel frame with "Khorjinee" connections, Housing Report No. 26, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100059.pdf, 2002.

Hashemi, B. H., Alemi, F., and Ashtiany, M. G.: Confined brick masonry building with concrete tie columns and beams, Housing Report No. 27, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100060.pdf, 2002.

Hashmat Lodi, S., Sangi, A. J., and Abdullah, A.: Brick masonry construction in Pakistan, Housing Report No. 173, World Housing Encyclopedia, https://www.world-housing.net/wp-content/uploads/2013/12/WHE-report173_letter.pdf, 2013.

Hicyilmaz, K., Bothara, J. K., and Stephenson, M.: Dhajji Dewari, Housing Report No. 146, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100164.pdf, 2008.

IEE Project TABULA: Typology Approach for Building Stock Energy Assessment, https://episcope.eu/iee-project/tabula/ (last access: 23 August 2026), 2009–2012.

Itskov, I. E., Umarbayevich, A. M., and Chernov, N. B.: Prefabricated large panel concrete buildings with two interior longitudinal walls, Housing Report No. 32, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100065.pdf, 2002.

Jackson, T. L., Feddema, J. J., Oleson, K. W., Bonan, G. B., and Bauer, J. T.: Parameterization of urban characteristics for global climate modeling, Ann. Assoc. Am. Geogr., 100, 848–865, http://www.jstor.org/stable/40863606, 2010.

Jaiswal, K. S., Sinha, R., and Goyal, A.: Reinforced concrete frame building with masonry infill walls designed for gravity loads, Housing Report No. 19, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100052.pdf, 2002.

James-Chakraborty, K.: Postcolonial thought and the emergence of global architectural histories, Oxford Research Encyclopedia of Literature, https://doi.org/10.1093/acrefore/9780190201098.001.0001/acrefore-9780190201098-e-1282, 2021.

Kamath, H. G., Singh, M., Malviya, N., Martilli, A., He, L., Aliaga, D., He, C., Chen, F., Magruder, L. A., Yang, Z.-L., and Niyogi, D.: GLObal Building heights for Urban Studies (UT-GLOBUS) for city- and street-scale urban simulations: development and first applications, Sci. Data, 11, 886, https://doi.org/10.1038/s41597-024-03719-w, 2024.

Kaushik, H. and Babu, K. S. R.: Assam-type House, Housing Report No. 154, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100172.pdf, 2009.

Khan, A. A. and Moin K.: Unreinforced brick masonry walls in mud mortar with flat timber roof, Housing Report No. 20, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100053.pdf, 2002.

Khan, A. A.: Traditional Naga Type House, Housing Report No. 147, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100165.pdf, 2008.

Kikegawa, Y., Genchi, Y., Yoshikado, H., and Kondo, H.: Development of a numerical simulation system toward comprehensive assessments of urban warming countermeasures including their impacts on the urban buildings' energy-demands, Appl. Energ., 76, 449–466, https://doi.org/10.1016/S0306-2619(03)00009-6, 2003.

Klyachko, M., Benin, A., and Bogdanova, J.: Timber log building, Housing Report No. 56, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100022.pdf, 2002a.

Klyachko, M., Benin, A., and Bogdanova, J.: Wood panel wall buildings (typical seria 181-115-77 cm of "Giprolesprom"), Housing Report No. 57, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100024.pdf, 2002b.

Klyachko, M., Gordeev, Y., and Kolosova, F.: Large concrete block walls with reinforced concrete floors and roof (typical series: 1-306c, 1-307c, 114c), Housing Report No. 54, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100019.pdf, 2002c.

Klyachko, M., Gordeev, Y., and Kolosova, F.: Small concrete block masonry walls with concrete floors and roofs, Housing Report No. 53, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100017.pdf, 2002d.

Klyachko, M., Mortchikchin, I., and Nudga, I.: Large reinforced concrete panel buildings (Series 122, 135 and 1-464c), Housing Report No. 55, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100020.pdf, 2002e.

Kotthaus, S., Smith, T. E. L., Wooster, M. J., and Grimmond, C. S. B.: Derivation of an urban materials spectral library through emittance and reflectance spectroscopy, ISPRS J. Photogramm., 94, 194–212, https://doi.org/10.1016/j.isprsjprs.2014.05.005, 2014.

Koumousis, V.: Reinforced concrete frame building with an independent vertical extension, Housing Report No. 17, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100050.pdf, 2002.

Kumar, A. and Pundit, J.: Timber Frame Brick House with Attic, Housing Report No. 116, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100113.pdf, 2005.

Kumar, A.: Rural mud house with pitched roof, Housing Report No. 23, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100056.pdf, 2002b.

Kumar, A.: Unreinforced brick masonry walls with pitched clay tile roof, Housing Report No. 22, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100055.pdf, 2002a.

Labus, M., Labus, K., and Bujok, P.: Thermal parameters of roofing slates from Czech Republic, J. Therm. Anal. Calorim., 140, 2215–2223, https://doi.org/10.1007/s10973-019-08969-0, 2020.

Lambert, L.: Introduction: colonialism as a continuous process: architecture as a spatial apparatus, The Funambulist, https://thefunambulist.net/magazine/10-architecture-colonialism/introduction-colonialism-continuous-process-architecture-spatial-apparatus-leopold-lambert (last access: 19 May 2025), 2017.

Landis, J. R. and Koch, G. G.: The measurement of observer agreement for categorical data, Biometrics, 33, 159–174, https://doi.org/10.2307/2529310, 1977.

Lang, D., Amador, A., Holliday, L., and Armando, C. R. L.: Vivienda de Minifalda (Wooden houses with heavy bases), Housing Report No. 148, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100166.pdf, 2008.

Lang, D., Holliday, L., and Beleton, O. G. F.: Vivienda de Adobe (adobe brick houses), Housing Report No. 144, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100162.pdf, 2007.

Lang, K. and Bachmann, H.: Urban residential buildings of the 19th century in the city of Basel, Housing Report No. 119, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100146.pdf, 2007.

Lean, H. W. et al.: The hectometric modelling challenge: gaps in the current state of the art and ways forwards towards the implementation of 100 m scale weather and climate models, Q. J. Roy. Meteor. Soc., 150, 4671–4708, https://doi.org/10.1002/qj.4858, 2024.

Leggeri, M., Lacava, G., and Viola, E.: Reinforced concrete frame building, Housing Report No. 30, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100063.pdf, 2002.

Levtchitch, V.: Gravity-Designed Reinforced Concrete Frame Buildings with Unreinforced Masonry Infill Walls, Housing Report No. 13, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100046.pdf, 2002.

Li, X. C., Zhao, L., Oleson, K., Zhou, Y., Qin, Y., Zhang, K., and Fang, B.: Enhancing urban climate-energy modeling in the Community Earth System Model (CESM) through explicit representation of air-conditioning adoption, J. Adv. Model. Earth Sy., 16, e2023MS004107, https://doi.org/10.1029/2023MS004107, 2024.

Lipson, M. J. et al.: Evaluation of 30 urban land surface models in the Urban-PLUMBER project: Phase 1 results, Q. J. Roy. Meteor. Soc., 150, 126–169, https://doi.org/10.1002/qj.4589, 2024.

Loaiza F., C. and Blondet, M.: Confined masonry building, Housing Report No. 50, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100021.pdf, 2002a.

Loaiza F., C. and Blondet, M.: Confined masonry houses, Housing Report No. 51, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100012.pdf, 2002b.

Loaiza F., C., Blondet, M., and Ottazzi, G.: Adobe house, Housing Report No. 52, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100014.pdf, 2002.

Lodi, S. H., Sangi, A. J., and Abdullah, A.: Adobe houses, Housing Report No. 166, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100193.pdf, 2012.

Lodi, S. H., Sangi, A. J., and Abdullah, A.: Reinforced concrete buildings with masonry infills, Housing Report No. 167, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100192.pdf, 2013.

Lopez M., M. A., Bommer, J., and Benavidez, G.: Vivienda de Adobe (Adobe house), Housing Report No. 14, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100047.pdf, 2002.

Lucchi, E.: Energy and climatic performances of modern architecture: a complete overview of building physics implications, Eng. Proc., 53, 19, https://doi.org/10.3390/IOCBD2023-15203, 2023.

Lutman, M. and Tomazevic, M.: Confined brick masonry house, Housing Report No. 88, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100096.pdf, 2002a.

Lutman, M. and Tomazevic, M.: Unreinforced Brick Masonry Apartment Building, Housing Report No. 73, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100082.pdf, 2002b.

Légifrance: Décret n°2006-1147 du 14 septembre 2006 relatif au diagnostic de performance énergétique et à l'état de l'installation intérieure de gaz dans certains bâtiments, https://www.legifrance.gouv.fr/loda/id/JORFTEXT000000269759, 2006.

Maki, N. and Tanaka, S.: Single-family wooden house, Housing Report No. 86, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100094.pdf, 2002.

Maldonado, N. G. and Tornello, D. M. E.: Base Isolation of Confined Masonry, Housing Report No. 152, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100170.pdf, 2008.

Marhatta, Y. B., Bothara, J. K., Magar, M. B., and Chapagain, G.: Pillar walaghar (URM infilled RC frame buildings), Housing Report No. 145, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100163.pdf, 2007.

Martilli, A., Krayenhoff, E. S., and Nazarian, N.: Is the urban heat island intensity relevant for heat mitigation studies?, Urban Clim., 31, 100541, https://doi.org/10.1016/j.uclim.2019.100541, 2020.

Martin, J. A.: PC Frame Buildings (Series 1-451), Housing Report No. 202, World Housing Encyclopedia, https://www.world-housing.net/wp-content/uploads/2024/09/record_202.pdf, n.d.a.

Martin, J. A.: PC Large Panel Building (Large panel series 1-451LP), Housing Report No. 203, World Housing Encyclopedia, https://www.world-housing.net/wp-content/uploads/2024/09/record_203.pdf, n.d.b.

Martin, J. A.: Reinforced Masonry (Series 1A-450), Housing Report No. 204, World Housing Encyclopedia, https://www.world-housing.net/wp-content/uploads/2024/09/record_204.pdf, n.d.c.

Masson, V., Heldens, W., et al.: City-descriptive input data for urban climate models: model requirements, data sources and challenges, Urban Clim., 31, 100536, https://doi.org/10.1016/j.uclim.2019.100536, 2020.

Mehrain, M. and Naeim, F.: Adobe House, Housing Report No. 104, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100130.pdf, 2004.

Mejia, L. G.: Clay brick/concrete block masonry walls with concrete floors (predating seismic codes or with a few seismic features), Housing Report No. 12, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100041.pdf, 2002b.

Mejia, L. G.: Gravity Concrete Frame Buildings (Predating Seismic Codes), Housing Report No. 11, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100040.pdf, 2002a.

Mhedhbi, Z., Masson, V., Hidalgo, J., and Haouès-Jouve, S.: Collection of refined architectural parameters by crowdsourcing using Facebook social network: case of Greater Tunis, Urban Clim., https://doi.org/10.1016/j.uclim.2019.100499, 2019.

Mirrahimi, S., Mohamed, M. F., Haw, L. C., Ibrahim, N. L. N., Yusoff, W. F. M., and Aflaki, A.: The effect of building envelope on the thermal comfort and energy saving for high-rise buildings in hot–humid climate, Renew. Sust. Energ. Rev., 53, 1508–1519, 2016.

Morakinyo, O. M., Fagbamigbe, A. F., and Adebowale, A. S.: Decomposition of factors associated with housing material inequality in under-five deaths in low and middle-income countries, Arch. Public Health, 80, 13, https://doi.org/10.1186/s13690-021-00768-0, 2022.

Morejón Blanco, G., Leyva Chang, K., Candebat Sanchez, D., Rivera Alvarez, Z., Berenguer Heredia, Y., Villalon Semanat, M., Lang, D. H., and Meslem, A.: Low-ductile RC frame buildings (C1L, C1M), Housing Report No. 183, World Housing Encyclopedia, https://www.world-housing.net/wp-content/uploads/2024/09/record_183.pdf, 2016a.

Morejón Blanco, G., Leyva Chang, K., Candebat Sanchez, D., Rivera Alvarez, Z., Berenguer Heredia, Y., Villalon Semanat, M., Lang, D. H., and Meslem, A.: Non-ductile RC frame buildings (E-14), Housing Report No. 186, World Housing Encyclopedia, https://www.world-housing.net/wp-content/uploads/2024/09/record_186.pdf, 2016b.

Moroni, O., Gomez, C., and Astroza, M.: Buildings with hybrid masonry walls, Housing Report No. 8, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100036.pdf, 2002a.

Moroni, O., Gomez, C., and Astroza, M.: Confined block masonry building, Housing Report No. 7, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100035.pdf, 2002b.

Moroni, O., Gomez, C., and Astroza, M.: Reinforced Clay/Concrete Block Masonry Building, Housing Report No. 5, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100018.pdf, 2002c.

Muravljov, N. and Dimitrijevic, R.: Confined masonry building with concrete floor slabs, Housing Report No. 69, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100044.pdf, 2002.

Nazarian, N., Krayenhoff, E. S., Bechtel, B., Hondula, D. M., Paolini, R., Vanos, J., et al.: Integrated assessment of urban overheating impacts on human life, Earths Future, 10, https://doi.org/10.1029/2022EF002682, 2022.

Oke, T. R., Mills, G., Christen, A., and Voogt, J. A.: Urban Climates, Cambridge University Press, Cambridge, 525 pp., https://doi.org/10.1017/9781139016476, 2017.

Oleson, K. W., Bonan, G. B., Feddema, J., and Vertenstein, M.: An urban parameterization for a global climate model. Part II: sensitivity to input parameters and the simulated urban heat island in offline simulations, J. Appl. Meteorol. Clim., 47, 1061–1076, http://www.jstor.org/stable/26172202, 2008.

Parajuli, Y. K., Bothara, J. K., and Upadhyay, B. K.: Concrete-block masonry construction in Pakistan, Housing Report No. 174, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100200.pdf, 2012.

Parajuli, Y. K., Bothara, J. K., and Upadhyay, B. K.: Traditional oval-shaped rural stone house, Housing Report No. 47, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100081.pdf, 2002a.

Parajuli, Y. K., Bothara, J. K., and Upadhyay, B. K.: Uncoursed rubble stone masonry walls with timber floor and roof, Housing Report No. 74, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100083.pdf, 2002b.

Peel, M. C., Finlayson, B. L., and McMahon, T. A.: Updated world map of the Köppen-Geiger climate classification, Hydrol. Earth Syst. Sci. Discuss., 11, 1633–1644, 2007.

Pigeon, G., Zibouche, K., Bueno, B., Le Bras, J., and Masson, V.: Improving the capabilities of the Town Energy Balance model with up-to-date building energy simulation algorithms: an application to a set of representative buildings in Paris, Energ. Buildings, 76, 1–14, https://doi.org/10.1016/j.enbuild.2013.10.038, 2014.

Rahul, A., Sood, A., Singh, Y., and Lang, D.: Thathara houses in Himachal Pradesh, Housing Report No. 170, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100196.pdf, 2013.

Rautela, P., Joshi, G. C., Singh, Y., and Lang, D.: Timber-reinforced Stone Masonry (Koti Banal Architecture) of Uttarakhand and Himachal Pradesh, Northern India, Housing Report No. 150, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100168.pdf, 2008.

Redmond, L. and DesRoches, R.: Reinforced-concrete frame with lightly reinforced-masonry infill, Housing Report No. 164, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100189.pdf, 2012.

Rodriguez, V. I., Yacante, M. I., and Reiloba, S.: Confined Block Masonry House, Housing Report No. 1, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100011.pdf, 2002a.

Rodriguez, V. I., Yacante, M. I., and Reiloba, S.: Solid brick masonry house with composite hollow clay tile and concrete joist roof slabs, Housing Report No. 70, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100045.pdf, 2002c.

Rodriguez, V. I., Yacante, M. I., and Reiloba, S.: Traditional Adobe House with Reinforcement, Housing Report No. 2, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100013.pdf, 2002b.

Rodriguez, V. I., Yacante, M. I., and Reiloba, S.: Traditional adobe house without seismic features, Housing Report No. 89, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100097.pdf, 2003.

Roetzel, A., Tsangrassoulis, A., Dietrich, U., and Busching, S.: Context dependency of comfort and energy performance in mixed-mode offices, J. Build. Perform. Simu., 4, 303–322, https://doi.org/10.1080/19401493.2011.558212, 2011.

Saravan, G.: How did Soviet architecture reflect political and ideological values?, Parametric Architecture, https://parametric-architecture.com/soviet-architecture-political-ideological/ (last access: 19 May 2025), 2024.

Sassu, M. and Cei, C.: "Casa Torre" construction: multistory tower masonry with stone pillars and wood or arched beams, Housing Report No. 113, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100110.pdf, 2005.

Sassu, M. and Ngoma, I.: Rammed earth house with pitched roof (Nyumba yo dinda OR Nyumba ya mdindo), Housing Report No. 45, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100078.pdf, 2002a.

Sassu, M. and Ngoma, I.: Unburnt brick wall building with pitched roof (nyumba ya zidina), Housing Report No. 46, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100079.pdf, 2002b.

Schoetter, R., Caliot, C., Chung, T., Hogan, R. J., and Masson, V.: Quantification of uncertainties of radiative transfer calculation in urban canopy models, Bound.-Lay. Meteorol., https://doi.org/10.1007/s10546-023-00827-9, 2023.

Senave, M., Roels, S., Verbeke, S., Lambie, E., and Saelens, D.: Sensitivity of characterizing the heat loss coefficient through on-board monitoring: a case study analysis, Energies, 12, 3322, 2019.

Simpson, A.: The effect of moisture on the thermal property of a reed thatch roof during the UK heating season, Energ. Buildings, 257, 111777, https://doi.org/10.1016/j.enbuild.2021.111777, 2022.

Sinha, R. and Ambati, V. R.: Low-strength dressed stone masonry buildings, Housing Report No. 80, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100088.pdf, 2002.

Sinha, R. and Brzev, S. N.: Unreinforced brick masonry building with reinforced concrete roof slab, Housing Report No. 21, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100054.pdf, 2002.

Sood, A., Rahul, A., Singh, Y., and Lang, D. H.: Dry stone construction in Himachal Pradesh, Housing Report No. 172, World Housing Encyclopedia, https://www.world-housing.net/wp-content/uploads/2013/12/Report_172_letter.pdf, 2013.

Sood, A., Rahul, A., Singh, Y., and Lang, D. H.: Mud wall construction in Spiti Valley (Himachal Pradesh), Housing Report No. 171, World Housing Encyclopedia, https://www.world-housing.net/wp-content/uploads/2013/12/Report_171_letter.pdf, 2012.

Stewart, I. D. and Oke, T. R.: Local climate zones for urban temperature studies, B. Am. Meteorol. Soc., https://doi.org/10.1175/BAMS-D-11-00019.1, 2012.

Sun, Y., Zhang, C., Zhao, Y., Li, J., Ma, Y., and Zhu, C.: A systematic review on thermal environment and thermal comfort studies in Chinese residential buildings, Energ. Buildings, 291, 113134, https://doi.org/10.1016/j.enbuild.2023.113134, 2023.

Synnefa, A., Dandou, A., Santamouris, M., Tombrou, M., and Soulakellis, N.: On the use of cool materials as a heat island mitigation strategy, J. Appl. Meteorol. Clim., 47, 2846–2856, http://www.jstor.org/stable/26172775, 2008.

Tassios, T. P. and Syrmakezis, K.: Multistory reinforced concrete frame building, Housing Report No. 15, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100048.pdf, 2002.

Tornay, N., Schoetter, R., Bonhomme, M., Faraut, S., and Masson, V.: GENIUS: a methodology to define a detailed description of buildings for urban climate and building energy consumption simulations, Urban Clim., 20, 75–93, https://doi.org/10.1016/j.uclim.2017.03.002, 2017.

United Nations: Make cities and human settlements inclusive, safe, resilient and sustainable, SDG Indicators, https://unstats.un.org/sdgs/report/2023/goal-11/ (last access: 23 August 2026), 2023.

Uranova, S. and Begaliev, U. T.: Reinforced concrete frame buildings without beams (seria KUB), Housing Report No. 39, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100071.pdf, 2002.

Van Assche, K.: Review of Cities After the Fall of Communism: Reshaping Cultural Landscapes and European Identity, by J. Czaplicka, N. Gelazis, and B. Ruble, Can. Slavonic Pap., 53, 102–103, http://www.jstor.org/stable/25822295, 2011.

Van Oldenborgh, G. J., Wehner, M. F., Vautard, R., Otto, F. E. L., and Seneviratne, S. I.: Attributing and projecting heatwaves is hard: we can do better, Earths Future, 10, e2021EF002271, 2022.

Velasquez Jofre, D., Abrahamczyk, L., and Schwarz, J.: Confined and Internally Reinforced Concrete Block Masonry Building, Housing Report No. 161, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100186.pdf, 2011.

Ventura, C. E. and Kharrazi, M. H. K.: Single-family wood frame house, Housing Report No. 82, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100089.pdf, 2002.

Vetturini, R., Cleri, A., Mollailoli, F., and Bazzurro, P.: Unreinforced stone wall rural housing (upper income), Housing Report No. 120, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100143.pdf, 2007a.

Vetturini, R., Mollailoli, F., and Bazzurro, P.: Unreinforced stone wall rural housing (lower and middle income), Housing Report No. 121, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100144.pdf, 2007b.

Wang, Y., Shi, S., Zhou, Z., Guo, S., and Zhao, B.: Air infiltration rate distribution across Chinese five climate zones: a modelling study for rural residences, Build. Environ., 252, 111284, https://doi.org/10.1016/j.buildenv.2024.111284, 2024.

Webber, K. and Abrahamczyk, L.: Confined and internally-reinforced concrete block masonry, Housing Report No. 207, World Housing Encyclopedia, https://www.world-housing.net/wp-content/uploads/2024/09/record_207.pdf, 2020.

Wells, N. M. and Harris, J. D.: Housing quality, psychological distress, and the mediating role of social withdrawal: a longitudinal study of low-income women, J. Environ. Psychol., 27, 69–78, https://doi.org/10.1016/j.jenvp.2006.11.002, 2007.

Wijanto, S.: Unreinforced clay brick masonry house, Housing Report No. 24, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100057.pdf, 2002.

World Bank: Population, total (SP.POP.TOTL), World Development Indicators [data set], https://data.worldbank.org/indicator/SP.POP.TOTL (last access: 23 August 2026), 2026.

World Housing Encyclopedia: World Housing Encyclopedia – an EERI and IAEE project, https://www.world-housing.net/ (last access: 16 July 2025).

Yakut, A. and Gulkan, P.: Tunnel form building, Housing Report No. 101, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100104.pdf, 2003.

Zhou, F. L., Xu, Z. G., and Liu, W. G.: Multistory base-isolated brick masonry building with reinforced concrete floors and roof, Housing Report No. 9, World Housing Encyclopedia, https://www.world-housing.net/WHEReports/wh100037.pdf, 2002.

Zhu, X. X., Chen, S., Zhang, F., Shi, Y., and Wang, Y.: GlobalBuildingAtlas: an open global and complete dataset of building polygons, heights and LoD1 3D models, Earth Syst. Sci. Data, 17, 6647–6668, https://doi.org/10.5194/essd-17-6647-2025, 2025.

~~Abram, J. (2021). Modernity and housing production in France after WWII. *Docomomo Journal*, Iss 65.~~

~~Adnan, A. B., Chik, T. N. T., & Baharudin, B. (2002). *Reinforced concrete frame building with timber roof* (Housing Report No. 44). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100076.pdf~~

~~Ahari, M. N., & Azarbakht, A. (2005). *Stonework building with wooden timber roof* (Housing Report No. 114). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100111.pdf~~

~~Al Dabbeek, J. N., & Al-Jawhari, A. H. W. (2002a). *Reinforced concrete frame with infill walls designed for gravity loading* (Housing Report No. 48). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100032.pdf~~

~~Al Dabbeek, J. N., & Al-Jawhari, A. H. W. (2002b). *Unreinforced concrete and masonry bearing wall construction (designed for gravity loads only)* (Housing Report No. 49). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100023.pdf~~

~~Alghamdi, S., Tang, W., Kanjanabootra, S., & Alterman, D. (2022). Effect of Architectural Building Design Parameters on Thermal Comfort and Energy Consumption in Higher Education Buildings. *Buildings, 12*(3), 329. https://doi.org/10.3390/buildings12030329~~

~~Ali, Q. (2006). *Unreinforced brick masonry residential building* (Housing Report No. 112). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100109.pdf~~

~~Ali, Q., & Muhammad, T. (2007). *Stone masonry residential buildings* (Housing Report No. 138). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100145.pdf~~

~~Alimoradi, A. (2002). *Steel frame with semi-rigid "Khorjini" connections and jack arch roof "Taagh-e-Zarbi"* (Housing Report No. 25). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100058.pdf~~

~~Ansary, M. (2003). *Single-storey brick masonry house (EMSB1)* (Housing Report No. 91). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100098.pdf~~

~~Arnold, C. (2002). *Wood frame single family house* (Housing Report No. 65). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100034.pdf~~

~~Awad, A., Bassam, H., & Talal, I. (2002a). *Moment resisting frame designed for gravity loads only* (Housing Report No. 60). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100027.pdf~~

~~Awad, A., Bassam, H., & Talal, I. (2002b). *Reinforced concrete frame with concrete shear walls - dual system* (Housing Report No. 59). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100026.pdf~~

~~Bartko, M., & Durica, P. (2023). Experimental Analysis of Thermo-Technical Parameters of Windows Glazing in the Pavilion Laboratory. *Buildings*, 13, 1026. https://doi.org/10.3390/buildings13041026.~~

~~Begaliev, U. T., & Uranova, S. (2002). *Single-family brick masonry house* (Housing Report No. 36). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100069.pdf~~

~~Bekloo, N. T. (2007). *Earring system (Shekanj) in dome-roof structures with unreinforced brick and adobe materials* (Housing Report No. 118). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100142.pdf~~

~~Bocher, E., Bernard, J., Le Saux Wiederhold, E., Leconte, F., & Petit, G. (2021). GeoClimate: a Geospatial processing toolbox for environmental and climate studies. *Journal of Open Source Software,* 6(65), 3541. https://doi.org/10.21105/joss.03541~~

~~Boesch, O. (2020) . RT20XX. La réglementation thermique des bâtiments : une histoire compliquée. *Tous urbains*, 30-31(2), 36-38. https://doi.org/10.3917/tu.030.0036~~

~~Bostenaru, M. D., & Sandu, I. (2002a). *A single-family, two-storey house with brick walls and timber floors* (Housing Report No. 84). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100092.pdf~~

~~Bostenaru, M. D., & Sandu, I. (2002b). *One family one storey house, also called "wagon house"* (Housing Report No. 85). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100093.pdf~~

Formatted: No underline, Font color: Auto

~~Bostenaru, M. D., & Sandu, I. (2002c). *Reinforced concrete frame structure with diagonal bracing and brick infill walls* (Housing Report No. 71). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100077.pdf~~

~~Bostenaru, M. D. (2003). *Early RC frame condominium building with masonry infill walls designed for gravity loads only* (Housing Report No. 96). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100101.pdf~~

~~Bostenaru, M. D. (2004). *Half-timbered house in the "border triangle" (Fachwerkhaus im Dreiländereck)* (Housing Report No. 108). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100106.pdf~~

~~Bueno, B., Norford, L., Pigeon, G., & Britter, R. (2012). A resistance-capacitance network model for the analysis of the interactions between the energy performance of buildings and the urban climate, *Building and Environment,* 54, 116–125.~~

~~Brzev, S. N., Greene, M., & Sinha, R. (2002). *Rubble stone masonry walls with timber frame and timber roof* (Housing Report No. 18). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100051.pdf~~

~~Chakraborty, T. C., Venter, Z. S., Demuzere, M., Zhan, W., Gao, J., Zhao, L., & Qian, Y. (2024). Large disagreements in estimates of urban land across scales and their implications. *Nature Communications*, 15, 9165, https://doi.org/10.1038/s41467-024-52241-5.~~

~~Charleson, A. W. (2009). *Reinforced Adobe* (Housing Report No. 107). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100139.pdf~~

~~Charleson, A. (2020). *Reinforced concrete frame and brick infill multi-storey apartment building* (Housing Report No. 208). World Housing Encyclopedia. https://www.world-housing.net/wp-content/uploads/2024/09/record_208.pdf~~

~~Cheng, Y., Zhao, L., Chakraborty, T. C., Oleson, K., Demuzere, M., Liu, X., Che, Y., Liao, W., Zhou, Y., & Li, X. "C." (2025). U-Surf: a global 1 km spatially continuous urban surface property dataset for kilometer-scale urban-resolving Earth system modeling. *Earth System Science Data*, 17, 2147–2174, https://doi.org/10.5194/essd-17-2147-2025.~~

~~Choudhary, M., Jaiswal, K. S., & Sinha, R. (2002). *Traditional rural house in Kutch region of India (bhonga)* (Housing Report No. 72). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100080.pdf~~

~~Clarke, R. P., & Ramnath, R. (2009). *Typical Single-Story Residential Construction Practices in Trinidad and Tobago* (Housing Report No. 156). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100174.pdf~~

~~Daly, D., Harada, T., Tibbs, M., Cooper, P., Waitt, G., & Tartarini, F. (2021). Indoor temperatures and energy use in NSW social housing, *Energy and Buildings,* 249, 111240, https://doi.org/10.1016/j.enbuild.2021.111240~~

~~Das, A., Islam, M. S., Alam, D. M. J., & Hoque, N. (2007). *Mud House of Bangladesh* (Housing Report No. 143). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100161.pdf~~

~~D'Ayala, D., & Speranza, E. (2002). *Single-family stone masonry house* (Housing Report No. 28). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100061.pdf~~

~~D'Ayala, D., Speranza, E., & D'Ercole, F. (2002). *Single-family historic brick masonry house (Casa unifamiliare in centro storico, Centro Italia)* (Housing Report No. 29). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100062.pdf~~

~~de Carvalho Araujo, L., Masson, V., Schoetter, R., Wurtz, J., Le Bihan, A., & Bonhomme, M. (2025). A global database on building architecture and construction materials for urban climate models [Data set]. Zenodo. https://doi.org/10.5281/zenodo.16096963.~~

~~de Munck, C., Pigeon, G., Masson, V., Meunier, F., Bousquet, P., Tréméac, B., Merchat, M., Poeuf, P., & Marchadier, C. (2012). How much can air conditioning increase air temperatures for a city like Paris, France, *International Journal of Climatology*. https://doi.org/10.1002/joc.3415~~

~~Demuzere, M., Bechtel, B., Middel A., & Mills, G. (2019). Mapping Europe into local climate zones. *PLoS ONE,* 14(4), e0214474. https://doi.org/10.1371/journal.pone.0214474~~

~~Demuzere, M., Kittner, J., Martilli, A., Mills, G., Moede, C., Stewart, I. D., van Vliet, J., and Bechtel, B. (2022). A global map of local climate zones to support earth system modelling and urban-scale environmental science, Earth Syst. Sci. Data, 14, 3835–3873, https://doi.org/10.5194/essd-14-3835-2022~~

~~Dimitrijevic, R. (2002). *Precast, prestressed concrete frame structure with concrete shear walls* (Housing Report No. 68). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100043.pdf~~

~~European Environment Agency (EEA), Copernicus Land Monitoring Service (2026). Urban Atlas 2021 - Product User Manual version 1.0.2. 41 pages. https://library.land.copernicus.eu/products/Urban_Atlas_CLMS_UA2021_LULC_PUM_v1.pdf~~

~~Farsi, M., & Lazzali, F. (2003). *Single-family reinforced concrete frame houses* (Housing Report No. 103). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100105.pdf~~

~~Faison, H., Comartin, C. D., & Elwood, K. (2004). *Reinforced Concrete Moment Frame Building without Seismic Details* (Housing Report No. 111). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100108.pdf~~

~~Farsi, M., Lazzali, F., & Ait-M, Y. (2002). *Stone masonry apartment building* (Housing Report No. 75). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100084.pdf~~

~~French, M. A. (2007a). *Adobe with sawn timber roof framing and corrugated iron sheeting* (Housing Report No. 136). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100149.pdf~~

~~French, M. A. (2007b). *Adobe with timber and clay tile roof* (Housing Report No. 134). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100147.pdf~~

~~Geotti-Bianchini, F., & Lohrengel, J. (1992). Thermal conductivity of float glass at room temperature. *Glastechnische Berichte*, 66 (2), 25-29.~~

~~Giuffrida, G., Caponetto, R., & Nocera, R. (2019). Hygrothermal properties of raw earth materials: A literature review. *Sustainability*, 11, 5342, https://doi.org/doi:10.3390/su11195342.~~

~~Gooding, T. (2016). Low-income housing provision in Mauritius: Improving social justice and place quality, Habitat International, Volume 53, Pages 502-516, ISSN 0197-3975, https://doi.org/10.1016/j.habitatint.2015.12.018.~~

~~Goretti, A., Malvolti, D., & Papa, S. (2002). *Brick masonry farmhouse with a "dead door"* (Housing Report No. 31). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100064.pdf~~

~~Greene M., & D'Ayala D. (2010). Final technical report: Providing building data in support of Pager. Submitted to the U.S. Geological Survey. Under the National Earthquake Hazards Reduction Program. Earthquake Engineering Research Institute.~~

~~Grimmond, C. S. B. et al. (2011). Initial results from Phase 2 of the international urban energy balance model comparison. *International Journal of Climatology*, 31, 244-272, https://doi.org/10.1002/joc.2227.~~

~~Gulkan, P., Aschheim, M., & Spence, R. (2002). *Reinforced concrete frame building with masonry infills* (Housing Report No. 64). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100031.pdf~~

~~Hackmayer, L. C., Abrahamczyk, L., & Schwarz, J. (2013). *Reinforced Clay Brick Masonry Building* (Housing Report No. 175). World Housing Encyclopedia. https://www.world-housing.net/wp-content/uploads/2013/12/Report_175_letter.pdf~~

~~Haldi, F., & Robinson, D. (2011). The impact of occupant's behaviour on building energy demand. *Journal of Building Performance Simulation*, 4:4, 323-338, http://dx.doi.org/10.1080/19401493.2011.558213.~~

~~Hashemi, B. H., & Ashtiany, M. G. (2002). *Semi-rigid steel frame with "Khorjinee" connections* (Housing Report No. 26). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100059.pdf~~

~~Hashemi, B. H., Alemi, F., & Ashtiany, M. G. (2002). *Confined brick masonry building with concrete tie columns and beams* (Housing Report No. 27). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100060.pdf~~

~~Hashmat Lodi, S., Sangi, A. J., & Abdullah, A. (2013). *Brick masonry construction in Pakistan* (Housing Report No. 173). World Housing Encyclopedia. https://www.world-housing.net/wp-content/uploads/2013/12/WHE-report173_letter.pdf~~

~~Hicyilmaz, K., Bothara, J. K., & Stephenson, M. (2008). *Dhajji Dewari* (Housing Report No. 146). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100164.pdf~~

~~IEE Project TABULA (2009 - 2012). Typology Approach for Building Stock Energy Assessment. https://episcope.eu/iee-project/tabula/~~

~~Itskov, I. E., Umarbayevich, A. M., & Chernov, N. B. (2002). *Prefabricated large panel concrete buildings with two interior longitudinal walls* (Housing Report No. 32). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100065.pdf~~

~~Jackson, T. L., Feddema, J. J., Oleson, K. W., Bonan, G. B., & Bauer, J. T. (2010). Parameterization of Urban Characteristics for Global Climate Modeling. *Annals of the Association of American Geographers*, *100*(4), 848–865. http://www.jstor.org/stable/40863606.~~

~~Jaiswal, K. S., Sinha, R., & Goyal, A. (2002). *Reinforced concrete frame building with masonry infill walls designed for gravity loads* (Housing Report No. 19). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100052.pdf~~

~~James-Chakraborty, K. (2021). Postcolonial Thought and the Emergence of Global Architectural Histories. *Oxford Research Encyclopedia of Literature.* https://oxfordre.com/literature/view/10.1093/acrefore/9780190201098.001.0001/acrefore-9780190201098-e-1282~~

~~Kamath, H. G., Singh, M., Malviya, N., Martilli, A., He, L., Aliaga, D., He, C., Chen, F., Magruder, L. A., Yang, Z. L., & Niyogi, D. (2024). GLObal Building heights for Urban Studies (UT-GLOBUS) for city- and street-scale urban simulations: Development and first applications. *Scientific Data*, 11:886, https://doi.org/10.1038/s41597-024-03719-w.~~

~~Kaushik, H., & Babu, K. S. R. (2009). *Assam-type House* (Housing Report No. 154). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100172.pdf~~

~~Khan, A. A. & Moin K. (2002). *Unreinforced brick masonry walls in mud mortar with flat timber roof* (Housing Report No. 20). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100053.pdf~~

~~Khan, A. A. (2008). *Traditional Naga Type House* (Housing Report No. 147). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100165.pdf~~

~~Kikegawa, Y., Genchi, Y., Yoshikado, H., & Kondo, H. (2003). Development of a numerical simulation system toward comprehensive assessments of urban warming countermeasures including their impacts on the urban buildings's energy-demands. *Applied Energy*, 76, 449-466. https://doi.org/10.1016/S0306-2619(03)00009-6.~~

~~Klyachko, M., Benin, A., & Bogdanova, J. (2002a). *Timber log building* (Housing Report No. 56). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100022.pdf~~

~~Klyachko, M., Benin, A., & Bogdanova, J. (2002b). *Wood panel wall buildings (typical seria 181-115- 77 cm of "Giprolesprom")* (Housing Report No. 57). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100024.pdf~~

~~Klyachko, M., Gordeev, Y., & Kolosova, F. (2002c). *Large concrete block walls with reinforced concrete floors and roof (typical series: 1-306c, 1- 307c, 114c)* (Housing Report No. 54). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100019.pdf~~

~~Klyachko, M., Gordeev, Y., & Kolosova, F. (2002d). *Small concrete block masonry walls with concrete floors and roofs* (Housing Report No. 53). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100017.pdf~~

~~Klyachko, M., Mortchikchin, I., & Nudga, I. (2002e). *Large reinforced concrete panel buildings (Series 122, 135 and 1-464c)* (Housing Report No. 55). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100020.pdf~~

~~Kotthaus, S., Smith, T. E. L., Wooster, M. J., & Grimmond, C. S. B. (2014). Derivation of an urban materials spectral library through emittance and reflectance spectroscopy. ISPRS Journal of Photogrammetry and Remote Sensing, 94, 194-212. http://dx.doi.org/10.1016/j.isprsjprs.2014.05.005.~~

~~Koumousis, V. (2002). *Reinforced concrete frame building with an independent vertical extension* (Housing Report No. 17). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100050.pdf~~

~~Kumar, A. (2002a). *Unreinforced brick masonry walls with pitched clay tile roof* (Housing Report No. 22). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100055.pdf~~

~~Kumar, A. (2002b). *Rural mud house with pitched roof* (Housing Report No. 23). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100056.pdf~~

~~Kumar, A., & Pundit, J. (2005). *Timber Frame Brick House with Attic* (Housing Report No. 116). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100113.pdf~~

~~Labus, M., Labus, K., & Bujok, P. (2020). Thermal parameters of roofing slates from Czech Republic. *Journal of Thermal Analysis and Calorimetry*, 140, 2215–2223. https://doi.org/10.1007/s10973-019-08969-0.~~

~~Landis, J. R., & Koch, G. G. (1977). The Measurement of Observer Agreement for Categorical Data. *Biometrics*, *33*(1), 159–174. https://doi.org/10.2307/2529310~~

~~Lang, D., Holliday, L., & Beleton, O. G. F. (2007). *Vivienda de Adobe (adobe brick houses)* (Housing Report No. 144). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100162.pdf~~

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~~Lang, D., Amador, A., Holliday, L., & Armando, C. R. L. (2008). *Vivienda de Minifalda (Wooden houses with heavy bases)* (Housing Report No. 148). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100166.pdf~~

~~Lang, K., & Bachmann, H. (2007). *Urban residential buildings of the 19th century in the city of Basel* (Housing Report No. 119). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100146.pdf~~

~~Lambert, L. (2017). Introduction: Colonialism as a Continuous Process: Architecture as a Spatial Apparatus. *The Funambulist*. Retrieved May 19, 2025, from https://thefunambulist.net/magazine/10-architecture-colonialism/introduction-colonialism-continuous-process-architecture-spatial-apparatus-leopold-lambert~~

~~Leggeri, M., Lacava, G., & Viola, E. (2002). *Reinforced concrete frame building* (Housing Report No. 30). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100063.pdf~~

~~Légifrance. (2006). Décret n°2006-1147 du 14 septembre 2006 relatif au diagnostic de performance énergétique et à l'état de l'installation intérieure de gaz dans certains bâtiments. https://www.legifrance.gouv.fr/loda/id/JORFTEXT000000269759~~

~~Levtchitch, V. (2002). *Gravity-Designed Reinforced Concrete Frame Buildings with Unreinforced Masonry Infill Walls* (Housing Report No. 13). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100046.pdf~~

~~Li, X. "C.", Zhao, L., Oleson, K., Zhou, Y., Qin, Y., Zhang, K., & Fang, B. (2024). Enhancing urban climate-energy modeling in the Community Earth System Model (CESM) through explicit representation of air-conditioning adoption. *Journal of Advances in Modeling Earth Systems*, 16, e2023MS004107. https://doi.org/10.1029/2023MS004107.~~

~~Lipson, M. J. et al. (2024). Evaluation of 30 urban land surface models in theUrban-PLUMBER project: Phase 1 results. *Quarterly Journal of the Royal Meteorological Society*, 150(758), 126–169. doi: 10.1002/qj.4589~~

~~Lean, H. W. et al. (2024). The hectometric modelling challenge: Gaps in the current state of the art and ways forwards towards the implementation of 100-m scale weather and climate models. *Quarterly Journal of the Royal Meteorological Society*, 150, 4671–4708, https://doi.org/10.1002/qj.4858.~~

~~Loaiza F., C., & Blondet, M. (2002a). *Confined masonry building* (Housing Report No. 50). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100021.pdf~~

~~Loaiza F., C., & Blondet, M. (2002b). *Confined masonry houses* (Housing Report No. 51). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100012.pdf~~

~~Loaiza F., C., Blondet, M., & Ottazzi, G. (2002). *Adobe house* (Housing Report No. 52). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100014.pdf~~

~~Lodi, S. H., Sangi, A. J., & Abdullah, A. (2012). *Adobe houses* (Housing Report No. 166). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100193.pdf~~

~~Lodi, S. H., Sangi, A. J., & Abdullah, A. (2013). *Reinforced concrete buildings with masonry infills* (Housing Report No. 167). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100192.pdf~~

~~Lopez M., M. A., Bommer, J., & Benavidez, G. (2002). *Vivienda de Adobe (Adobe house)* (Housing Report No. 14). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100047.pdf~~

~~Lucchi, Elena. (2023). Energy and Climatic Performances of Modern Architecture: A Complete Overview of Building Physics Implications. *Engineering Proceedings* 53, no. 1: 19. https://doi.org/10.3390/IOCBD2023-15203~~

~~Lutman, M., & Tomazevic, M. (2002a). *Confined brick masonry house* (Housing Report No. 88). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100096.pdf~~

~~Lutman, M., & Tomazevic, M. (2002b). *Unreinforced Brick Masonry Apartment Building* (Housing Report No. 73). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100082.pdf~~

~~Maki, N., & Tanaka, S. (2002). *Single-family wooden house* (Housing Report No. 86). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100094.pdf~~

~~Maldonado, N. G., & Tornello, D. M. E. (2008). *Base Isolation of Confined Masonry* (Housing Report No. 152). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100170.pdf~~

~~Marhatta, Y. B., Bothara, J. K., Magar, M. B., & Chapagain, G. (2007). *Pillar walaghar (URM infilled RC frame buildings)* (Housing Report No. 145). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100163.pdf~~

~~Martilli A., E. S. Krayenhoff, N. Nazarian (2020): Is the Urban Heat Island intensity relevant for heat mitigation studies? *Urban Climate*, Volume 31, 10.1016/j.uclim.2019.100541~~

~~Martin, J. A. (n.d.a). *PC Frame Buildings (Series 1-451)* (Housing Report No. 202). World Housing Encyclopedia. https://www.world-housing.net/wp-content/uploads/2024/09/record_202.pdf~~

~~Martin, J. A. (n.d.b). *PC Large Panel Building (Large panel series 1-451LP)* (Housing Report No. 203). World Housing Encyclopedia. https://www.world-housing.net/wp-content/uploads/2024/09/record_203.pdf~~

~~Martin, J. A. (n.d.c). *Reinforced Masonry (Series 1A-450)* (Housing Report No. 204). World Housing Encyclopedia. https://www.world-housing.net/wp-content/uploads/2024/09/record_204.pdf~~

~~Masson, V., W. Heldens, et al. (2020). City-descriptive input data for urban climate models: Model requirements, data sources and challenges. *Urban Climate*, 31, 100536. doi: 10.1016/j.uclim.2019.100536~~

~~Mehrain, M., & Naeim, F. (2004). *Adobe House* (Housing Report No. 104). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100130.pdf~~

~~Mejia, L. G. (2002a). *Gravity Concrete Frame Buildings (Predating Seismic Codes)* (Housing Report No. 11). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100040.pdf~~

~~Mejia, L. G. (2002b). *Clay brick/concrete block masonry walls with concrete floors (predating seismic codes or with a few seismic features)* (Housing Report No. 12). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100041.pdf~~

~~Mhedhbi, Z., Masson, V., Hidalgo, J., Haouès-Jouve, S. (2019). Collection of refined architectural parameters by crowdsourcing using Facebook social network: case of Greater Tunis. *Urban Climate.* DOI : 10.1016/j.uclim.2019.100499~~

~~Mirrahimi, S., Mohamed, M. F., Haw, L. C., Ibrahim, N. L. N., Yusoff, W. F. M., & Aflaki, A. (2016). The effect of building envelope on the thermal comfort and energy saving for high-rise buildings in hot–humid climate. *Renewable and Sustainable Energy Reviews*, *53*, 1508-1519.~~

~~Morakinyo, O.M., Fagbamigbe, A.F. & Adebowale, A.S. (2022). Decomposition of factors associated with housing material inequality in under-five deaths in low and middle-income countries. *Arch Public Health* 80, 13. https://doi.org/10.1186/s13690-021-00768-0~~

~~Morejón Blanco, G., Leyva Chang, K., Candebat Sanchez, D., Rivera Alvarez, Z., Berenguer Heredia, Y., Villalon Semanat, M., Lang, D. H., & Meslem, A. (2016a). *Low-ductile RC frame buildings (C1L, C1M)* (Housing Report No. 183). World Housing Encyclopedia. https://www.world-housing.net/wp-content/uploads/2024/09/record_183.pdf~~

~~Morejón Blanco, G., Leyva Chang, K., Candebat Sanchez, D., Rivera Alvarez, Z., Berenguer Heredia, Y., Villalon Semanat, M., Lang, D. H., & Meslem, A. (2016b). *Non-ductile RC frame buildings (E-14)* (Housing Report No. 186). World Housing Encyclopedia. https://www.world-housing.net/wp-content/uploads/2024/09/record_186.pdf~~

~~Moroni, O., Gomez, C., & Astroza, M. (2002a). *Buildings with hybrid masonry walls* (Housing Report No. 8). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100036.pdf~~

~~Moroni, O., Gomez, C., & Astroza, M. (2002b). *Confined block masonry building* (Housing Report No. 7). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100035.pdf~~

~~Moroni, O., Gomez, C., & Astroza, M. (2002c). *Reinforced Clay/Concrete Block Masonry Building* (Housing Report No. 5). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100018.pdf~~

~~Muravljov, N., & Dimitrijevic, R. (2002). *Confined masonry building with concrete floor slabs* (Housing Report No. 69). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100044.pdf~~

~~Nazarian, N., Krayenhoff, E. S., Bechtel, B., Hondula, D. M., Paolini, R., Vanos, J., et al. (2022). Integrated assessment of urban overheating impacts on human life. *Earth's Future*, 10, 10.1029/2022EF002682~~

~~Oleson, K. W., Bonan, G. B., Feddema, J., & Vertenstein, M. (2008). An Urban Parameterization for a Global Climate Model. Part II: Sensitivity to Input Parameters and the Simulated Urban Heat Island in Offline Simulations. *Journal of Applied Meteorology and Climatology,* 47(4), 1061-1076. http://www.jstor.org/stable/26172202~~

~~Oke, T. R., Mills, G., Christen, A., & Voogt, J. A. (2017). *Urban Climates*. Cambridge: Cambridge University Press. 525 pages. https://doi.org/10.1017/9781139016476~~

~~Parajuli, Y. K., Bothara, J. K., & Upadhyay, B. K. (2002a). *Traditional oval-shaped rural stone house* (Housing Report No. 47). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100081.pdf~~

~~Parajuli, Y. K., Bothara, J. K., & Upadhyay, B. K. (2002b). *Uncoursed rubble stone masonry walls with timber floor and roof* (Housing Report No. 74). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100083.pdf~~

~~Parajuli, Y. K., Bothara, J. K., & Upadhyay, B. K. (2012). *Concrete-block masonry construction in Pakistan* (Housing Report No. 174). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100200.pdf~~

~~Peel, M. C., Finlayson, B. L., Mcmahon, T. A. (2007). Updated world map of the Köppen-Geiger climate classification. *Hydrology and Earth System Sciences Discussions*, 11 (5), pp.1633-1644.~~

~~Rodriguez, V. I., Yacante, M. I., & Reiloba, S. (2002a). *Confined Block Masonry House* (Housing Report No. 1). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100011.pdf~~

~~Pigeon, G., Zibouche, K., Bueno, B., Le Bras, J., & Masson, V. (2014). Improving the capabilities of the Town Energy Balance model with up-to-date building energy simulation algorithms: an application to a set of representative buildings in Paris. *Energy and Buildings*, 76, 1-14, https://doi.org/10.1016/j.enbuild.2013.10.038.~~

~~Rahul, A., Sood, A., Singh, Y., & Lang, D. (2013). *Thathara houses in Himachal Pradesh* (Housing Report No. 170). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100196.pdf~~

~~Rautela, P., Joshi, G. C., Singh, Y., & Lang, D. (2008). *Timber-reinforced Stone Masonry (Koti Banal Architecture) of Uttarakhand and Himachal Pradesh, Northern India* (Housing Report No. 150). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100168.pdf~~

~~Redmond, L., & DesRoches, R. (2012). *Reinforced-concrete frame with lightly reinforced-masonry infill* (Housing Report No. 164). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100189.pdf~~

~~Rodriguez, V. I., Yacante, M. I., & Reiloba, S. (2002b). *Traditional Adobe House with Reinforcement* (Housing Report No. 2). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100013.pdf~~

~~Rodriguez, V. I., Yacante, M. I., & Reiloba, S. (2002c). *Solid brick masonry house with composite hollow clay tile and concrete joist roof slabs* (Housing Report No. 70). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100045.pdf~~

~~Rodriguez, V. I., Yacante, M. I., & Reiloba, S. (2003). *Traditional adobe house without seismic features* (Housing Report No. 89). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100097.pdf~~

~~Roetzel, A., Tsangrassoulis, A., Dietrich, U., & Busching, S. (2011). Context dependency of comfort and energy performance in mixed-mode offices. *Journal of Building Performance Simulation*, 4:4, 303-322, http://dx.doi.org/10.1080/19401493.2011.558212~~

~~Saravan, G. Parametric Architecture. (2024). How did Soviet Architecture Reflect Political and Ideological Values? Parametric Architecture. Retrieved May 19, 2025, from https://parametric-architecture.com/soviet-architecture-political-ideological/~~

~~Sassu, M., & Cei, C. (2005). *"Casa Torre" construction: multistory tower masonry with stone pillars and wood or arched beams* (Housing Report No. 113). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100110.pdf~~

~~Sassu, M., & Ngoma, I. (2002a). *Rammed earth house with pitched roof (Nyumba yo dinda OR Nyumba ya mdindo)* (Housing Report No. 45). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100078.pdf~~

~~Sassu, M., & Ngoma, I. (2002b). *Unburnt brick wall building with pitched roof (nyumba ya zidina)* (Housing Report No. 46). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100079.pdf~~

~~Senave, M., Roels, S., Verbeke, S., Lambie, E., & Saelens, D. (2019). Sensitivity of characterizing the heat loss coefficient through on-board monitoring: A case study analysis. *Energies*, 12, 3322, 08.~~

~~Schoetter, R., Caliot, C., Chung, T., Hogan R.J., Masson, V. (2023) Quantification of uncertainties of radiative transfer calculation in urban canopy models. *Boundary-Layer Meteorology,* https://doi.org/10.1007/s10546-023-00827-9~~

~~Sinha, R., & Ambati, V. R. (2002). *Low-strength dressed stone masonry buildings* (Housing Report No. 80). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100088.pdf~~

~~Simpson, A. (2022). The effect of moisture on the thermal property of a reed thatch roof during the UK heating season. *Energy and Buildings*, 257, 111777. https://doi.org/10.1016/j.enbuild.2021.111777.~~

~~Sinha, R., & Brzev, S. N. (2002). *Unreinforced brick masonry building with reinforced concrete roof slab* (Housing Report No. 21). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100054.pdf~~

~~Sood, A., Rahul, A., Singh, Y., & Lang, D. H. (2012). *Mud wall construction in Spiti Valley (Himachal Pradesh)* (Housing Report No. 171). World Housing Encyclopedia. https://www.world-housing.net/wp-content/uploads/2013/12/Report_171_letter.pdf~~

~~Sood, A., Rahul, A., Singh, Y., & Lang, D. H. (2013). *Dry stone construction in Himachal Pradesh* (Housing Report No. 172). World Housing Encyclopedia. https://www.world-housing.net/wp-content/uploads/2013/12/Report_172_letter.pdf~~

~~Stewart, I. D. and T. R. Oke. (2012). Local Climate Zones for Urban Temperature Studies. doi: 10.1175/BAMS-D-11-00019.1~~

~~Sun, Y., Zhang, C., Zhao, Y., Li, J., Ma, Y., & Zhu, C. (2023). A systematic review on thermal environment and thermal comfort studies in Chinese residential buildings. *Energy and Buildings*, *291*, 113134. https://doi.org/10.1016/j.enbuild.2023.113134~~

~~Synnefa, A., Dandou, A., Santamouris, M., Tombrou, M., & Soulakellis, N. (2008). On the Use of Cool Materials as a Heat Island Mitigation Strategy. *Journal of Applied Meteorology and Climatology*, *47*(11), 2846-2856. http://www.jstor.org/stable/26172775~~

~~Tassios, T. P., & Syrmakezis, K. (2002). *Multistory reinforced concrete frame building* (Housing Report No. 15). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100048.pdf~~

~~Tornay, N., Schoetter, R., Bonhomme, M., Faraut, S., & Masson, V. (2017). GENIUS: A methodology to define a detailed description of buildings for urban climate and building energy consumption simulations. *Urban Climate*, *20*, 75-93. https://doi.org/10.1016/j.uclim.2017.03.002~~

~~United Nations. (2023). Make cities and human settlements inclusive, safe, resilient and sustainable. SDG Indicators. https://unstats.un.org/sdgs/report/2023/goal-11/~~

~~Uranova, S., & Begaliev, U. T. (2002). *Reinforced concrete frame buildings without beams (seria KUB)* (Housing Report No. 39). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100071.pdf~~

~~Van Assche, K. (2011). [Review of *Cities After the Fall of Communism. Reshaping Cultural Landscapes and European Identity*, by J. Czaplicka, N. Gelazis, & B. Ruble]. *Canadian Slavonic Papers / Revue Canadienne Des Slavistes*, *53*(1), 102–103. http://www.jstor.org/stable/25822295~~

~~Van Oldenborgh G.J., Wehner M.F., Vautard R., Otto F.E.L., & Seneviratne S.I.. (2022). Attributing and projecting heatwaves is hard: We can do better. *Earth's Future,* 10(6):e2021EF002271~~

~~Velasquez Jofre, D., Abrahamczyk, L., & Schwarz, J. (2011). *Confined and Internally Reinforced Concrete Block Masonry Building* (Housing Report No. 161). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100186.pdf~~

~~Ventura, C. E., & Kharrazi, M. H. K. (2002). *Single-family wood frame house* (Housing Report No. 82). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100089.pdf~~

~~Vetturini, R., Cleri, A., Mollailoli, F., & Bazzurro, P. (2007a). *Unreinforced stone wall rural housing (upper income)* (Housing Report No. 120). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100143.pdf~~

~~Vetturini, R., Mollailoli, F., & Bazzurro, P. (2007b). *Unreinforced stone wall rural housing (lower and middle income)* (Housing Report No. 121). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100144.pdf~~

~~Wang, Y., Shi, S., Zhou, Z., Guo, S., & Zhao, B. (2024). Air infiltration rate distribution across Chinese five climate zones: A modelling study for rural residences, Building and Environment, Volume 252, 111284, ISSN 0360-1323, https://doi.org/10.1016/j.buildenv.2024.111284.~~

~~Webber, K., & Abrahamczyk, L. (2020). *Confined and internally-reinforced concrete block masonry* (Housing Report No. 207). World Housing Encyclopedia. https://www.world-housing.net/wp-content/uploads/2024/09/record_207.pdf~~

~~Wells, N.M., & Harris, J.D. (2007). Housing quality, psychological distress, and the mediating role of social withdrawal: A longitudinal study of low-income women, Journal of Environmental Psychology, Volume 27, Issue 1, 2007, Pages 69-78, ISSN 0272-4944, https://doi.org/10.1016/j.jenvp.2006.11.002.~~

~~Wijanto, S. (2002). *Unreinforced clay brick masonry house* (Housing Report No. 24). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100057.pdf~~

~~World Housing Encyclopedia. (n.d.). *World Housing Encyclopedia – An EERI and IAEE Project*. Retrieved July 16, 2025, from https://www.world-housing.net/~~

~~Yakut, A., & Gulkan, P. (2003). *Tunnel form building* (Housing Report No. 101). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100104.pdf~~

~~Zhou, F. L., Xu, Z. G., & Liu, W. G. (2002). *Multistory base-isolated brick masonry building with reinforced concrete floors and roof* (Housing Report No. 9). World Housing Encyclopedia. https://www.world-housing.net/WHEReports/wh100037.pdf~~

~~Zhu, X. X., Chen, S., Zhang, F., Shi, Y., & Wang, Y. (2025). GlobalBuildingAtlas: an open global and complete dataset of building polygons, heights and LoD1 3D models. *Earth System Science Data*, 17, 6647–6668,~~

~~https://doi.org/10.5194/essd-17-6647-2025.~~