SURVEY OF BUILDINGS IN BRNO 2018–2020

METHODOLOGY

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INTRODUCTION

The survey of buildings in Brno carried out in the years 2018 to 2020 aimed to find out the necessary information about the structure and usage of individual buildings. It was designed to refine information from existing secondary data sources (e.g. RUIAN – Registry of Territorial Identification, Addresses and Real Estate, SLDB 2011 – Census), update them and add missing or new data. The survey was organised and coordinated by the Brno City Chief Architect's Office (KAM).

However, the purpose of the survey is not to record data on individual buildings, but to establish a geodatabase that will allow analyses of the city's urban and functional structure. The data obtained have added value especially for analyses and evaluations of the urban structure at the level of streets, blocks and city districts. For this reason, the results of the survey cannot be considered as a technical documentation (inventory) of buildings used for building management, but rather a basis for the needs of spatial and strategic planning. The data are also used to create a 3D model of Brno.

METHODOLOGY

The methodology contains the workflow in creating the final layer of buildings in Brno in 2020. It is divided into several parts. Each of them is individually described. The primary environment for layer creation are ArcGIS Pro and Jupyter Notebooks. Python programming language was used for data processing and checking the results.

The survey was conducted on the layer of buildings from 2018 and was supplemented by buildings from 2020. Buildings that have been demolished in the meantime have been removed from the layer. At the same time, the buildings were manually segmented into partial segments according to different heights and types of roofs. The basic 3D city model of Brno from 2017 and information from the survey were used for the segmentation.

The survey consisted of several steps:

1. DETERMINATION OF ATTRIBUTES TO BE SURVEYED

The basic input parameter is the type and nature of the surveyed information. The survey methodology was determined based on the defined attributes.

Table 1 Attributes entering the survey of buildings

Type of information	Attribute	Category
Floor area ratio	Number of above-ground floors	number
	Number of roof-level floors	number
	Number of terraced floors	number
	Number of floors in a slope	number
	Roof type	used attic
		sloping roof
		flat roof
		combination
Usage	Usage of the 1st floor	list of functional uses*
	Share in the total gross floor area of the 1st floor	percentage
	Usage of the 2nd floor	list of functional uses*
	Share in the total gross floor area of the 2nd floor	percentage
	Usage of the n-th floor	list of functional uses*

* The list of functional uses is given in the following section

2. DEFINITION OF ATTRIBUTES

Individual attributes are defined with regard to the complexity of data collection. Thus, these definition are mostly open, but minimising the degree of subjective input.

Above-ground floorfloor = all visible floors having a floor on at least one side of the building for the most part above the ground; floors, including roof-level floors, terraced floors and floors in a slope

Roof-level floor = used attic, i.e. roof with windows (skylights, dormers) or a floor partly covered by a sloping roof

Terraced floor = a floor smaller than the floor with the largest floor area, which with its retreat gives rise to a terrace, balcony or other element

Floor in a slope = a floor meeting the definition of an above-ground floor, which is at least on one side of the building completely nested in the terrain

Roof type[1]:

Used attic = see definition of a roof-level floor

Sloping roof = roof with a predominantly sloping structure

Flat roof = roof with a predominant horizontal structure

Combination = none of the roof types predominates, it is a combination of both

Table 2: Category of functional uses

Category		Functional use
I.	II.	
housing	housing	housing
	garage	garage
public amenities	public administration	office
		court
		police
		fire service
		postal office
		embassy
		other public administration object
	cultural facility	theatre
		museum
		cinema
		gallery
		other cultural facility
	healthcare facility	hospital
		physician
		dentist
		other healthcare facility
	social service facility	social service facility
	education	school
		university
		student accommodation
	other public amenities	church building
		monument, castle, chateau
		army
		prison service
		funeral agency
		zoo

[1] The final version has been modified and the information about roofs is treated differently. Values were determined for the following types of roof: flat, gable, hip, pyramid, etc. Information about functional usage has been preserved and it is stored in separate attribute..

Category		Functional use
I.	II.	
commercial facilities	retailing services	retailing services
	consumer services	consumer services
	unused commercial space	unused commercial space
	offices	offices
	catering	catering
	accommodation	accommodation
	science, research	science, research
	wholesale	wholesale
exhibitions	exhibitions	exhibitions
multipurpose facilities for culture and sports	multipurpose facilities for culture and sports	multipurpose facilities for culture and sports
sport	sports facilities	sports facilities
light industry	light production, assembly	light production, assembly
not used	not used	not used
production and storage	warehouse, distribution, logistics	warehouse, distribution, logistics
	industrial production	industrial production
	agricultural and forestry production	agricultural and forestry production
technical Infrastructure	waste processing	waste processing
	other technical infrastructure facilities	other technical infrastructure facilities
transport infrastructure	parking house	parking house
	fuel station	fuel station
	railway station, station	railway station, station
	airport	airport
	depot	depot
	other transport infrastructure facilities	other transport infrastructure facilities
	non-residential garage	non-residential garage
recreation	recreation	recreation
gardens	gardens	gardens
other use	other specific use	other specific use
passage	passage	passage
unused attic	unused attic	unused attic

The functional division into 58 purposes is relatively detailed (see table); it allows flexible aggregation of individual uses based on the preferred classification. The survey uses an approach inspired by the categories used by spatial planning documentation. The results of the survey are using the category I.

Share of functions:

In the first two floors of a building, more than one function can be listed, if they are present on a given floor, with each purpose being assigned a share of use for that purpose in the total floor area. The third and higher above-ground floors contain only the predominant purpose of the given floor.

3. DATA COLLECTION

3.1 Staffing of data collection

The scope of the survey of building is demanding not only in terms of time, but also in terms of staff. The pilot phase of data collection, which consolidated the final form of the methodological instructions by gradually verifying and streamlining the data collection methodology, was carried out mainly by KAM staff. In most areas, the survey was conducted mainly by trained students of Brno's universities in the fields of urban planning, construction, geography and spatial planning. Their work was continuously consulted and controlled.

3.2 Technical solution of data collection

All data collection took place on a GIS platform using the ArcGIS software. Data editing in the ArcGIS online environment was used as a basis; data collection in the field was carried out via the Collector for ArcGIS application. The obtained data were immediately stored (online) in the underlying layer, which enabled an effective evaluation of any deficiencies or deviations. Tablets were used for field data collection.

3.3 Methodological instructions for data collection

In the first stage of data collection, buildings' floor area ratios and roof types were the main recorded information. For this purpose, mainly online map applications were used, offering angle view images and 3D photomesh projections (GoogleMaps, 2018; Mapy.cz, 2018). The information was entered into the base layer of buildings from the Map of the Topographical Situation of the City of Brno (MMB – Brno City Council, 2018). The number of above-ground floors of each building was evaluated by visual reading. Due to the large amount of data, time-consuming nature of the survey and difficult evaluation of the floors of the smallest buildings (worse 3D images, physical inaccessibility in the field – see below), buildings with a floor area of 30 m^2 and less were considered to have 1 floor[2].

In the second stage, the focus was mainly on the functional uses of buildings. For the correctness of estimation, several existing data sources were used, which served as an auxiliary information source. These were mainly the SLDB 2011 (CZSO, 2011) – information on the number of inhabitants, number of dwellings, type of house, classification of buildings; RUIAN (ČÚZK – Czech Office for Surveying, Mapping and Cadastre, 2018) – information on the method of use; Brno retail research 2017 (KAM, 2018) – information on retail facilities; Register of Economic Entities (ARES, 2018) – information on registered offices of economic entities; and Planning Analytical Materials 2016 (MMB, 2016) – information on public amenities. The latest (at that time) aerial photograph of Brno (MMB, 2018) was used to verify the current development and improve physical orientation during the field research. Objects with a floor area of 30 m^2 and less were automatically assigned a function resulting from the Map of the current land use (part of the Planning analytical materials – MMB, 2016).

In the third stage, all collected information was further specified and finalised directly in the field. Each object was subjected to an external visual evaluation, the results of which were compared with statistical data and information found in stages 1 and 2. Due

[2] Buildings with floor area of 30 m^2 and less make up only 4.7% of the floor area of all buildings in the city. In terms of gross floor area, this is a negligible share, less than 1%.

to time, financial and legislative demands, the survey was not carried out inside buildings. In addition, this procedure would only minimally refine the information on the functional use, as the information obtained using the above data sources can be considered a highly probable estimate of the functional use of the objects. At the level of streets and city blocks, data can be used for spatial and statistical analyses[3] .

4. DATA CONTROL

The collected data were controlled during the field work itself via the ArcGIS Online platform. The feedback was thus provided to the workers within a few hours.

After the end of the field survey (stage 3), a multi-phase automatic control of the collected data took place. This concerned mainly the removal of illogical combinations and attributes that did not make sense due to the design of buildings or the share of functional uses of the building.

5. DATA EVALUATION AND ANALYSIS

The data structure used for the collection itself differs from the data structure entered into spatial analyses[4]. To evaluate the data, it was necessary to establish a mechanism that would transform the structure of data from the survey to a structure suitable for analysis. An automatic data transformation process was set up, which, among other things, helped to revise the structure of some attributes during data collection.

The main output was information on the number of m^2 of gross floor areas of buildings divided according to functional uses and related to any area. With the help of the created geodatabase, it is thus possible to analyse various areas for the needs of evaluating the character and functional structure of the built-up area.

Thanks to information on the functional use of individual floors, it is possible to analyse the predominant usage of buildings or, for example, only the ground floor; this is suitable for evaluating the attractiveness of the living space of streets and public spaces.

Information about the type of roof and the number of floors can be further used to refine the city's 3D model. Analyses of the "roof" landscape and the number of floors are essential especially for setting the height zoning of the city or assessing the suitability of individual construction plans in terms of the relationship to the nature of the surrounding buildings.

6. CREATION OF A WEB APPLICATION

The results of the survey are published via a web map application. It was created using the JavaScript API from ESRI (ArcGIS API for JavaScript), available on the ESRI developer website. The charts are drawn using the JavaScript libraries amCharts and Chart.js. The

[3] Inaccuracies may occur at the level of individual objects, especially in the composition and distribution of individual functions within the given floors. This issue is not essential for the calculation of functional area statistics. The inaccuracies are visible especially when visualising the composition of functions.

[4] The data structure for analysis proved to be unsuitable for data collection. For this reason, a different data structure was set up for the collection itself, even though it meant the data would have to be later transformed into a form enabling statistical and spatial analysis.

input map layers are hosted on an ESRI server and published through the ArcGIS Portal environment. The 3D view was created based on the C-THROUGH project.

None of the published data contain personal data.

7. LIMITS

Like in any surveys, there are some limiting factors that need to be considered when interpreting the data. These are:

7.1 Inaccessibility of some objects – It is difficult to physically approach a number of buildings in the field, especially in the case of private areas and buildings in inaccessible courtyards. However, the share of such objects is not significant. For these objects, data collection was limited to the use of secondary sources.

7.2 Estimation of functional use – The usage of the individual floor are determined on the basis of available secondary sources and on the basis of field verification. However, it is complicated to establish the exact functional use of some buildings, let alone of their individual floors. This is mainly due to non-existent secondary data and the complexity of estimating the purpose from the outside. In these cases, the estimate may not be completely correct. However, at the level of streets, blocks or city districts, this limitation does not affect the information value of the data.

7.3 Time – The layer of buildings may not necessarily contain all buildings in the city, especially the new buildings. Even though the layer is regularly updated, it logically becomes outdated the very moment it is updated.

RESULTS, USE AND UPDATING OF DATA

The survey mapped **109,516** buildings and a total of **127,629** segments[5]. Spatial visualisation of data, certain basic analyses and the interpretation of results can be found in the web map application HERE.

The results of spatial analyses are the basis especially for the creation of spatial (land-use) plans and spatial studies. In combination with other data (especially socio-economic data, e.g. retail facilities, population, occupied jobs), data from the survey of buildings are used to assess the intensity of use of different types of land and to design the capacity of development sites in the city. Last but not least, it serves to assess an area's potential and to design the functional structure of new urban districts.

Regular data updates are essential to keep the dataset relevant for future use. Updates are not expected to be as demanding as data collection (time, finances) in the initial survey, which included the creation of a methodology, the creation of a new geodatabase and the collection of all defined attributes. The data are already being updated and edited. Minor updates focusing on adding data to newly built or, conversely, demolished buildings are planned to take place once a year. A major update revising information for all objects is expected once every 5 years.

[5] As the data changes continuously, the final number is linked to the initial survey.

SOURCES

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