



## Base Earthquake

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### Abstract

Regardless of how much we follow the signs of their potential occurrence, disasters always come to us as a surprise for their force and extent, although we work day after day to develop a system and improve the way of action by learning to use new tools and creating new platforms. None of us had been prepared for what followed the 2020 earthquake, when the engineers of the Croatian Centre for Earthquake Engineering, the company GDI, and representatives of the City of Zagreb joined forces. Base Earthquake and all the analyses which resulted from this amazing synergy represented fundamental values for all the actions that followed: from damage reporting to the Solidarity Fund to ensuring individuals' right to accommodation and exemption from the City of Zagreb utility charges. We strongly believe in the success of restoration plans because we hope they will reflect the same selflessness, knowledge, commitment, and a tremendous amount of positive energy. In other words, we can say that during this earthshaking lesson we have learnt five of Italo Calvino's Six Memos for this Millennium (Lightness, Quickness, Exactitude, Visibility, Multiplicity), and we hope to prove that we have also acquired the last one that the author never managed to complete – consistency, i.e. that we will carry out the restoration in a regenerative and intelligent way, with the same courage and faith in the future of those that came before us.

**Key words:** Base Earthquake, Zagreb, Banija, earthquakes, 2020, restoration

# 1 Introduction

*Although they are at the same time means of survey, measure, exploration and navigation, they are also rhetorical images. Maps are, indeed, never neutral or value-free or ever completely scientific.*

David Harvey, *The New Nature of Maps*

Understanding and recording phenomena, especially those of the same the extent and type as the earthquakes that struck first Zagreb and its surroundings, and then the area of Banija, is necessary for a number of reasons: to protect the lives of citizens who inevitably need to leave hazardous buildings (because all earthquakes are most often accompanied by aftershocks when the ground calms), to evaluate the damage and make short-term and long-term assistance and restoration plans.

Delineating or mapping within this process serves as a kind of conceptual glue that connects the tangible world of buildings, settlements and cities with the intangible dimension of human life, all with the help of computer platforms and tireless volunteer engineers.

There is a multiple dependence on technological and human resources because damage is recorded in the field, which is then followed by hours and hours of tireless work on the earthquake database so that large amounts of data are translated into readable information.

Eminent professor James Corner understood mapping as a process that precedes the map, just as 'order is the outcome of the act of ordering'[1] and the challenge of determining the criteria and modality of mapping is the first step.

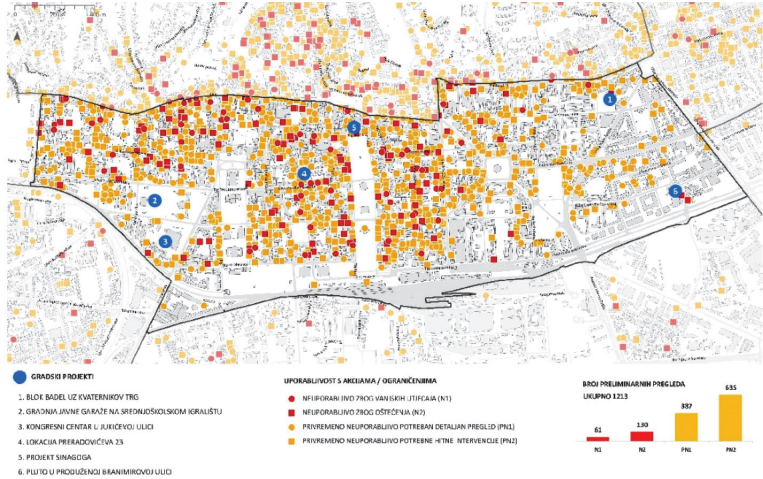
Although an integral part of our scope of work is the daily work with spatial data and information, this situation was a real challenge not only because of the nature of the information that we collected but also because of the deadlines that were imposed due to the need to draw conclusions in order to prepare the data for applying to the Solidarity Fund and develop a legislative framework for reconstruction, all for the purpose of the targeted action of helping the most vulnerable.

While evaluating the damage and identifying the buildings in detail our existing bases that we regularly use have proven to be very useful. Thus, by overlapping the damage to buildings with the three-dimensional model of the City of Zagreb, we were able to size the extent of earthquake damage (Figure 1). It is precisely this overlap that allowed us to arrange the information quickly, that gave the on-field mapping some momentum and helped to precisely determine the consequences of the earthquake and its spatial circumstances.

Donji grad

Broj pregleda  
1213

Broj zgrada  
889



07 2020



GRAD ZAGREB  
GRADSKI URED ZA  
STRATEGIJSKO PLANIRANJE  
I RAZVOJ GRADA

HCPI  
Hrvatski centar za  
potresno inženjerstvo



UHS  
Ured za upravljanje u  
hitnim situacijama

Zagreb potres 2020.  
Zagreb obnova 2020.

Figure 1. Spatial analysis of the inspected buildings in the Lower Town area, with a recorded degree of damage, source: City Office for Strategic Planning and Development of the City

## 2 Working together

The earthquake in Zagreb on 22 March 2020 was an event that shook everyone and showed us that it is necessary to be prepared for emergency situations. It was then that the first *GIS Base Earthquake Zagreb 2020* was created, a database of quick inspections with assessments of the usability of buildings in coordination with the Croatian Centre for Earthquake Engineering, on the GDI platform, in the OEM - City Office of Emergency Management and in cooperation with a large number of experts from various institutions. Nevertheless, we believe that the database was mostly created by volunteers, experts and other engineers in the field, and the period until the last inspection lasted significantly longer than the deadlines planned for the first rapid inspections.

Why did it last longer then and why is a similar situation happening today in Petrinja? We will try to explain only one aspect of the difficult circumstances for working with data in the GIS database.

Simultaneously with the field surveys, which were collected live, a multidisciplinary team of experts who use GIS tools worked in the background doing the accompanying work necessary to make the field data credible. Taking into account the sudden circumstances in which the *GIS Base Earthquake Zagreb 2020* was created, we are aware of the challenges we faced at the time. The biggest challenge was to coordinate the addresses on the platform developed by on-site experts with the official addresses of the Register of spatial units used by the majority of institutions included in the restoration process. Citizens' applications came from several sources: application forms, emails, phone calls,

or written forms collected by engineers directly in the field during the first days until the application was prepared for direct entry (Figures 2, 3).

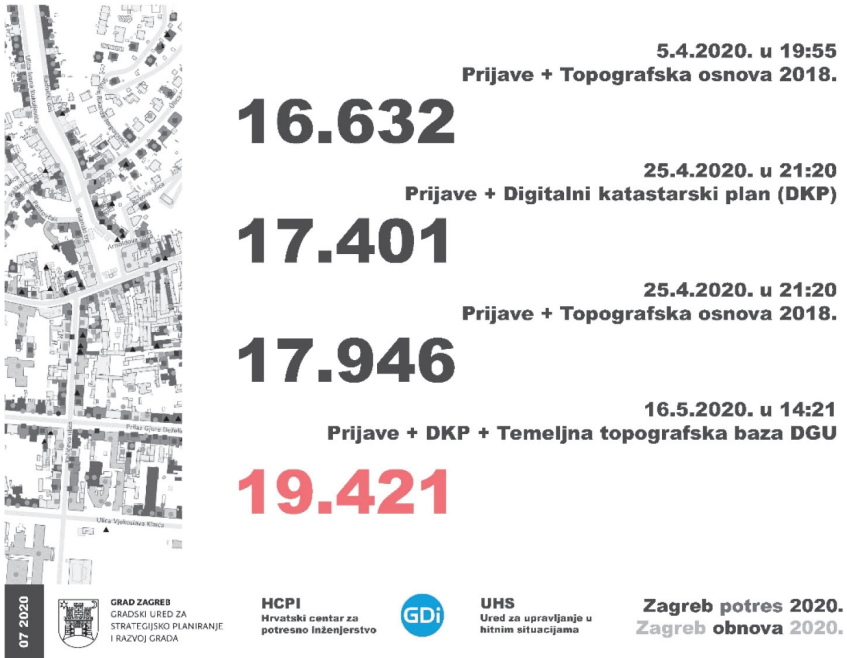


Figure 2 Number of applications with overlaps on available platforms

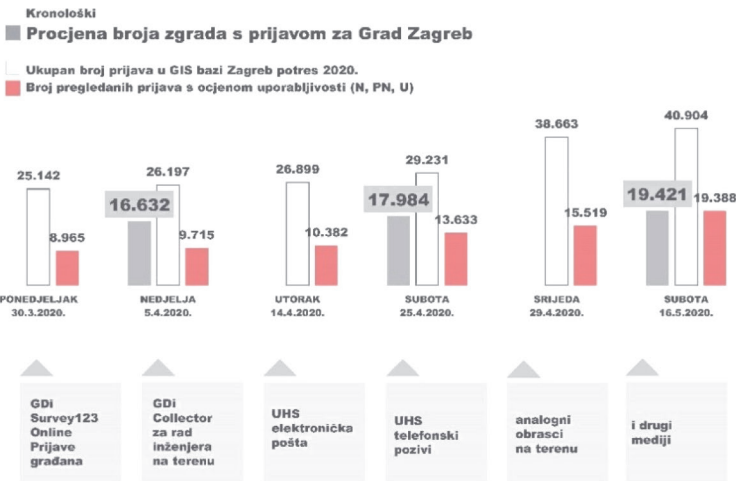
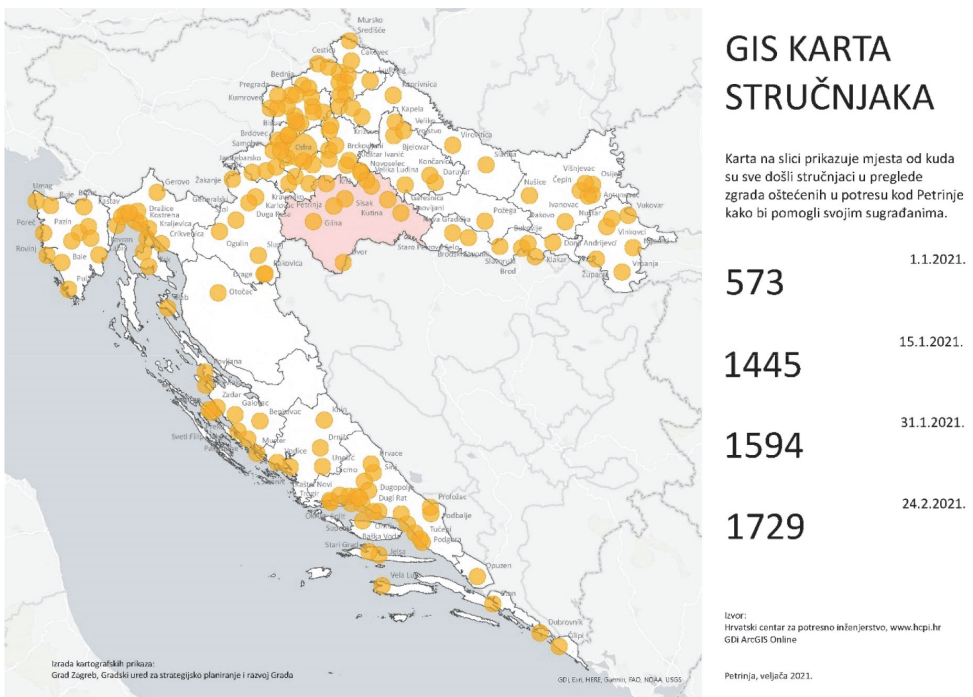


Figure 3 Reviewed and unreviewed applications in chronological order from 30 March to 15 June 2020

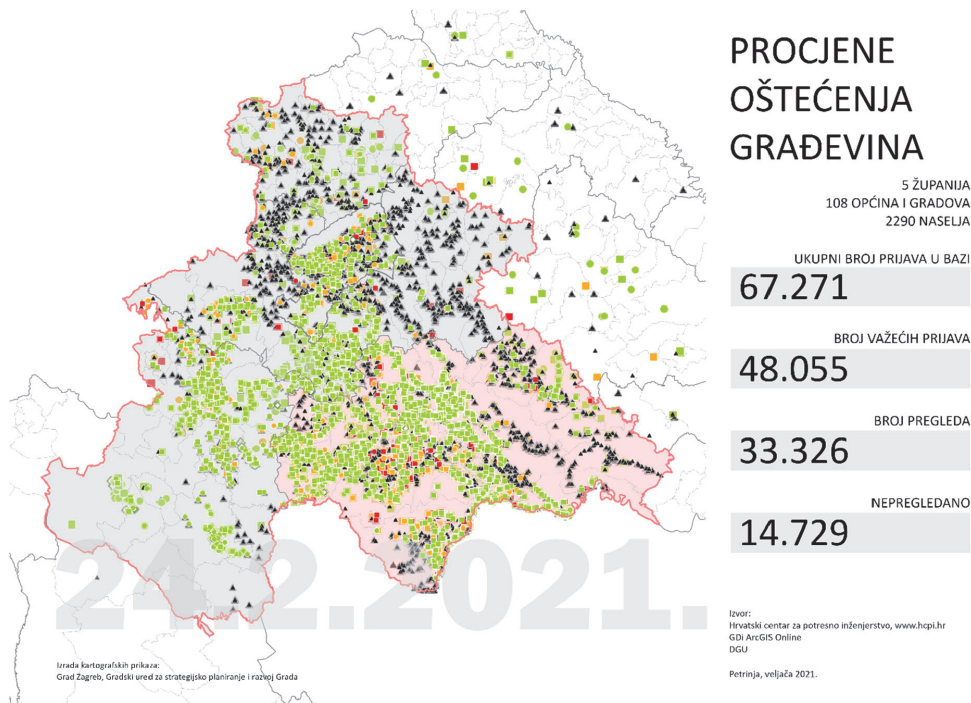
As early as then, the excessive burden of responsibility and work was transferred to the on-site engineers because their primary goal was the safety of citizens and the assessment of the usability of buildings by giving recommendations on whether citizens can stay in their homes. Despite the lockdown in March, the motivation was great and the response of engineers was not lacking, so in Zagreb more than 500 volunteer engineers registered to perform inspections, and today in Petrinja we have approximately 1,600 registered volunteer engineers, who are unfortunately additionally burdened with the preparation of data inventory which was supposed to be ready for their intervention (Figure 4). In Zagreb, we did not insist on the mandatory entry of all data on rapid inspections, but the motive was to help people as soon as possible and provide them with information whether their homes are safe to live in. The GIS database developed in those circumstances requires additional processing of input data and continuation of work in the existing database in the coming period of at least a dozen experts experienced in field inspections and general experience with spatial data because only edited data will be a good basis for correct answers and questions related to the assessment of restoration costs and other related tasks.



**Figure 4. Cartographic representation of the provenance of HCPI member volunteer engineers**

When on the 28 December 2020 the earthquake struck Petrinja, all of us who worked on the *GIS Base Earthquake Zagreb 2020* already knew at 6:28 that day that we have to work smarter when creating the *GIS Base Earthquake Petrinja*. Input data that was essential was not ready then and even today it is not ready. It would have been extremely useful if we had had access to the Building Register with information on the existing state, into which we would enter the data acquired by rapid inspections. However, despite the lack of an up-to-date base of the existing state, we have improved the entry of applications by linking them to official addresses. Mandatory fields have been set in the application for quick inspections, which additionally burdened the engineers with the task of quick usability assessments because they are obliged to enter data on the number of floors, purpose, area, age, maintenance, number of housing units, household members and ownership of the inspected buildings. Had we had all this data at our disposal before going out on site, we would have reduced the workload for the GIS experts in the background who simultaneously control the quality of the input data. The challenge is also to disqualify multiple applications of citizens for a rapid inspection at the same address, and the second part of the job is to properly position the inspection of the building and enter the correct address according to the Register of Spatial Units to link data on rapid inspections with spatial and other data.

There are many challenges in working with live data because the addresses in citizens' applications and official addresses in the field are not fully coordinated, and a similar situation is repeated in the Sisak-Moslavina County because there are settlements where addresses in citizens' applications do not correspond to the situation in the field and official addresses with residences. For example, citizens are convinced that they live in their street with house number 1, when in fact their house number is 2A, their next door neighbour has a house number 2 sign on their house, but the official address is in fact house number 4. Therefore, it will be difficult for officials in local self-government units and citizens to find certificates on stickers. During the rapid inspections, we realized, among other things, how the data on buildings and addresses should be updated in the field and digitally, regardless of whether the citizens have fulfilled their obligation or left it to state institutions. (Figure 5)



**Figure 5. Number of reports and damage assessments of buildings in the area of five counties, State in February 2021**

In addition, data on rapid inspections is collected for the most part during January and February at low temperatures, and the mobile data necessary to operate the application is not available in all parts affected by the earthquake. You can only guess how much harder it is to enter data regarding the inspections later than on-site.

All these obstacles are overcome on the go and we cooperate with each other because the data we collect is important for creating spatial analyses. Targeted thematic spatial analyses lead to results that give us guidelines for making strategic decisions when making new technical regulations or new urban plans.

Rapid inspections with usability assessments are extremely useful right at the beginning of a disaster to determine if all people are safe, if anyone is left in the ruins, and they are also useful to firefighters as information for rapid interventions, Civil Protection, Croatian Mountain Rescue Service, local self government and other stakeholders of operational services located in the Headquarters.



**Figure 6. Work of experts in the Petrinja headquarters; a photograph of the aftermath of the earthquake in the centre of Petrinja**

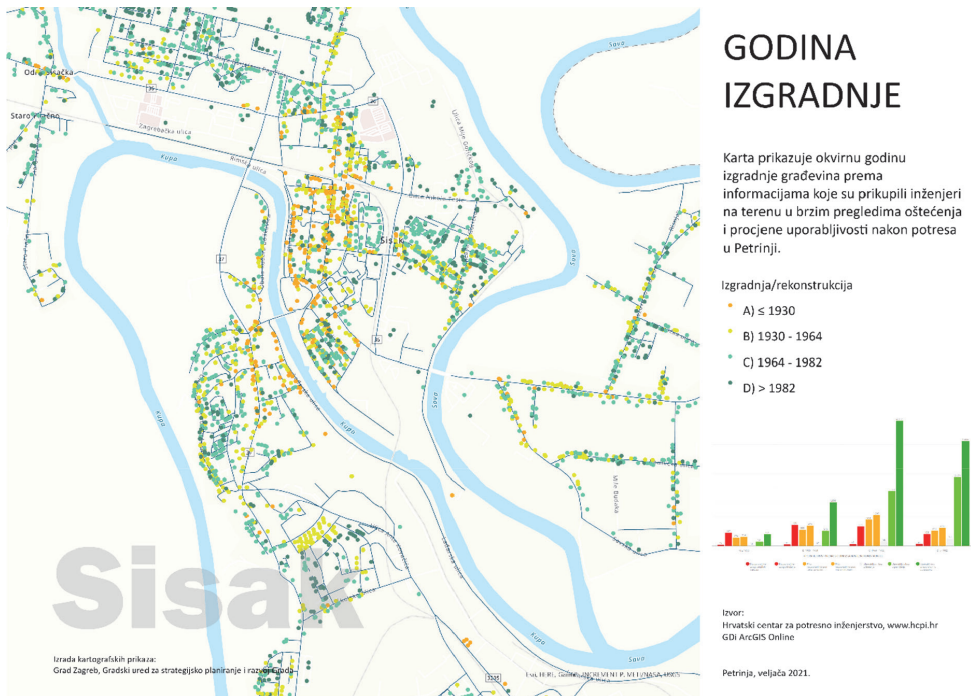
Consequences of earthquakes require various analyses such as, for example, revising existing technical regulations or creating new ones, using data on types of load-bearing structures on damaged buildings, number of floors, purpose, age of the building, building maintenance and other data collected during rapid inspections. The data is extremely valuable, especially the photo documentation from the field.

The first analyses, based on spatial data from the *GIS Base Earthquake Petrinja*, were used during quick surveys for rational management of on-site teams to produce as many applications in the same settlement, city or municipality for insight into live data on the spatial distribution of uninspected and inspected buildings.

### 3 Conclusion

The number of analyses and quality decisions depends on the data collected in the database, so it can be said that after the earthquake in Petrinja we made a big step forward thanks to the experience after the earthquake in Zagreb. However, it can always be better with the operational support of all institutions involved. It is necessary to understand the circumstances of data collection to see their actual accuracy and value, and this does not diminish the value of the database, but we just want to emphasize how important the preparation is. We need to be responsible and everyone should edit data from their jurisdiction for us to be readier in the challenging situations to come.





**Figure 7. Cartographic representation of approximate construction periods according to the information collected by engineers during rapid inspections**

No map is a territory, it can only describe a certain characteristic in detail and is by its very nature the result of a directed reading of space and an instrument by which special aspects can be illuminated. Maps filter information and in the hands of experts who can professionally interpret it ‘the map has never been far from the action’ [2]. This means that the mapping action has a deeper role in defining the space it describes (Figure 7). As a specific form of analytical knowledge that can be used directly in spatial planning, mapping earthquakes is for us a preparation for urban concepts and further action. We are proud that our activity, i.e. the fact that we are an active participants in team activities, has enabled mapping to become a performative instrument, but also a generator of operations and the holder of a conceptual idea.



**Figure 8. Gathering of engineers in the central headquarters in Petrinja**

## References

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