



## The Sendai framework until 2030 and experiences after the earthquake disaster in Croatia 2020

Ljubomir Mišćević

<sup>1</sup> Full Professor, University of Zagreb, Faculty of Architecture, [miscevic@arhitekt.hr](mailto:miscevic@arhitekt.hr)

### Abstract

The paper explains in more detail the fifteen-year agreement of the Sendai Framework for Risk Reduction through seven global goals and four priority actions. Relevant are the experiences of earthquakes in Skopje, Dubrovnik and the Montenegrin coast, which resulted in stricter regulations for securing buildings from seismic destruction in the SFRY regulations. In the case of Skopje in 1963, a world urban-architectural competition for the reconstruction of the city was organized by the UN. In the case of Dubrovnik the 1979 earthquake coincided with the city's entry in the UNESCO World Heritage Register so the reconstruction model was based on defined postulates. The aftermath of the earthquake on the Montenegrin coast has resulted in further tightening of federal regulations. The experience of working on the development of a City Management Plan in the field of safety on the example of the city of Dubrovnik is also briefly described. The devastating consequences on the structures after the earthquake in Zagreb, neighboring counties and in Banovina are evident on the buildings (or their parts) that were performed without the necessary mandatory projects in accordance with the Legal Framework (illegal construction). On buildings that are constructed according to the prescribed requirements for resistance to seismic stresses, the damage is significantly less, depending on the year of construction and regulations from that time. Based on such experiences after the earthquakes in Zagreb and Banovina, no changes in the existing regulations are envisaged for the time being in terms of more rigorous requirements, but it is certainly necessary to revise the marking of some spatial earthquake zones according to existing displays. Deep, complete and integral high-energy renovation is possible and expected as a "Build Back Better" model of renovation which achieves tenfold energy savings ("factor 10"), while achieving thermal, visual and acoustic comfort and a high level of sustainability, accessibility and security. The paper also briefly presents one of the proposed models of typical houses for reconstruction after the earthquake in Banovina. In this system of modular new construction, it is proposed to represent all the requirements of advanced sustainability (choice of materials, construction systems and technologies, circular management, etc.) and high energy efficiency with a starting level of passive house energy standard plus (energy class A ++), which is more advanced than prescribed nZEB standards according to the current definition in Croatia.

**Key words:** Sendai framework, reducing disaster risks, "factor 10" renovation, energy efficiency, "Build Back Better" renovation model, city management plan, sustainability, safety

## 1 Introduction

The first part of the paper explains the Sendai framework for disaster risk reduction for the coming period until 2030. To understand the document, it is necessary to know and understand the key words; Climate Change, Community-based DRR, Environment & Ecosystems, Health & Health Facilities, Recovery, Risk Identification & Assessment, Urban Risk & Planning, Governance, Economics of DRR, Disaster Risk Management, Social Impacts & Social Resilience, Inclusion and Cultural Heritage.

The second part of the paper lists various selected activities and proposals that can serve as elements of a platform for further development and continuous improvement of regulations in the Republic of Croatia and the implementation of measures based on advanced professional models and experiences after two earthquakes in Zagreb, March 22 and December 29 and in Banovina December 29 2020.

## 2 Sendai Framework for Disaster Risk Reduction 2015-2030

The Sendai Framework is an excellent and binding document as the most professionally conceived and applicable globally. The specifics of individual threats in (micro) location areas must be additionally noticed, analyzed and timely prevented by the responsibility of local, regional and state administration.

The Sendai Framework for Disaster Risk Reduction 2015-2030 outlines seven clear targets and four priorities for action to prevent new and reduce existing disaster risks:

1. Understanding disaster risk
2. Strengthening disaster risk governance to manage disaster risk
3. Investing in disaster reduction for resilience
4. Enhancing disaster preparedness for effective response, and to "Build Back Better" in recovery, rehabilitation and reconstruction.

It aims to achieve the substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries over the next 15 years.

The Framework was adopted at the Third UN World Conference on Disaster Risk Reduction in Sendai, Japan, on March 18, 2015.

The recommendations of the Sendai framework have been implemented in the Dubrovnik City Management Plan, which will be adopted in early 2021.

## 3 Selected presentations of the author reference for the paper

At the invitation of the Ministry of Culture of the Republic of Croatia to participate in a three-day international conference co-organized by UNESCO Croatia, I gave a lecture entitled: Recent research, declarations and agreements as a platform for the future Disaster Risks Reduction and Management criteria. In the part of the expert workshop, the

conference also had the task of transferring knowledge in the context of joint action from the field of education to operable models in the field for the purpose of prevention, ie reduction and mitigation of the consequences of disasters (1.b).



Figure 1. The first pages of selected lectures reference for work

## 4 Previous catastrophic earthquakes in the region

Catastrophic earthquake in Skopje, July 26, 1963. 6.1 on the Richter scale (9 degrees on the Mercalli scale) resulted in the horrific destruction of the city with 1,070 dead and about 4,000 injured. (9 on the Mercalli scale), more than 100 people were killed, and there were no casualties in Dubrovnik, which was inscribed on the UNESCO World Heritage List that year.

These earthquakes significantly affected the urgent tightening of legislation in the field of prevention of earthquake destruction in the SFRY.

## 5 Superposition of seismic maps in the Republic of Croatia

Superposition of all threats is necessary for a comprehensive risk assessment that includes specific geological and morphological consequences. The synthesis of representations in addition to natural threats must also include previously predicted anthropogenic threats and consequences, such as sociological ones due to population emigration, reduction of economic activities, etc.

The images from the Ordinance on the methodology for drafting vulnerability assessments and protection and rescue plans, adopted by the State Administration for Protection and Rescue (OG 174/04 and 79/07), are an excellent starting point for preventive and post-threat, consequential risk assessment.

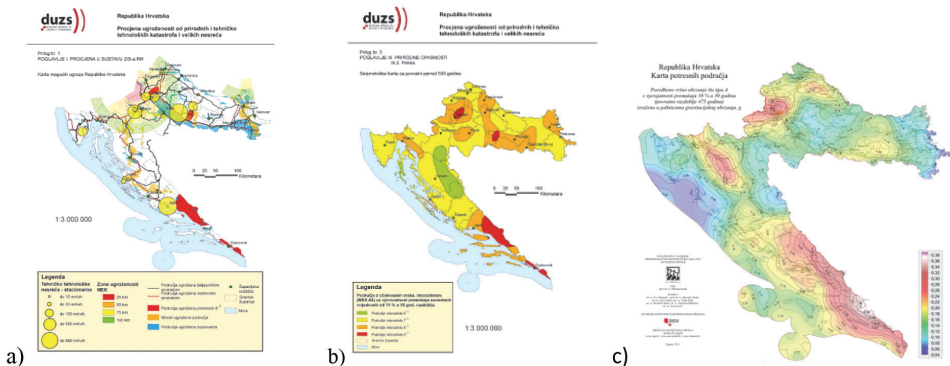


Figure 2. a) Assessment of vulnerability to natural and technical technological disasters and major accidents, Map of possible threats in the Republic of Croatia (DUZS, 2009), b) III.2: Earthquake, c) Map of seismic areas

## 6 Geological phenomenon as a consequence of earthquakes

Earthquakes often cause subsidence, faults and landslides depending on the geological characteristics and consequent deformations of the terrain on the surfaces in certain areas. Since the earthquake in Sisak-Moslavina County on December 29, 2020, unprecedented holes have opened up in the ground as a geological phenomenon. In the village of Mečenčani, which is about 25 kilometers away from Petrinja, they appeared in the largest number. The holes widened daily and new ones appeared, and the ground continued to tremble. Geologists discover, monitor, measure and supervise them accompanied by the police who surrounded them. Gardens collapsed, and in some places holes opened up near or even under houses.

The holes are still increasing, and based on previous geomechanical tests, it is difficult to predict where and in what size it will open. In addition to arable land, wells, communications and buildings are endangered. Soil subsidence is not the same in all parts of the county. Where it appeared, the buildings tilted. The method and time of terrain remediation is questionable, especially if deeper limestone and other soil layers (eg aquifers) are deformed and collapsed. Restoration can only begin in areas where there have been no major soil changes.



**Figure 3. Holes in the ground as a result of the earthquake in the village of Mečenčani. a) Aerial view, b) Hole next to the house (source: Damir Krajac / Cropix), c) Hole under the house (source: Darko Tomas / Cropix)**

In addition to the complexity of the overall consequences of earthquake destruction, this rare phenomenon is an additional burden in finding intervention measures to protect people, domestic animals and open space.

Before the start of reconstruction on this and similar sites, it is certainly mandatory to make geological maps as basic spatial planning bases with an assessment of the risk of reconstruction of buildings and possible further new construction and superimpose them with other maps relevant to risk assessments.

## 7 Tender for architectural reconstruction after the Homeland War

War destruction during the Homeland War in the Republic of Croatia was caused in all regions, diverse in climatic conditions, traditional and modern building materials and construction methods. In order for the construction reconstruction to be of the highest quality and efficient and timely prepared, even during the war operations, in September 1992, under the auspices of the Croatian Academy of Sciences and Arts (HAZU), a tender was announced for the implementation of practically tested (!) projects that can be type renovation projects. Out of 150 submitted works, in the category of small detached family houses, semi-detached, residential rows and small apartment buildings, a total of 50 were selected, of which 11 apartment buildings. In March 1993, the Catalog of Selected Projects with economic indicators of all and with the prices of project documentation was published.

Unfortunately, the expected interest and implementation of the selected projects by the twelve-member jury did not materialize for several reasons. These reasons were largely unexpected, though predictable.

## 8 Legalization of illegal construction

The process of legalization of illegal construction in the Republic of Croatia began as an important precondition for the membership of the Republic of Croatia in the EU. In the

urban-architectural, constructional infrastructural context, one must be aware of the fact that the so-called legalized construction, which was previously an illegal, large and permanent threat to the safety of citizens in several possible types of threats, until it is restored in an appropriate manner.

It was the illegal construction that suffered the most, which does not meet even the basic requirements of the structure for resistance to seismic stresses.

## 9 Experiences after the earthquake in Zagreb

The Office for Emergency Situations of the City of Zagreb (UHS) has been continuously warning about various threats for many years and assessing the risks of their possible effects, especially earthquakes. It continuously proposes and implements prevention measures in order to reduce the consequences of possible natural and anthropogenically caused disasters, organizing and conducting conferences, demonstration exercises and dissemination of various thematic leaflets. A few years ago, in all public spaces of city administration institutions, buildings for education, health, in business and commercial complexes, etc., maps with areas for evacuation of citizens in case of a devastating earthquake similar to what happened after 140 years, on Sunday, March 22 at 06:24 with a magnitude of 5.5 on the Richter scale.

The headquarters of this City Office was also the operational headquarters of the Croatian Center for Earthquake Engineering (HCPI), which was also an educational and logistical center for hundreds of members of the Civil Protection of the City of Zagreb, primarily civil and architectural engineers, as well as other volunteers who began with rapid inspections of demolished and damaged buildings in the epicenter (Markuševac) and in the wider area of the central historical protected ensemble of architectural heritage with individually protected buildings. Nearly a thousand experts and other registered volunteers participated in rapid inspections and individual logistical interventions, including tours in two neighboring counties. The earthquake that occurred in Zagreb on Tuesday, December 29 at 12:19 was as a consequence of a stronger earthquake in the area of Banovina near Petrinja of 6.2 on the Richter scale.

When the system is not built in a timely manner and verified by prevention practices, unintended and harmful consequences of management that are not coordinated for a number of reasons result in professionals and people with experience. It is in crisis situations that the behavior of individuals - natural persons as well as all institutional levels as legal entities is best observed.

The earthquake in Zagreb was marked by incredible activity and efforts of volunteer engineers and students of the Faculty of Civil Engineering, Architecture and other faculties and other experts, in the organizational and logistical framework of the Zagreb Emergency Office, which is the seat of the Civil Protection of Zagreb. The participation of fire brigades, police, ambulance, army, Croatian Mountain Rescue Service (HGSS) and others, including citizens who are in solidarity then and still help fellow citizens, must certainly be emphasized.



As in the case of Zagreb, with the incredible volunteer activities and efforts of engineers organized by HCPI, enriched by the experience of earthquakes in Zagreb, the earthquake in Banovina confirmed the existence of the Croatian “Big Heart”. This is a previously accepted term for solidarity of the citizens of the Republic of Croatia who, first of all, lived and experienced true human solidarity based on the experience of the Homeland War and turned it into a spontaneous large-scale public action starting a few hours after the earthquake.

The unwillingness to mitigate the consequences after the earthquake devastation in the rural area of Banovina is fortunately mitigated by temporary logistics for housing people.

The peculiarity of the consequences of the earthquake in the Banovina in rural and often difficult to access areas is in the fact that the requirements are completely different from the urban space. Continuous care for livestock and other domestic animals is more important for some residents than a roof over their own head, because livestock and agriculture are their only livelihood.

The Law on the Reconstruction of Zagreb cannot for the most part be complementary to the Law or bylaw for the rural area of Sisak-Moslavina and neighboring counties. The example of the earthquake in Zagreb shows how long it takes for the Law on Reconstruction to come to life.



Figure 4. The first articles by the author about the earthquake published in the professional magazine *Gospodarski list*

## 10 High energy efficient deep renovation

Deep, complete and integral highly energy efficient renovation is possible and expected as a “Build Back Better” model of renovation. In the restoration of the architectural heritage, it is possible to achieve tenfold energy savings up to “factor 10”, as well as achieve thermal, visual and acoustic comfort and a high level of sustainability, accessibility and safety.

## **10.1 Proposal in the public debate for the amendment of the Law on reconstruction after the earthquake in Zagreb**

Many individuals, groups of citizens and institutions participated in the public consultation process on the draft Law on Reconstruction after the earthquake in Zagreb and neighboring counties, who wanted to contribute to the quality of the document with their proposals and advice to supplement or amend it. I quote my proposed amendment with a clear analysis of the draft Law which does not even understand the need to combine energy renovation with structural renovation, let alone the implementation of the advanced concept of high energy efficiency.

"I suggest listing the term / terms; sustainable energy efficient renovation, its / their elaboration at the level of an additional article of the Law. Unfortunately, there are no key words in the entire Bill such as energy, energy efficiency, etc., except in the context of condensing heaters.

Post-earthquake reconstruction in Zagreb must include advanced energy efficiency models (recommended for individual buildings and reconstruction up to "factor 10"), because through the long-term process of this reconstruction, after its completion, the requirements assumed and prescribed by the scenarios for 2030 and 2050 year, according to the currently adopted obligations of the EU member states. Reconstruction of Zagreb can be an example of possible achievement of UN development goals, EU Green Plan until 2050 and other advanced scenarios in the field of circular economy, decarbonisation, adaptation to climate change - as a model of reconstruction for climate neutrality, etc. The final version of this Law will confirm responsibility of individual stakeholders."

Ljubomir Mišćević, 14<sup>th</sup> June 2020, 23:59

The potential for savings in existing buildings is obvious. With conventional renovations, it is possible to achieve 20-30% energy savings for heating compared to the previous state, while the "factor 10" renovations (up to the passive house standard) achieve up to 90% savings! (Source: CPD)

## **10.2 "Factor 10" and the new perception diagram with addition of plus energy buildings**

The Columnne "F" on diagram shows passive house data with addition of renewable energy sources (RES), where is a huge amount of solar radiation as in south region of Croatia (according to REHVA it is in zones 1 & 2 for nZEB), that easily secure the jump over zero level and becomes "+ energy" or "Passive house plus" or "Passive house Premium" as it is defined by Passive House Institute in Darmstadt.



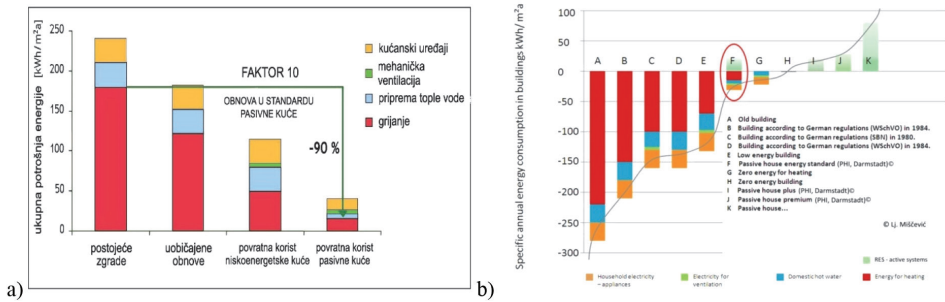


Figure 5. a) Passive House renovation model up to "factor 10", b) Diagram of energy consumption with addition of plus energy buildings. Author: Ljubomir Mišćević, 2013

## 11 Catalog of projects of typical houses for reconstruction after the earthquake in Banovina

Organized by the Faculty of Architecture, University of Zagreb and the Ministry of Physical Planning, Construction and State Assets it is planned to make a catalog of projects of typical houses for reconstruction after the earthquake in Banovina.

One of the three proposed models (2A) of different net usable living space with a total of twenty variants in a system called PGS, shown in the pictures was designed by Full Prof. Art. Ljubomir Mišćević M. Arch. And Mark Mišćević Mag. Eng. Arch. The linear growth of the house is assumed, primarily as prefabricated modular wooden houses, but possibly feasible from other materials and systems such as semi-prefabricated.

In this system of modular new construction, it is proposed to represent all the requirements of advanced sustainability (choice of materials, construction systems and technologies, circular management, etc.) and high energy efficiency with a starting level of passive house energy standard (energy class A+), which is more advanced than prescribed nZEB standards according to the current definition in Croatia.

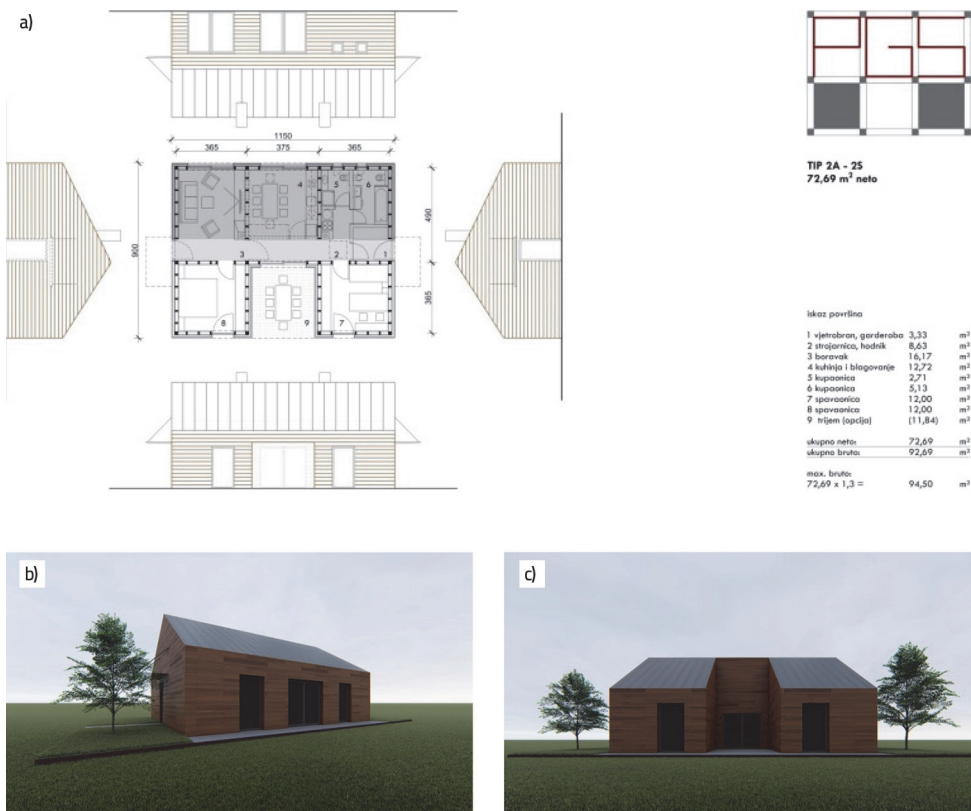


Figure 6. a) Proposed ground floor plan and b), c) 3D models (type 2A) of the System called PGS, shown in the pictures was designed by Full Prof. Art. Ljubomir Mišćević M. Arch. and Mark Mišćević Mag. Eng. Arch., 2021.

## 12 Conclusion

The Sendai Framework is an excellent and binding document as the most professionally conceived and applicable globally. The specifics of individual threats in (micro) location areas must be additionally noticed, analyzed and timely prevented by the responsibility of local, regional and state administration.

Energy renovation is underway in the Republic of Croatia. The feasibility of the set goals has significantly failed, so one of the opportunities in the experienced difficulties is to combine energy reconstruction with construction after earthquake destruction, but at the level of energy efficiency that will certainly be even higher than the current regulations (so-called nZEB), because the process achieving quality renovation is certainly time consuming.

The Prime Minister of the Republic of Croatia, according to the envisaged concept of development, describes Croatia until 2030 in three words as; competitive, safe and in-

novative. EU funding for the National Recovery and Resilience Program will certainly support this effort.

The Banovina earthquake raised awareness of the actual level of development policies and their implementation. The naturally caused catastrophic consequence is the driver of decisions for urgent investments in critical infrastructure, such as the continuation or completion of the construction of the highway from Zagreb to Sisak.

In order to get as close as possible to the set goals in the coming years, less than nine years, including the seventeen goals of global sustainable development by 2030, according to the United Nations (UN) and the Green Plan of the European Union (EU) by 2050, which is officially announced by the Republic of Croatia at the beginning of the EU presidency on 1 January 2020, many urgent measures need to be taken to achieve binding quantitative scenarios of member states, but also the expected possible qualitative and innovative advanced models that can only ensure the implementation of these programs.

The author proposes the need to implement a possible in-depth, comprehensive and integral highly energy efficient renovation, especially due to the experience in the Republic of Croatia after the earthquake in 2020 and the synergy of mental, organizational, financial, professional design and implementation development and adoption of reconstruction models, based on the experience of the best global practice, at the level of the energy standard of the passive house (A + and more), which is known to the wider professional and self-public as the "factor 10" renovation.

## References

- [1] Miščević, Lj. (2017): Recent researches, declarations and agreements as the platform for the future Disaster Risks Reduction and Management criteria, Workshop on Managing Disaster Risks in UNESCO Designated Sites, Croatian Commission for UNESCO, Ministry of Culture RH, Island of Hvar, Croatia, 25-28
- [2] Miščević, Lj. (2020): Potres je potaknuo pitanje održive gradnje kuća, *Gospodarski list*, br. 7, travanj 2020., Zagreb, ISSN 0350-3100, 41 - 43
- [3] Miščević, Lj. (2020): Miščević, Lj.: Održiva obnova - od Zakona do provedbe, *Gospodarski list*, br. 10, lipanj 2020., Zagreb, ISSN 0350-3100, 76 - 77
- [4] Žagar, Z., Miščević, Lj. (2014): Građenje u plavnim područjima, VI. Konferencija Hrvatske platforme za smanjenje rizika od katastrofa, *Poplave u RH, teorija i praksa, naučne lekcije*, Valbandon, 22. 10. 2014.
- [5] Miščević, Lj. (2019): Pristupačnost zgrada i kompleksa za turizam kao sinergijski element prostornog koncepta sigurnosti, *Sigurnost u turizmu (SIGTUR)*, Opatija
- [6] <https://www.preventionweb.net/terminology/view/51750>
- [7] <https://www.youtube.com/watch?v=wCLNhcz1PPM>