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An Overview on Earthquake Hazard and Seismic Risk Management Policies of Macedonia

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Abstract

Facing significant earthquake losses in 1960ties, Yugoslavia undertook serious multidisciplinary measures to define a technically consistent and economically justifiable level of acceptable seismic risk by assuring adequate technical-juridical environment and a system for its effective and efficient implementation. Being a constitutive unit of SFRY, Macedonia was obliged to implement the federal legislation that was modified to comply with the specificities pertinent to the Republic. The authors of the paper consistently present some segments and aspects of these efforts, focusing the discussion on the genesis of the legal environment (technical regulations, context and time-line of laws adopted) and its implications for the creation of a seismic risk free environment for citizens and protection of national wealth.

Keywords: Macedonia, earthquake, disaster, hazard, risk, management, legislation.

1. Introduction

The losses that Yugoslavia suffered in the 1960s due to a destructive (1963, M6.1 Skopje, Macedonia, 1,070 killed, ~3,000 injured, 15% loss of GDP) and two damaging (1967, M6.6 Debar, Macedonia /20 killed – total for SFRY and Albania/; 1969, M6.6, Banja Luka, Bosnia and Hercegovina, 15 killed, 1,117 injured) earthquakes triggered an alarm and raised a strong awareness of the SFRY Government of the seismic risk to which the population and national wealth were exposed. The scale of the Skopje earthquake losses forced the Yugoslav Government to implement a public loan mechanism for assuring resources for Skopje's revitalization and reconstruction as the last measure, without abandoning other development programmes.

The analysis of the root factors that turned Skopje earthquake into a catastrophe showed that what happened was neither an act of God, nor seismic delinquency of nature, but the result of inappropriate technical regulatory framework, lack of knowledge and awareness, marginalizing the insufficient existing earthquake resistance requirements, the use of low quality construction materials, construction flaws, etc., as well as the softness of the legal and administrative system allowing investors and contractors to alleviate systemic solutions that were already incorporated in the legislation in effect.

Avoiding to fall into the trap of treating this natural disaster as an unavoidable act of nature, as an ideological interpretation, in fact, an efficient strategy for deflecting political responsibility for the created vulnerability in the hazardous environments and the faced socio-economic consequences [1, 2], the Yugoslav Government correctly understood that the root factors of the Skopje disaster and the 15% loss of national GDP were rather of subjective or systemic than environmental nature.

While the Skopje earthquake of 1963 and several other earthquakes that took place in 1960s were the first milestone requiring an immediate action in formulating, developing and adopting indispensable socio-environmentally compatible legislative environment for assuring technically consistent, economically justifiable, sustainable and seismically safe development of the country, the Montenegro earthquake of 1979 causing another concentrated loss of ~18% of the national GDP, was the second one.

As a result, further tuning of the technical regulatory framework and strengthening of the already established legislation environment were required. However, disintegration processes in Yugoslavia and resulting changes in economic priorities, fading of historic memory, other problems of the transitional societies, including ruthless profit building accompanying construction works, significantly weakened the seismic safety margins achieved by the end of the 1990s. Consequently, root factors for a new seismic disaster started to build-up and accumulate.

Some aspects of inherited legislation environment, its genealogy and implications, as well as recently instrumented solutions for strengthening and maintaining seismic risk reduction instruments and mechanisms for assuring seismic risk free development of Macedonia, are discussed in the subsequent text. Please note that the references to the country name(s) and the names of the federal units of Yugoslavia reflect the political reality at the time when the discussed legislation was adopted/enforced, the essential decisions were made and the discussed seismic risk reduction policies were set up.

2. General Aspects of 1963 Skopje Earthquake

The Skopje valley has a rather long history of minor seismicity with a number of damaging local earthquakes. The earliest earthquake of 518 AD caused considerable damage to Skupi (old Skopje) and perhaps accounted for its desertion in 519 AD. The accounts of this earthquake are rather confused and, in all probability, grossly exaggerated. In 1555, another earthquake struck Skopje and inflicted some damage. Strong earthquakes occurred in 1890 and 1921. Despite the fact that the early seismic history of the Skopje valley is not very well known, the available information shows that extremely shallow earthquakes of medium magnitude (5 – 6¼) are common.

A unique characteristic of the 1963 Skopje earthquake was the extreme localization of destruction concentrated within an area of not more than 5 sq.km., a typical feature of a shallow, medium magnitude shock that happened very close to the city (most of this area was occupied by Skopje at that time). As a matter of fact, the effects of the earthquake could not be seen outside a radius of more than 6 to 7 km (4 miles) around the city [4, 5].

While the epicentral intensity was estimated IX on the MCS seismic intensity scale, the basic intensity in the Skopje urban area was evaluated to amount to VIII½ on the MCS scale [5]. The destructive part of the ground motion that was very violent, but of a very short duration, ceased before causing total collapse of the majority of damaged structures which were left shattered, on the verge of collapse, but still standing, after the earthquake, whose total duration did not exceed 5 s, [3].

In 1963, there was no strong motion instrument network in Macedonia. Researchers estimated various values of PGA in Skopje, ranging from 0.08g [3] to ≈ 0.5-0.6g [6] and about 30% g that lasted not more than 1/3 of a second [4]. Based on the study of the behaviour of various types of structures during the 1963 earthquake, in 1972 IZIIS [7], it was concluded that, on the average: 1) PGA was ~ 0.36%g; 2) Sa(at 0.1-0.4s) ~ 0.55g; and 3) Sa(at 0.4-2.5s) gradually dropped from 0.55 to 0.22g, which values were taken as final.

July 26, 1963 Skopje (M=6.1) earthquake was the largest catastrophe affecting post WWII Yugoslavia. It left 1,070 people killed, about 3,300 injured. More than 9,000 buildings were destroyed instantly or were later demolished. About 10,200 buildings withstood the earthquake with various damage levels (Table 1). In this event, Skopje lost 82.4% of its administrative value [2].

Being the first post WWII catastrophe, degrading the city to 17.6% of its administrative value and causing a loss of about 15% of the 1962 Yugoslav GDP, Skopje earthquake demanded a particular attention from the Yugoslav society. Considering that it was not only a property damage problem, but an adverse phenomenon degrading all the national development programmes, all aspects of the Skopje catastrophe were studied in all details for setting up proper and environmentally consistent development policies in the seismic regions of Yugoslavia.

Table 1- 1963 Skopje earthquake losses (in%) to dwelling houses, dwellings, living area and inhabitants involved (Source: Petrovski & Milutinovic, 1990 [8]; Milutinovic, 2001 [2])

Degree of Damage	Dwelling houses	Dwellings	Living area	Inhabitants involved
Destroyed	11.3	9.2	7.0	8.5
Heavily damaged	44.1	33.0	29.9	36.4
Damaged	22.0	32.9	39.9	30.6
Slightly damaged	16.5	20.1	19.8	20.3
Undamaged	6.1	4.8	3.4	4.2

3. Decisions Following 1963 Skopje Earthquake

By November 1963, the Alliance of Yugoslav Laboratories collected and compiled very detailed data on more than 250 affected, dominantly damaged structures and provided a Preliminary Report to the Federal Secretariat of the Industry. The major findings on structural behaviour [9, 10] are summarized in Table 2. By the end of December 1963, the Information on Preliminary Results on Earthquake Consequences for Buildings and Structures in Skopje [11] was presented to the Board on Communal Affairs of the Federal Council of the Federal Assembly of Yugoslavia (Agenda item 5), the findings and conclusions of which are summarized in Tables 3 and 5, respectively.

By and large, the structures of Skopje set a poor record of behaviour in the 1963 earthquake (Table 2). Structural failures were numerous and most of the failures were either beyond repair or repairable only at a great expense. Without going into further details, as partially presented in Table 2, RC frame buildings, dominantly moment resisting frame structures, behaved well, although designed for wind forces only, or seldomly (3 towers in Karposh settlement only) by consideration of the 1948 PTP2 Code earthquake provisions. Tall RC frame structures, up to 15 stories in height, performed far better because, being flexible, they were out of the earthquake dominant frequency range. Moreover, being important engineering undertakings in SR Macedonia (SRM) at that time, they were designed and constructed with particular care.

The general findings and conclusions (in fact, the Yugoslav operative action plan in the field) of the Committee on Communal Affairs of the Federal Council of the Federal Assembly of Yugoslavia elucidating the major root factors causing an unacceptable level of ethic and material property damages are presented in Tables 4 and 5, respectively.

Table 2 - Breakdown on Behaviour of Building Structural Typology in 1963 Skopje Earthquake

Structures well designed and constructed for normal operation conditions Tall reinforced-concrete skeleton structures, modern engineering structures such as factories, mills, bridges, dams, underground installations, highway embankments, railways, which were not designed to resist earthquake forces, but were well designed and constructed for normal operation conditions, suffered little damage. Two concrete dams near Skopje suffered absolutely no damage. *RC frame construction* Reinforced-concrete frame (built both with and without concrete shear walls or cores) structures suffered comparatively little damage and only two small structures of this type collapsed, one being the roof of the Skopje Fair). With these two exceptions there were no collapses of concrete frames in the city and no lives were reported lost. Framed structures without shear walls experienced non-structural damage (partition wall and plaster cracking) at the ground floor, with damage progressively decreasing on the upper floors. None were designed for earthquake forces although some were designed to withstand a wind force of about 0.95-1.00 kPa	*Masonry construction* Brick wall structures (unreinforced load-bearing brick walls supporting concrete floor slabs not tied in any way to the walls, dominantly used for residential construction) suffered more than any other type. Due to the high occupancy at the time of the quake (5.15 A.M.), they accounted for the largest number of deaths. *Hybrid or mixed (RC columns with brick bearing wall) construction* Mixed construction (reinforced concrete floor slabs supported partly by unreinforced masonry walls and partly by concrete columns), accounting for about 5% of new construction, suffered considerably and although many of these buildings did not collapse, they were left completely shattered, beyond repair. *Old adobe construction* Adobe construction, particularly with timber bracing, resisted the shock with some damage but behaved far better than the brick or the hybrid construction. Some loss of life was experienced due to the tiled roof collapses.
City Lifelines A few pipes of the water distribution system in the city and some underground telephone cables were damaged by the fallen buildings or by heavy debris. In other places, only a slight leaks were found and, in one place only, a subsidiary main water pipe was damaged by relative movement of its supporting structure where it crossed a ravine.	

Table 3 - General Findings of the Committee on Communal Affairs of the Federal Assembly [11]

Skopje earthquake showed that earthquake engineering had nationally completely been neglected and that, despite the fact that, due to its geographical position, Yugoslavia is one of more seismically endangered countries, all measures providing better protection of human life and material property against earthquake devastation had been neglected, as well.
While still incomplete, the preliminary assessment of the Yugoslav construction practice in seismic regions did show a number of intrinsic – subjective weaknesses which contributed to significantly enlarged and heavier earthquake consequences, then if timely eliminated when perceived.
It is necessary that authorities, within their mandates, immediately undertake all measures that contribute to full elimination or effective and efficient mitigation of earthquake consequences in Yugoslavia.

Table 4 - General Conclusion of the Committee on Communal Affairs of the Federal Assembly [11]

It is necessary to prepare and adopt regulations that will govern the construction in seismic regions.
The information on the preliminary results on the earthquake effects upon the buildings in Skopje, together with the views of the Committee, should be distributed to bodies and organizations for taking efficient measures based on gathered experience as well as for more consistent application of existing regulations that have not been overcome by technical development, which is valid for the entire territory of Yugoslavia.
Having concluded that there was no consistent application of the basic construction rules and norms in Skopje and because probably there are painful phenomena in other regions, the Committee believes that measures should be undertaken for rigorous implementation of existing technical regulations that are not overcome by construction techniques, not only in seismic, but also in all regions of Yugoslavia.
The Committee considers it necessary to continue with intensive study, compilation and systematization of experiences from the construction in earthquake prone areas to make this used in the preparation of technical regulations in these areas, in order that they can directly be applied by organizations participating in the construction process.

Understanding that Skopje was not a particular case, but national practice, the identified root factors and conclusions (Tables 3 and 4) were formulated with particular recognition and emphasises on: (1) Necessity that all competent authorities commit themselves to proposing and undertaking of all necessary measures for elimination of subjective weaknesses, both in legislation and in the work of relevant administrative bodies and businesses dealing with construction; (2) All necessary modifications relevant to earthquake engineering should be included in the curricula of authorities, schools and faculties dealing with education and training of professionals and other technical personnel in the field of civil engineering; (3) Technical inspection, especially construction inspection and other supervisory bodies, should strengthen the control over the quality of design, production of building materials and construction works; and, (4) the Federal Secretariat for the industry, as the authority responsible for adoption of technical regulations, based on the lessons from the Skopje earthquake and other international experiences, should, as soon as possible, but not later than mid-1965, adopt provisional technical regulations for design and construction in seismic areas, and revise and harmonize all accompanied technical regulations and norms.

4. Governmental Seismic Risk Reduction Policies

Facing the loss of 15% of GDP, understanding that the primary root factors of the Skopje's disaster were rather of systemic than environmental nature, and undertaking the responsibility for it, the Government of Yugoslavia, including all federal units, based on the Recommendations and Conclusions of the Committee on Communal Affairs of the Federal Assembly, undertook immediate action to formulate, develop and adopt adequate legislative environment to assure ready implementation and transfer of the lessons learnt for assuring future technically consistent, economically justifiable, sustainable and seismically safe development of the country.

As mandated, the Federal Secretariat for the industry, in cooperation with other relevant governmental agencies, undertook a complex, all domain, course in creating a legal environment that shall assure seismic-risk free or, in fact, all risks free development of the country. In the domain of seismic risk control and mitigation, consistent and harmonized measures and activities were undertaken in the following directions:

1. *Prevention and protection based on national and regional planning and urban development*
   - Seismic Zoning
   - Seismic Microzoning
   - Implementation of seismic zoning in national, regional and sub-regional development and physical development planning
   - Implementation of seismic microzoning in city planning and land development
   - Other measures being temporary or permanent constrains to various planning levels
2. *Engineering prevention and protection*
   - provisional technical regulations for design and construction in seismic areas
   - harmonization of all related technical regulations, standards and norms
3. *Emergency and disaster relief management*
   - Establishment of various administrative level Solidarity Funds and Regulative framework for their use for immediate post-disaster relief and reconstruction and recovery assistance.

     Post-Disaster Measures

     - Modification of the mandate of Civil Protection and establishing a Council for civil protection against natural disasters at all administrative levels (National, Republic, Municipal)
     - Development of a unified methodology and procedure for loss assessment and declaration

     Legal Framework

     - Development of a Legal Framework, laws, integrating and harmonizing pre- and post-disaster measures and activities.

Much of the post-Skopje earthquake measures and activities undertaken by the Yugoslav Government were later quite well recognized as outstanding sustainable development principles in UN Rio Agenda 21, Section I. Social and Economic Dimensions, Chapter 7: Promoting Sustainable Human Settlement Development, and Chapter 8: Integrating Environment and Development in Decision-making [11].

4.1. Genesis of earthquake resistant design regulations and implications

Within the territory of Yugoslavia, the first earthquake prevention measures were instituted in Slovenia following the Ljubljana earthquake of 1895 (I ≈ VIII degrees in MCS scale). In the absence of methods for earthquake resistance analyses of structures, seismic resistance of brick structures was accomplished by top-down increase of thicknesses of bearing walls, assuring: (1) a lower centre of gravity of the structure, and, (2) that the strongest, the base bearing sections, receive the highest earthquake loading stresses (Bubnov, 1981).

Between the two World Wars, Slovenia adopted standards for building loading requiring very low horizontal loads for seismic analysis, i.e., a uniform horizontal load of 2% of the weight of the structure [12].

Following the Second World War, in 1948, Yugoslavia adopted the Provisional Regulations for Building Loading - PTP2 (Official Gazette of (OGo) FNRJ No. 61/48), the part of which were regulations concerning horizontal seismic forces to which buildings may be subjected. The estimates of these forces were quite low (1 to 3 % of the structural dead load and one half of the live load), with the result that the wind loads often posed a greater hazard to buildings than the seismic forces in itself.

Shortly after the adoption of these regulations, the Yugoslav specialists came to the conclusion that they were not adequate for ensuring sufficient resistance of structures to earthquake loadings. This stimulated the Slovenian Ministry for Industry to create a special governmental commission to prepare updated regulations for earthquake resistant design. In 1963, the Government of NR Slovenia officially adopted the Regulations for Design and Construction of Structures in Seismic Regions (OGoSRS No. 18/63 of June 13, 1963).

The 1963 Skopje Earthquake took place just 40 days following the enforcement of the Slovenian Seismic Regulations. Facing the formidable devastation, the Government of Macedonia immediately enforced the Law on the Procedure for Retrofitting of Social Standard Facilities Damaged by Skopje Earthquake (OGoSRM No. 31/63 of 6 September 1963) which was accompanied by the Recommendation for Eliminating the Consequences of the Earthquake in Skopje in the Field of Education, and the Recommendation on Measures for Elimination of the Consequences of the Earthquake at the University of Skopje (the same Official Gazette).

To avoid pure retrofit being estimated as unjustifiable investment in earthquake prone areas, and assure feasibility and sustainability of all technical interventions during the initial phase of Skopje reconstruction, the Government of Macedonia enforced Regulations for Design and Construction of Structures in Seismic Regions (OGoSRM No. 33/63 of 24 September 1963), which, in fact, represented a translated version of the Slovenian regulations.

The regulations were in effect until 30 September 1964, when, at Yugoslav level, they were replaced by the first National Provisional Technical Regulations for Construction in Seismic Regions (OGoSFRY No. 39/64 of 30 September 1964) – in the following referred to as SDC64 (Seismic Design Code of 64), which were almost immediately followed by withdrawal of the Law on the Procedure for Retrofitting Social Standard Facilities Damaged by Skopje Earthquake (OGoSRM No. 44/64 of 31 December 1964).

Although based on strength design principles, with no amendments and modifications, SDC64 lasted until 5 June 1981, when it was withdrawn and partially replaced by ductility based design Technical Regulations for Building Construction in Seismic Regions (OGoSFRY No. 31/81 of 5 June 1981) – in the following referred to as BSDC81. Such changes were triggered by 1979, Montenegro Earthquake, causing 18% GDP losses to Yugoslavia. With several minor amendments and modifications for some technical details, rather than strategic policies, the BSDC81 has been in effect until now.

4.2. Genesis of seismic zoning and implications

The first seismic zoning map of Yugoslavia, accompanying PTP2 (Table 5) was based on compilation (Seismological Survey of Belgrade) of data on damaging earthquakes affecting its territory. It divided the territory of Yugoslavia into 3 zones – zones of low and high damage and zone of catastrophic destruction.

The changes in seismic zoning did not influence the value of the coefficient of seismicity, Ks, which remained stable, being 0.025, 0.05 and 0.1 for seismic zones VII, VII and IX degrees, respectively. The major seismic zoning implications were a decrease of the territory associated with seismicity of IX degree (Figure. 4.1) then, reappearance of a territory for which seismic design was not required (intensities lower than VII; 1.06% of the territory of Macedonia being 25,713 sq.km.). While the decrease of IX degree intensity zone was compensated by a substantial increase of zone VIII, as a consequence of replacing the maximum intensity with RP500 intensities, the reappearance of zone VI not requiring seismic protection was strategically and technically unacceptable.

Table 5 - Official Building Codes and Seismic Zoning Maps of Republic of Macedonia
(Source: Salic & Milutinovic, 2012 [15])

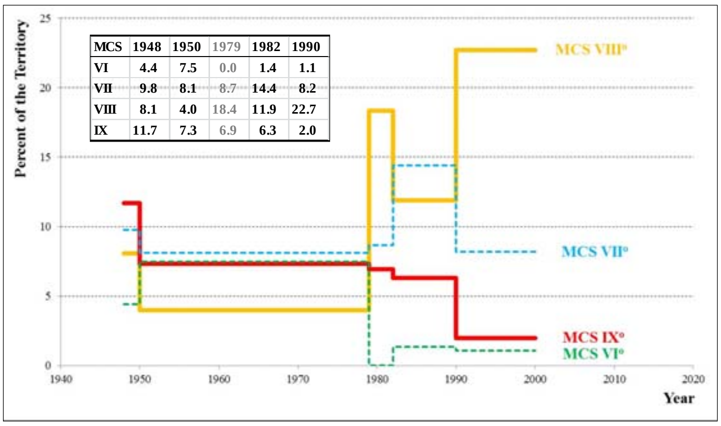
Code	Seismic Zoning Map
Provisional Technical Regulations (PTP) for Loading of Structures", Part 2, No. 11730, 12 July 1948 – PTP2.	**1948*: Seismic Zoning Map of FNR Yugoslavia,** (*OGoFNRY No. 61/48 of June 17, 1948*)
	1950*: Seismic Zoning Map of Yugoslavia, Seismological Bureau of FNRY, Belgrade. *(Author: Jelenko MIHAJLOVIC)* <u>*Base:*</u> *Compilation of intensities of earthquakes occurred in the period 360AD-1950AD*
Provisional Technical Regulations for Construction in Seismic Regions", OGoSFRY No. 39/64 (1964).	**1967: Engineering Geology Map of SFR Yugoslavia (1:500,000), Federal Geological Institute, Belgrade.** *(Authors: P. CUBRILOVIC, L. PALAVESTRIC and T. NIKOLIC)* <u>*Base:*</u> *Compilation of seismicity data for the territory of Yugoslavia, Intensities by MCS Seismic Intensity Scale.*
	1979: Seismic Zoning Map of Macedonia, Seismological Observatory, Skopje. *(Author: D. HADZIEVSKI, OGoSRM No. 2/79)* <u>*Base:*</u> *Compilation of seismicity data for the territory of Macedonia, Intensities by MCS Seismic Intensity Scale.*
Provisional Regulations for Construction of Buildings in Seismic Regions", OGoSFRY No. 31/81 (Amendments 49/82, 29/83, 21/88, and 52/90), adopted in 1981.	**1982*: Provisional Seismic Zoning Map of Yugoslavia** (*OGoSFRY No. 49/82*) <u>*Base:*</u> *Statistical analysis of known earthquakes that had struck the territory of Yugoslavia in the past.*
	1987/1990*: Seismic Zoning Maps of SFRY (1:1,000,000) for Return Periods of 50, 100, 200, 500, 1000 and 10000 years. *(Author: Seismological Association of SFR Yugoslavia, 1987; Degrees by MSK-64 Seismic Intensity Scale).* OGo SFRY 52/90: <u>*Article 6:*</u> *Map for Return Period of 500 years is adopted for design of buildings of II and III category (residential, and administrative, public and industrial buildings not classified in category I).*

MCS / MSK-64: Mercali-Cancani-Sieberg/ Medvedev-Karnik-Sponheurer 1964 Seismic Intensity Scales
* Seismic Zoning Map Accompanying Technical Regulations for Construction in Seismic Regions

An essential product for engineering prevention, but even more valuable for urban planning and land development is the Seismic Microzonation Map of Wider Urban Area of the City of Skopje enforced officially by OGoSRM No. 25/68 of 17.07.1968. It divides the wider urban area of Skopje into 3 basic seismic intensity zones, indicating areas where, due to the typology of the surface deposits, increase/decrease of seismic effects is expected and quantifying the associated Ks Coefficients. Since its enforcement, it has been a regular input for urban planning and elaboration of regional and general urban plans of the city.

After 1967 Debar earthquake, Seismic Microzonation of Debar Urban Area [14] was elaborated. IZIIS-Skopje performed subsequent microzonation studies for Leskovac, Serbia (1968), Ulcinj, Monte Negro (1968), Banja Luka, Bosnia and Herzegovina (1969).

Following the 1979 Montenegro earthquake, detailed microzonation studies were performed for 10 Montenegrin municipalities (Bar, Budva, Danilovgrad, Kolasin, Kotor, Herceg Novi, Mojkovac, Plevlja, Tivat and Ulcinj), as well as the municipality of Ston (Croatia). The objectives of the listed microzonations were definition of elements for development of the Spatial (Physical) Plan of Montenegro, regional spatial plans of the listed municipalities and general urban plans of the listed towns being the municipal administrative centres. A number of microzonations were also carried out for towns in Republic of Slovenia and other seismic prone regions.



MCS	1948	1950	1979	1982	1990
VI	4.4	7.5	0.0	1.4	1.1
VII	9.8	8.1	8.7	14.4	8.2
VIII	8.1	4.0	18.4	11.9	22.7
IX	11.7	7.3	6.9	6.3	2.0

Fig. 1 - Variations of the Size of Seismic Zones (in %) Caused by Changes of Seismic Zoning Map

5. Law on Construction of Investment Facilities

Since 1961, the entire process of construction in Yugoslavia, and Macedonia, has been controlled by the Basic Law on Construction of Investment Facilities (Federal Law) and the related Republics' Laws adopted based on the Basic Law, all focused on social standard facilities, residential buildings and communal infrastructure.

The first Basic Law on Construction of Investment Facilities (OGoFNRY No. 45/61 of 15 November 1961) overruled and replaced the Decree on Design and the Decree on Construction (enforced by OGoFNRY No. 32/58), controlling until then the process of design and construction of built environment. Macedonia adopted the first Law on Construction of Investment Facilities in 1962 (OGoNRM No. 33/62 of 10 October 1962). Both, the Federal and Republics' Laws were "lex perfecta".

The Federal Law of 1961 is organized in 11 sections: (1) Basic Provisions; (2) Investment Program; (3) Construction Approval; (4) Technical Control of Investment Facility; (5) Elaboration of Investment Programme and Investment Technical Documentation; (6) Construction of Investment Facility; (7) Construction of Investment Facility for Market; (8) Self (within the Company) Execution of Works; (9) Legal Supervision of Investment; (10) Penalty Provisions; and, (11) Transition and Closing Provisions.

- The Federal Law, as well as the NRM one, defined that "Technical documentation on investment facility consists of, in accordance with character of the investment, one or more designs (parts) such as: design of technological process, design of civil engineering part, design of installations, and other designs." It prescribes that "… technical solutions must comply with technical regulations, norms and obligatory standards, results of investigation studies and other studies, as well as use and technology, i.e., exploitation and economic concept of investment facility". Before the construction is approved, investment-technical documentation shall pass Technical Control that includes the following checks: conformity with the adopted technical regulations, norms and obligatory standards and proofs on: (1) stability of designed structure, (2) security against fires, life and health of the inhabitants, traffic and surrounding structures; and, (3) technical measures eliminating or minimizing damages that the investment facility with its existence, use and operation poses to the environment. The construction supervision, obligatorily governmental, is mandated to check weather: the Contractor respects this Law and the regulations made thereunder, as well as all other technical regulations, norms and standards;
- the investment facility is constructed in accordance with its investment-technical documentation;
- the quality of works, elements and construction materials, installations and equipment meet requirements being prescribed by relevant technical regulations, norms and standards in effect;
- consistent technical measures are applied to ensure the proper construction of an investment facility as well as safety measures for ensuring the security of investment facility, the life and health of its occupants, safe transport and safety of adjacent structures, and of technical systems (technology) used for complete elimination or minimization of damage that investment facility, due to its existence, use and/or operation, poses to the environment.

The authority responsible for inspection affairs may also supervise the work of manufacturers of construction materials used to construct the investment facility, in terms of technical characteristics and quality of produced construction materials, as well as in terms of obtaining the necessary attests or investigations and tests.

While positive in all aspects, the Law on Construction of Investment Facilities in legal, rather than in technical, details regulates the entire construction process, starting from design, construction approval (construction permit), technical control of designs (review), supervision of construction and technical acceptance of the constructed investment facility, including not only the quality of workmanship, but also the quality of construction materials. However, there were no references as to the potential seismic impacts and prevention measures to eliminate or mitigate the consequences. The law of 1967 (OGoSRM 035/67) follows the paradigm set by the 1961 Law.

Table 6 - Chapter VII: Design and Construction of Investment Facilities in Seismic Regions (SRM.1973.035)

Article 82: (C.1) For elaboration of investment technical documentation and for construction of investment facilities in seismic regions, there must be implemented the parameters defined by: the Seismic Zoning Map of the Republic, the maps of detailed seismic zoning of regions, the maps of detailed seismic microzoning of sub-regions and settlements, seismological and engineering seismological investigations of particular sites, and all technical regulations for construction in seismic regions, as well.
Article 83: (C.2) *Seismic regions* are regions of earthquake intensity VII, VIII and IX degree according to MCS (Mercalli-Cancani-Sieberg) seismic intensity scale, defined by the maps pursuant to Article 82 of this Law.
Article 84: (C.1) Development of the Seismic Zoning Map of the Republic shall be financed by the Republic. The Republic Secretariat for Industry and Trade takes care for its preparation and adoption. (C.2) The deadline for adoption of the Map is three years from the day of adoption of this Law. (C.3) For cities and larger urbanized settlements located in regions of MCS seismic intensity of VII, VIII and IX degrees, the municipalities are obliged to prepare microzonation maps within a period of five years following the adoption of the Seismic Zoning Map of the Republic.
Article 85: (C.1) For facilities of more complex structural system and of particular significance, as specified in Article 33, paragraph 1-15 of this law, to be constructed in seismic regions of seismic intensity of VIII and IX degree, in the case the site is not included in the maps as requested in Article 84 of this Law, the investors are obliged to elaborate a site microzonation map before preparing the investment technical documentation. (C.2) For facilities whose collapse or damage could cause severe consequences to the environment, lives and health of people and heavy damage to the economy (high dams, nuclear facilities, reservoirs with content threatening the environment and people, furnaces and similar facilities), investors are obliged to ensure, following special seismological and engineering seismological investigations, reliable parameters and criteria for up-to-date earthquake resistant design.
Article 86: (C.1) Preparation and revision of spatial and urban plans requires taking into account corresponding seismic zoning/microzoning maps and related data.
Article 87: (C.1) For public facilities (schools, hospitals, facilities for cultural entertainment, sports and other public gatherings and catering facilities covering an area larger than 1,000 m^2) and dams, in accordance with Article 33, paragraph 1, item 1, located in regions of seismic intensity of IX degrees and designed and constructed as seismically non-resistant, within a period of 3 years following the enforcement of this Law, the earthquake resistance and safety coefficients against collapse shall be evaluated and reported in special technical documentation. (C.2) If the coefficient of safety is less than 1.15, investors, i.e., users of the facility are obliged to strengthen, within a period of 10 years following the enforcement of this Law, the facility to comply with the enforced technical regulations, or to reclassify its use for eliminating the imminent threat to human lives. (C.3) If Investors or users do not act in accordance with the preceding paragraph, the mandated technical inspection shall issue adjudication for either banning the use or for reuse of the facility.
Article 88: (C.1) The Republic Secretariat for Industry and Trade is mandated for the approval of the Map of Seismic Zonation of Socialist Republic of Macedonia and the approval of a detailed Municipal Microzonation Maps, as well as parameters derived based on special investigations, which will be used in the design process.
Article 89: (C.1) Technical measures and conditions for construction of investment facilities and facilities of citizens and citizens' legal entities in seismic regions are determined by special technical regulations. (C.2) Technical regulations will determine facilities to be designed with higher parameters for assuring increased seismic resistance and facilities for which these technical regulations are not applicable.

Seismic protection and mitigation aspects were entered, for the first time, in terms of an entire chapter (9 articles), in the Law in 1973 (OGoSRM 35/73 of 15 October 1973; amendments and changes 46/73, 9/74 and 47/74). This was the major change of the paradigm, clearly identifying the needs for: (1) national and regional seismic zoning; (2) microzoning of urban areas; and (3) construction sites beyond microzoned areas. The Law also extended the governmental interest in seismic risk control, being initially focused only on social standard facilities, residential buildings and communal infrastructure, to build environment in private property. For the first time, the Law recognized the role of physical and urban planning in seismic protection and control of the seismic risk and, introduced and prescribed seismic mitigation measures and activities, including a time frame for their completion, represented by rigorous seismic stability and resistance assessment, and if needed, structural strengthening of the standard public facilities (schools, hospitals, facilities for cultural entertainment, sports and other public gatherings and catering facilities covering an area larger than 1,000 m2) and dams located in regions of seismic intensity of IX degrees if the evaluated coefficient of safety is lower than 1.15.

The 1983 Law on Construction of Investment Facilities (OGoSRM 15/83 of 18 May 1983, including amendments and changes 11/87, 20/88, 18/89 and 47/89) reaffirmed the seismic risk control postulates set and introduced in the 1973 Law. However, replicating Article 87 (mitigation of seismic risk of standard public facilities) indicated that the “Lex Perfecta” mechanism of the 1973 Law malfunctioned. Moreover, Article 86 (“preparation and revision of spatial and urban plans have to take into account corresponding seismic zoning/microzoning maps and related data”) was withdrawn so that the integrated (spatial development planning and urbanistic control combined by mass engineering seismic protection of individual facilities) seismic protection and seismic risk control were degraded to engineering protection of individual facilities, only.

The Law of 1990 (OGoSRM No. 15/90) was the beginning of the set-back policy referring to integrated seismic risk management. It reduced the seismic risk control to two articles, the first one recognizing that “it is needed” and the second one reaffirming the use of various levels of seismic zoning and microzoning maps as a necessary input for elaboration of investment technical documentation in seismic zones of VII, VIII and IX degree MSC seismic intensity. However, amendments and modifications of the Law of 31 March 1999 (OGoRM No. 18/1999) degraded the legal seismic risk control mechanisms to sole implementation of “standards and norms for design of structures”.

6. Law on Construction

This “Lex Perfecta” Law explicitly (Table 7) requested that, among other, the construction has to be with assured “Mechanical Resistance, Stability and Seismic Protection (MRSSP)”, stating (Article 4): Structures have to be designed and constructed in such way that, during construction and their life time, they will not develop, in general, disruption of mechanical resistance, stability and seismic protection, and in particular: (1) Total or partial collapse of the structure; (2) Damage to parts of the structure or equipment as a result of large deformations of the load bearing structure; and, (3) Disproportional deformation and damage of the structure relative to the cause generating it.

While the Law recognized the need for rigorous check of mechanical resistance, stability and seismic protection of construction, it neither foresaw nor regulated the mechanism of its operative implementation. It took 8 years until this aspect was resolved by Modifications and Amendments of the Law on Construction (OGoRM No. 163/13 of 26 November 2013). UKIM-IZIIS elaborated a Price List referring to the Amount of the Compensation for Opinions on Designed and As-built Degree of Mechanical Resistance, Stability and Seismic Protection (OGoRM No. 28/14 of 6 February 2014). Adopting the Price List, the Government of RM nominated the UKIM-IZIIS to establish a system and carry out all the activities prescribed by the relevant provisions of OGoRM Nos. 51/05, 130/09 and 28/14. Table 8 presents some statistics on distribution of design flaws by construction typology for the period January 2014 - end of December 2015.

7. Concluding Remarks

Two major earthquakes (1963, Skopje & 1979 Montenegro) set milestones and margins of acceptable seismic risk policies in Yugoslavia and Macedonia. Following these two events, the entire technical and legal regulatory framework was strengthened, as demonstrated by the 1973 and 1983 Laws on Construction of Investment Facilities. The Law of 1990 significantly relaxed the seismic requirements while the Law of 1999 eliminated them completely from the Law on Construction of Investment Facilities. This degraded the integrated systemic seismic risk reduction system to solely technical regulations and their implementation, i.e., to the concept of engineering seismic risk protection at which Skopje faced 1963 earthquake.

The Law on Construction enforced in 2005, substituting the already significantly deconstructed Law on Construction of Investment Facilities, provided a sound legal framework for strengthening the entire construction process. However, it took 8 years before operational mechanism – segment seismic protection and control of acceptable seismic risk were worked out and put into operation. In the meantime, the new, post-1991, socio-economic and political reality, transitional economy, corruption and mentality paradigm changes, did continue to weaken the systemic and engineering risk prevention and protection systems.

Table 7 - An Excerpt from the Modifications and Amendments of the Law on Construction (OGoRM 163/13)

(1) To determine the fulfilment of the conditions pursuant to Article 4 of this Law, it is necessary to present a positive *Opinion* on designed and as-built degree of mechanical resistance, stability and seismic protection of a structure, obtained and issued by a scientific&research entity – scientific institute specialized in the field of protection of structures against seismic effects.

(2) The *Opinion* on designed level of mechanical resistance, stability and seismic protection of a structure refers to the *structural design* part of the technical documentation, which is an integral part of the basic design and is submitted by the *Investor* as a document accompanying the request for obtaining the construction permit.

(3) The entity which performs scientific&research activity - scientific institute specialized in the field of protection of structures against seismic effects shall:

- For structures with GDA of less than 5,000 m2, provide the MRSSP Opinion to the Investor within 15 days from the receipt of the Request, or within 30 days for structures with GDA larger than 5,000 m2 and line infrastructure facilities;
- Otherwise, it will legally be considered that the Opinion is positive. In such a case, the liability for compensation of possible future damages to the structure shall rest in the scientific&research entity.
- The opinion on as-built MRSSP degree shall be obtained by the Contractor (Builder) during the: (1) execution of the construction works, and (2) after the completion of the entire structural system of the structure.

(8) If, after completion and putting the structure into operation, the structure suffers damages due to non-fulfilment of the requirements for mechanical resistance, stability and seismic protection, the liability for compensation shall rest in the entity carrying out scientific&research activities.

Table 8 – An Excerpt from Statistics on 2014/2015 Design Flaws

Engineering Structures, Ground Structures (roads, railway) and Infrastructure:

Considering the character of engineering structures, ground structures and infrastructure, the objected number of designs to which *Remarks* were given is negligible.

Buildings Structures:

- 47.9% (7% of the reviewed Gross Developed Area, GDA) of the issued *MRSSP Opinions* account for structures with GDA < 300 m^2; 52.1% (93% of GDA) refer to structures with GDA > 300 m^2.
- 39% of the submitted designs of buildings were returned for correction/remake with a *Remark*. After the first correction/remake, positive *MRSSP Opinions* were issued to 29.03% of the corrected/remade designs. As to 9.5%, 1.66% and 0.01% of such designs, positive *MRSSP Opinions* were issued after the second, the third and the fourth correction/remake, respectively.
- In the period January 2013 – October, 2015, 58% of the objected designs were objected, a *Remark* was given and were returned for correction/remade. This percentage dropped to 49% in the period April-June, to 35% in the period July – August, and to 28% in the period September-December 2014.

Based on the three year experience in implementation of the OGoRM 163/13 Construction Law – segment "MRSSP Opinion", inconsistency of technical designs and weak and inconsistent design review were isolated as critical links. Even if construction supervision and technical acceptance had been at the prescribed level (which was not the case) it is hard to believe that sound seismically safe structures would have been built based on technically inconsistent, incomplete and, in quite a lot of instances, erroneous technical documentation. In simple words, disaster root factors regenerated and started to build up, increasing the vulnerability of the country to seismic impacts in general, and particularly of the Skopje city, whose exposure and related costs have been tripled since 1963.

Based on the above, UKIM-IZIIS strongly supports the modifications and the amendments of the recently enforced OGoRM 163/13 Law on Construction that have introduced the "MRSSP Opinion" system of assurance of designed and as-built level of mechanical resistance, stability and seismic protection of the built environment as a legal instrument for high quality control and operative monitoring of the process of design and construction in the Republic of Macedonia. Consistent and controlled implementation of the Law, which is already showing positive results, shall result in construction with increased designed and "as built" seismic safety, i.e., increased protection of the population and material property against seismic effects which was and is the primary strategic determination and intention of the Government of the Republic of Macedonia.

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OGoRM	– Official Gazettes of Republic of Macedonia, all in Macedonian
OGoNRS/OGoSRS	– Official Register of Peoples (N) and Socialist (S) Republic of Slovenia, all in Slovenian