Lessons from M 7.2 Seismic Event and How to Preserve Awareness Forty Years Later: The Case of the Vrancea, Romania, March 4, 1977 Earthquake

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Abstract. Almost four decades after the $M_{G,R} = 7.2$ ($M_w = 7.4$) catastrophic earthquake of March 4, 1977 hit Romania, the population fears a new strong earthquake; however, awareness on preparedness and mitigation measures is rather low. As the last $M_w > 6$ has occurred in 1990, there is an increasing percentage of young population that has not yet witnessed a strong earthquake, and which has a rather fuzzy representation of urban and geological earthquake effects. After each strong seismic event in the past, due to its specific attributions, the National Institute for Building Research, INCERC, collected a considerable amount of information about the earthquake effects on built environment and lifelines, geological effects etc. To this, information from various documentary sources about damage caused by historic earthquakes was added by the institute’s specialists. Stored today in the archives of the National Institute for Research and Development in Construction, Urban Planning and Sustainable Spatial Development, “URBAN-INCERC”, INCERC Bucharest Branch, this information is invaluable today for evaluating the present and future seismic risk of the country. Nonetheless, it could represent an essential educational resource for university students and young professionals in the field of civil engineering, seismology, geology, economy, sociology, history etc. and for raising population awareness on seismic risk mitigation measures. The paper presents new approaches for the dissemination and re-valuation of the March 4, 1977 earthquake data, from the perspective of present scientific knowledge.

1. Introduction
On March 4, 1977, a $M_{G,R} = 7.2$ ($M_w = 7.4$) earthquake hit Romania, causing 1,578 deaths, thousands of injured and damage to about 32,900 of buildings. Losses, estimated to 2 billion USD, induced long-term perturbations in the entire socio-economic and industrial system of the country. In 1986 and 1990, other earthquakes caused additional, yet smaller damage.
After each strong seismic event, the National Institute for Building Research, INCERC, by its attributions, was a main actor in data collection and interpretation, as well as in damage and loss assessment, acquiring a vast amount of information about earthquake effects. Today, this information is invaluable, as it provides a multifaceted view on Romania’s built environment of then – and now, since many of the described buildings still exist today. Besides earthquake damage descriptions, a wealth of subsidiary data from the period sheds additional light on the pre-1977 built heritage. Moreover, to the archive an important source of knowledge on seismic damage of old heritage buildings in historical earthquakes was added by research conducted by the institute’s specialists [1, 2, 3]. Thus, the INCERC archives have a two-fold value. First, they reveal the history of the described buildings (condominiums, factories, heritage buildings), with their past seismic damage, repairs and strengthening records. This is a resource of knowledge about their (and similar buildings) vulnerability, in future earthquakes. Then, there is a bigger picture behind – the built heritage, which is a component of the country’s social, historical and cultural identity.

Deposited today in the archives of the National Institute for Research and Development in Construction, Urban Planning and Sustainable Spatial Development "URBAN-INCERC", many of the above resources are still not accessible to the wide public. The main reason resides, at present, in their “raw” and weakly organized nature.

The information archived at URBAN-INCERC represents not only a scientific asset, but also an essential educational resource for students, authorities and professionals in civil engineering, heritage conservation, seismology, geology, economy, sociology etc. Nonetheless, it could be an important factor in actions for maintaining citizen’s awareness and preparedness for future earthquakes. Based on 2014 data from the National Institute of Statistics in Romania, a study of the authors revealed, in this context, that 56.31 % of the population of the country has not witnessed of the 1977 earthquake, while 33.75 % are too young to have consciously witnessed at least the 1990 Mw > 6 earthquakes. Thus, a very large proportion of the population lacks direct experience with the earthquake effects.

The paper presents new approaches for the dissemination and re-valuation of the March 4, 1977 earthquake data, from the perspective of present scientific knowledge.

2. Background

The written sources on earthquakes impact on the Romanian territory are dated from 984 A.D., with historical damaging events in 1471, 1738, 1802, 1838. In the 20th century, the earthquake resistant design of buildings became a stringent issue after the destructive $M_{G,R}=7.4$ ($M_w=7.7$) November 10, 1940 Vrancea earthquake. The first earthquake resistant design regulation of the Ministry of Public Works was issued in 1942 / 1943 (provisional rules). Compulsory code editions were issued in 1963, 1970, 1978, 1981, 1991/1992, 2006 and 2013. A first seismic zoning map was enforced in 1952, while new zoning maps and standards were enforced in 1963, 1978, 1991 and 1993, following the seismic events of 1977, 1986 and 1990-1991 [1, 4].

According to the laws in force at the time of the March 4, 1977 earthquake, the data about the physical laws of the earthquake on constructions were collected by local authorities and building design institutes of each county administrative centre (county seat) of Romania. They were subsequently sent to ICCPDC (Central Institute for Research, Design and Guidance in Civil Engineering), having INCERC as a main pillar. The primary data included: damage reports, datasheets, drawings and photographs for various categories of buildings – dwellings, heritage buildings, public works etc.; explanations on technical causes of damage. Later, technical solutions adopted for repair and strengthening were added, as well as conclusions and proposals for the improvement of the national seismic code. Despite the amount and complexity of this information, many aspects of the costs and consequences of the 1977 earthquake’s impact were largely ignored, hidden or neglected in the years that followed. Only part of these data was published, as internal reports with limited circulation (ICCPDC, [5]) and later in a book [6]. Under the rules of the communist regime of the time, the information on the actual extent of the socio-economic impact of earthquakes was a matter of political control. Therefore, while technical data on different categories of buildings were only partly censored,
data susceptible to show the overall value and the territorial distribution of losses, as well as detailed
data on casualties, were not released. Thus, although the 1977 earthquake provided scientists with a
great living laboratory and unique and valuable lessons in the earthquake engineering, able to change
concepts and regulations, in the years that followed, the official actions were mostly concerned with
other projects, ignoring the potential threat from future earthquakes. Many heritage buildings were
abusively demolished after 1977, others neglected. Today, almost 40 years after, there is a strong need
for data recovery and re-valuation. Some unpublished data were discovered in the ICCPDC-INCERC
archives and in World Bank Reports after 1990’s and partially evaluated [3, 7, 8, 9]. Other data were
recently found in the ancient “Securitate” and in the Romanian Communist Party archives, providing a
very important source of knowledge, to be evaluated and correlated.

3. Gaps in earthquake knowledge transfer and lessons from the March 4, 1977 earthquake
In Romania, the recurrence of earthquakes at large time intervals requires preserving citizen awareness
and a continuous knowledge transfer stream, in engineering terms, as well as in common language. A
questionnaire survey for investigating the earthquake preparedness of Bucharest citizens, conducted as
a component of the Japan-Romania Project on Seismic Risk Reduction [2, 7], has revealed a paradox.
Undoubtedly, most people showed a remarkable awareness about the seismic risk; however, in fact, this
was merely combined with public apathy and reluctance to engage in strengthening works by using the
legal system and the special incentives of the Law on Seismic Risk Reduction – Government Ordinance
No. 20/1994. The “living with risk” syndrome is in this case both a positive and a negative factor and
the present situation is still the main reason for which only 73 buildings were strengthened in Bucharest
between 1994 and 2016, out of over 400 officially listed in the highest class of seismic risk (Seismic
Risk List of Bucharest Buildings, [10]). Therefore, an important issue is how to transfer knowledge,
bridging thus the gap between seismology and earthquake engineering, on one part, and between
professionals’ and citizens’ understanding, on the other part. If organized for dissemination, the data in
URBAN-INCERC archives could play a key role in this process.

4. Lessons from the behaviour of specific types of structures, stored in URBAN-INCERC
archives
To illustrate the content of the URBAN-INCERC archives, some cases of building damage and collapse
from the March 4, 1977 earthquake are presented as follows.

1. The total or partial “pancake” collapse of a great number of pre-1940 buildings with frames
without moment-resisting joints and masonry infills (Scala, Continental, Nestor, Casata
buildings etc.). The main causes were inadequate architectural conformation, lack of ductility
and insufficient transverse reinforcement.

2. Damage caused by the 1940 earthquake was disregarded and only slightly repaired by the
owners; this led in 1977 to the collapse of 28 high-rise buildings. Such is the case of the Casata
building, which underwent important damage of the corner column in 1940 (Figure 1). This was
later on forgotten, due to ownership change following the post-1948 nationalization. In 1977,
the building collapsed on the column side that was damaged in 1940.

3. Only three buildings erected after 1960, all in Bucharest, underwent total or partial collapse [6]:
   a) section A of the Lizeanu apartment building, 33 Stefan cel Mare St. (Figure 2), with soft-
story effect; this effect caused damage under the limit of collapse in other similar buildings
from the North Railway Station area, Stefan cel Mare St. etc.; the design was withdrawn
before 1963; however, many structures alike still exist;
   b) a section of the OD 16 apartment building, part F, 7 Pacii St. (Figure 3), significant for the
behaviour of structures with a single longitudinal shear wall and with low ductility flanges;
similar effects were produced by cracking and/or damage of reinforced concrete shear walls
with low shear reinforcement, for many buildings erected in the period 1960 – 1977,
especially for which sliding formworks were used;
c) The Computing Centre of the Ministry of Transports (Figure 4), significant for the collapse of overloaded columns with rather strong vertical rebars (20 and 25 mm-diameter), but with insufficient transverse reinforcement below the well-reinforced capitals.

Figure 1. Casata (Broșteni) building: a, b) after the 1940 earthquake, showing damage of corner column over the 1st floor [11]; c) after the 1977 earthquake [5]

Figure 2. Lizeanu building before [12] and after the 1977 earthquake [5]

Figure 3. Collapse and overturning of a section of the “OD 16” building in 1977 [5]

Figure 4. Pancake collapse of the Computing Centre of the Ministry of Transports in 1977 and detail of column failure [5]
Under the 1970’s political regime in Romania, hundreds or thousands of structures with slight or apparently no damage were declared officially as safe after the 1977 earthquake, even though professionals listed all inspected structures for further evaluation. The assessment and possible retrofit were never done to the needed extent [1, 3, 8]

5. Conclusions
The pro-active awareness on seismic risk underlying factors is a key factor in ensuring owners’ participation in risk mitigation projects. The hidden and un-repaired building damage poses a significant threat in future earthquakes; therefore, collective memory about it should be continuously renewed, by using new approaches. The engineering re-evaluation of past earthquake damage and losses requires searching, retrieving and providing access to additional data, including that from recently de-classified archives.

Acknowledgement(s)
Funding for the presented research was provided by the Romanian Ministry of National Education, UEFISCDI Agency, under Contract No. 72/2012, Project BIGSEES, and by the European Centre for Buildings Rehabilitation, ECBR.

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