

THE ROMANIAN EARTHQUAKE OF MARCH 4, 1977 REVISITED: NEW INSIGHTS INTO ITS TERRITORIAL, ECONOMIC AND SOCIAL IMPACTS AND THEIR BEARING ON THE PREPAREDNESS FOR THE FUTURE

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ABSTRACT :

The Vrancea, Romania earthquake of March 4, 1977 was one of the worst earthquake disasters of the 1970's around the world. It caused the loss of 1,578 lives and injured an additional 11,321, with 90% of the fatalities being in the capital city Bucharest. The reported damages included 32,900 collapsed or heavily damaged dwelling units, 35,000 homeless families, thousands of damaged buildings, as well as many other damages and destructions in industry and infrastructure. A 1978 World Bank report estimated a total loss of US\$ 2.048 billion, with Bucharest, accounting for 70% of the total. More detailed but until recently classified and largely ignored damage data (ICCPDC reports, December 1978) contain information from 19 counties plus Bucharest, with the total damage value reaching Romanian Lei 3.7 billion, out of which damage in Bucharest accounts for 42%. Loss data from 20 ministries having assets in 25 affected counties amounts to Romanian Lei 3.5 billion. Thus, the total loss reaches Romanian Lei 7.25 billion. The territorial loss was heavy in many counties and its geographic distribution surprising, with limited damage in the epicentral region and extensive damage in faraway counties and reasons for this surprising pattern are discussed. The paper aims to quantify and bring-out in the open the extent of this disaster so that its effects are fully appreciated, thus serving towards the formulation of a new national strategy of seismic risk reduction.

KEYWORDS: *Romania earthquake, March 4, 1977 disaster, loss reevaluation, loss to GNP ratio*

1. DATA ON MARCH 4, 1977 DAMAGE, LOSSES AND IMPACT AND RATIONALE FOR A RE-EVALUATION

After March 4, 1977 Vrancea earthquake losses were accounted and available in the initial official communiqués, local technical books, papers and some reports of international specialist delegations. Casualties were reported in 1977, in rounded figures, as 1,570 deaths, 11,300 injured (with 90% of the victims in Bucharest) with and 35,000 homeless families. Official damage data referred to some 2 billion US Dollars\$ losses, a number of 32,900 collapsed or heavily damaged dwellings, tens of thousands of damaged properties, many other damages and destructions in 763 commercial and industrial units and other effects in the whole spectrum of the economy. The post-earthquake reconnaissance reports and studies presented seismological, engineering issues and some disaster management aspects (Berg et al, 1977; Fattal et al., 1977; JICA Report, 1977 etc).

In 1977-78 a special action was undertaken by the Central Institute ICCPDC-Bucharest to collect data on damage from ministries and counties, but most of these data were considered classified material. In 1978, a first four volume report was published, with limited circulation, addressing the damage incurred and lessons learned, with some data on the territorial spread distribution of the damages (ICCPDC, 1978). In 1982, an excellent volume on the earthquake was published (Balan et al., 1982) but it does not sufficiently address the social and economic impacts, the human casualty effects and the disaster management aspects. What is symptomatic is that the

economic value and social effects of the earthquake were never discussed in detail and were generally given limited consideration in all of the above reports and official communiqués. Some ICCPDC reports that include a preliminary valuation of damages became available only after the 1990's.

A World Bank Report was the only international contemporary report addressing the socio-economic aspects in some detail referring to the US\$ 2 billion loss estimate and including more detailed sectorial loss figures by economic sector and impact considerations. This report was used as background information for a loan to Romania (World Bank, 1978) and was neither quoted in local references nor available in Romania until 1992 (Georgescu and Kuribayashi, 1992). According to this report, out of Romania's 40 counties, 23 were strongly affected, with Bucharest recording the highest losses. Counties far-away from Vrancea region in the south-east of the country (Teleorman, Dolj and Prahova) but also in north-east (Iasi, Bacau) suffered significant damage, but any no details were given. The US Foreign Disaster Assistance Office (OFDA, 1988) indicates the same total loss, while others (Munich Re, 1998; Coburn and Spence, 1992; 2002) suggest only some US\$ 800 million loss.

The fact that the damage from the 1977 earthquake was extensive is evidenced by contemporary data and by the fact that Romania received aid from 55 countries and 12 organizations. We have enough evidence that many direct and indirect loss data were presumably underestimated or neglected in 1977-8, while other economic losses were only briefly described. Since the immediate and long-term impact on development was not treated as a matter of public concern and debate, the authors considered that it is of great interest to quantify and bring-out in the open the extent of this disaster so that its effects are fully appreciated, thus serving towards the formulation of a new national strategy of seismic risk reduction. As main issues of interest and correlation with other seismological and engineering data, there are the territorial distribution of losses and correlations with the loss extent.

2. LOSS VALUE AND STRUCTURE IN ICCPDC REPORTS

The ICCPDC reports are internal government reports with loss estimates data produced by the authorities at the request of the Central Government, at the end of 1978, in the local currency (Romanian Lei). In the reports issued by each affected ministry and county separately the overall amount of damages is given in physical units and reaches values of 32,897 collapsed or demolished dwellings, 34,582 homeless families, 763 industrial units affected and many other damages in all sectors of the economy. In total there were:

- 742,259 collapsed or damaged dwellings (or 12% of Romania's dwelling stock in 1977), out of which 35,600 dwellings were collapsed or condemned (4.8%), 351,835 dwellings to be strengthened (47.4%) and 354,824 dwellings to be repaired (47.8%);
- 8,228 social-cultural units lost and damaged, representing 28.8% of national stock.

The total damage value from these two categories (housing and socio-cultural buildings) is Ro Lei 3,725,177,000, out of which Bucharest damage accounts for 41.7% or Ro Lei 1,553,362,000 (excluding social-cultural buildings of ministries and central institutions that have not been reported for Bucharest). Housing represented 90.45% of this total loss, while social and cultural buildings represented 9.55%.

Value of loss suffered by 20 ministries having assets in the 25 affected counties amounts to Ro Lei 3,523,194,000. Thus, the total loss derived from the ICCPDC reports (December 1978) reaches Ro Lei 7,248,371,000. In terms of the relative composition of the losses, there is some similarity as to the share of housing in the total ICCPDC loss, but Bucharest's loss share cannot be compared with other data, since it is given only with respect to housing and socio-cultural buildings. The above can thus be considered as a first level estimate of the actual 1977 loss expressed in Romanian Lei. In order to better document the magnitude of this disaster we must check their completeness, relevance, and consider the then applicable exchange rates of the local currency. At the time of the earthquake in Romania different Lei to US\$ exchange rates were used (e.g. for internal trade, for external trade etc.). If the losses in US\$, officially communicated in December 1977 and, recorded by the 1978 World Bank report, are assumed to be equivalent to the aforementioned losses derived from and the ICCPDC reports in Ro Lei had been equivalent, a rough conversion would lead to a rate of 3.53 Ro Lei per US\$,

which is lower than any exchange rate used at the time. Actually the exchange rate for foreign trade (ca. 20 Ro Lei per US\$ in 1977) was considered at the time as the one that was closer to the true value of the local currency. For comparison if a Romanian citizen brought US\$ into the country the conversion rate into Ro Lei was of 4.970 Ro Lei per US\$ in 1977 and 4.559 Ro Lei per US\$ in 1978. This exchange rate was at the time considered as quite unfair.

Therefore we tend to believe that some component of loss was added at central level, when aggregation was made for communication to the World Bank. There is a certain feeling that the number of damaged elements and their geographic distribution area that was heavily damaged is correctly described in the ICCPDC reports, but loss estimates are either underestimated or other loss values are missing in the final value of preliminary ICCPDC loss table. We may suppose that the missing losses were, at least, those mentioned before, as well as others that appear in the World Bank Report of 1978 but were not reported by ICCPDC for unknown reasons.

3. DATA ON TERRITORIAL DISTRIBUTION OF LOSSES BASED ON ICCPDC REPORTS, ROMANIA (1978)

Damage derived from the ICCPDC reports is now known for 19 counties plus Bucharest City. Figures 1 to 3 show the territorial distribution of the dwelling stock that was destroyed, needing strengthening or needed repair (lighter damage), respectively. The data are presented in terms of descending order for the counties that existed in 1977 administrative organization of Romania.

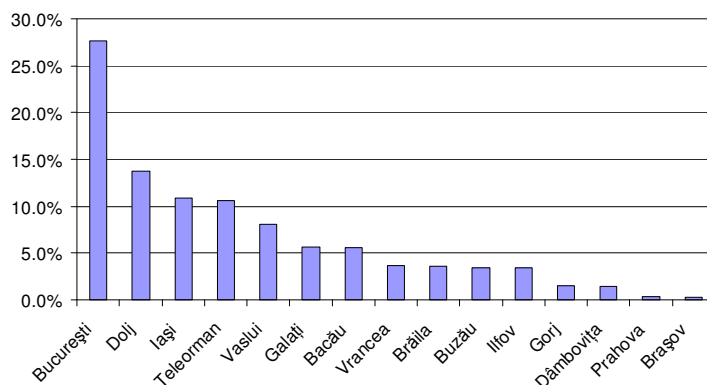


Fig. 1. Territorial distribution of destroyed dwellings in 1977 (%)

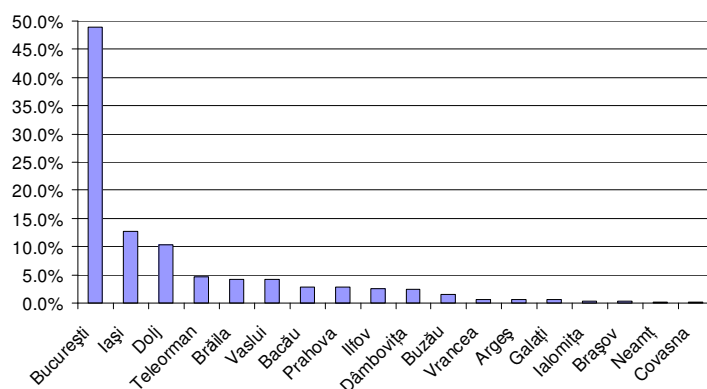


Fig. 2. Territorial distribution of dwellings requiring strengthening in 1977 (%)

This territorial distribution of damages gives us a better understanding and may contain many hidden messages that we need to explain. The loss was heavy in many counties and its geographic distribution surprising, with limited damage in the epicentral region and extensive damage in faraway counties. Each graph of Figures 1 to 3

has some meaning, but the sum of all situations, expressed as the proportions of affected dwelling units compared to the total dwelling stock of each county in 1977, may give a broader image, as shown in Figure. 4.

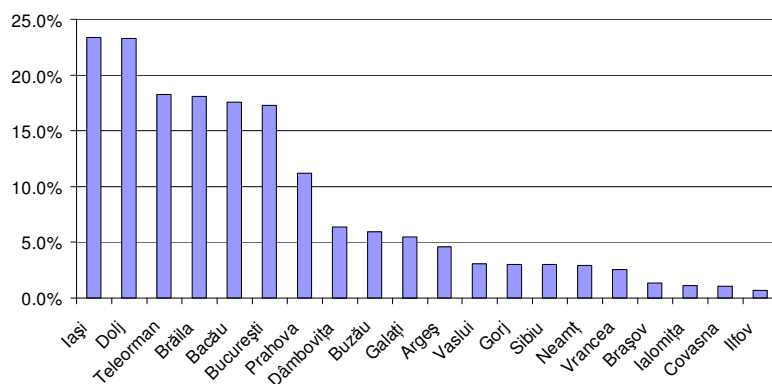


Fig. 3. Territorial distribution of dwellings requiring repair in 1977 (%)

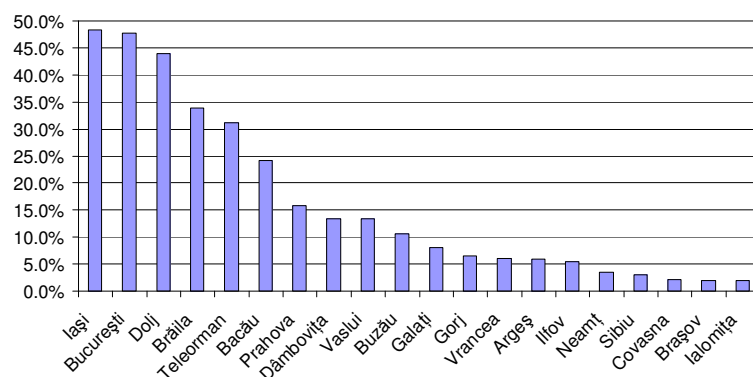


Fig. 4. Territorial distribution of affected dwellings in 1977 (%)

In comparison with usual attenuation patterns, one may wonder why counties in the epicentral region were largely unaffected, when counties more than 100-km away, suffered nearly 50% damage rates? For example, Iasi County (48.3%) and Bucharest City (47.8%) are on the first places, although their sites are situated at considerable distances from the Vrancea seismogenic zone. The large number of old buildings in Iasi and the long-period effects on slender buildings in Bucharest are among first explanations at hand. Dolj County (43.8%) even further from Vrancea is on the third place, something that to this day has not been fully explained and a combination of the previous two causes can be put under debate, without full arguments for each. One reason may be that Dolj County was in the lowest zone of the Romanian earthquake code in the 1963-1977 period (zone of intensity VI). Also note that Craiova (capital of Dolj) was reportedly devastated during the April 1790 Vrancea earthquake.

Braila County was the 4th worst affected county in 1977 (33.9% affected dwellings), but neighbouring Galati County was not affected to the same extent (11th with 8% of its affected dwellings). Braila and Galati cities (217,000 and 300,000 people respectively), are built on „loess” which in the past has caused lots of damage (not related to earthquake shaking e.g. due to ground subsidence) related to the rise of the water table, rise of phreatic waters from the Danube which is crossing the cities or from leaks (from the canals), many old tunnels which caused damage before and during the earthquake. Also many houses are from load-bearing masonry in these two counties.

Galati has newer buildings, many areas were rebuilt as the industries were developed. Could it be also that the

differences in damage between Galati and Braila may be explained by the effect of loess that is more extensive in Braila County, since the Danube is crossing the whole county, while in Galati county the river is only passing through, forming the southern border of the county? Some of the difference could also be due to attenuation patterns, although Galati County is somewhat nearer to the Vrancea 'source zone than Braila county.

In the south, the towns of Alexandria and Zimnicea (in Teleorman County, in the 5th place) had an older housing stock and being rural areas had a large number of low-income inhabitants. In these areas, many houses were made from a mixture of earth and wood and the bricks were made until in the 60's from local clay somewhere in the outskirts of each village. The toughness of the bricks depended of how much fuel and, straw, was available for the local kilns. The mortar used at the time did not have enough lime. In many cases some villagers used sand and clay mortar and after the 50' s more lime, cement etc. and gradually industrial bricks. Some of the difference could also be due to attenuation patterns, although how can we explain the fact that Ilfov which is nearer Vrancea than Teleorman was not seriously affected? Ilfov was also a rural county though clearly of higher income levels due to its proximity to Bucharest.

Prahova County, that is 7-th on the list of affected counties with 15.8% affected dwellings and was also seriously affected by the 1940 earthquake and has always been in zone of intensity VIII of every version of the Romanian earthquake codes. Vrancea County, that includes the nominal epicenter, is 13th on the list of affected counties (with only 5.6% affected dwellings). A possible explanation of these differences are given by the fact that Vrancea County was devastated in the 1940 earthquake and much of its housing was built after post-1945 and were incorporating with ring-beams, with more extensive use of brick masonry than instead of adobe; since 1963. Vrancea County has always been in the highest zone of the Romanian Earthquake Code (the county is found within the MSK zones of intensity VIII and IX), and although base shear forces may not be that great as experienced during 1977, this must have also contributed in the reduction of damage in Vrancea County.

Buzau County has 9.7% affected dwellings. Buzau city on the other hand suffered much more damage in spite of the fact that it is further from the epicentrer, founded on better soil and had better maintained buildings. The effects of the earthquake were strongly felt in the Buzau river valley (towards the hills): Patarlagele, Viperesti, Cislau, Calvini, Chiojdu etc. This can be related to the earthquake rupture trace, which has developed along a line towards S-E, in Buzau County.

4. FINANCIAL DATA ON DAMAGE AND LOSS IN WORLD BANK REPORT (1978)

In physical terms, the World Bank Report concluded that the overall effect of the earthquake on the housing sector of Romania was 156,000 apartments in urban zones and 21,500 houses in rural zones were destroyed or very seriously damaged; in addition 366,000 apartments in urban zones and 117,000 houses in rural areas needed to be repaired. The sum of the above is 660,500 dwelling units or around 11% of Romania's dwelling stock at the time. These figures are not commonly discussed in Romania, where the figure most frequently mentioned is that of 32,900 destroyed or heavily damaged dwellings and occasionally a figure of 182,000 damaged dwellings is also mentioned. The number of damaged housing units derived from the ICCPDC reports is 12.4% greater than in the World Bank report that was published somewhat earlier, while in the World Bank report, the loss in Bucharest accounts for 70% of the total, i.e. US\$ 1.4 billion.

In monetary terms, using all descriptive data from the World Bank Report, the values related to other indirect effects of the earthquake, have been obtained. As a consequence of this approach, details can be found in it results (Georgescu and Kuribayashi, 1992, Georgescu and Pomonis, 2007.):

- the total reported losses account for US\$ 2.048 billion (US\$ 1.683 billion in direct losses and US\$ 0.3647 billion in production losses);
- the loss to constructions represented 69.4% of the total or 84.3% of the direct losses; the housing sector losses (US\$1.0328 billion) represented 71.4% of construction losses, or 61.4% of the direct losses and 50.4% of the total losses;

-the loss in industry represented 21.8% of the total; the indirect, production losses were prevalent in industry and agriculture, while in transport, communication, health, education, local industry and especially in housing, the loss to constructions was prevailing.

Based on indirect losses for March 4, 1977 earthquake, indicated in World Bank Report and / or evaluated by the authors, other non-reported, indirect losses, could amount around US\$ 2.4953 billion, with the total indirect losses reaching as much as US\$ 2.860 billion and the ratio of indirect to direct losses being 1.7; by adding the reported and estimated losses, the total possible loss could reach US\$ 4.5433 billion.

5. THE ECONOMIC IMPACT OF THE LOSSES

The ratio of losses to the estimated Gross National Product-GNP (or to the Gross Domestic Product-GDP) of Romania in 1977 also need to be re-appraised. In the case of 1970's Romania, the exact size of the GNP is difficult if not impossible to be accurately estimated in US\$ or other foreign currency. The GNP or GDP evolution of Romania until 1989 and the GNP of all East European countries have been frequently re-evaluated (Jackson, 1985, Lancieri, 1993). For international comparisons, the GNP of countries with Centrally Planned Economies (CPE) was obtained in that epoch by the World Bank from domestic data using applicable exchange rates (in Romania an exchange rate of 20 Ro Lei per US\$ was used in 1977).

In order to have a new insight, the authors used alternative dollarUS\$ GNP estimates for Romania and revised loss to GNP ratio. The Romania annual GNP series from the World Bank or United Nations or other statistical books or almanacs are quite different. The GNP of Centrally Planned Economies-CPE's has been an object of study for years, because their systems of National Accounts were different (Jackson, 1985). A review of the various estimates of the GNP of CPEs is made by Lancieri (1993) and concluded that past values of GNP per capita for CPE's during 1970-1990 were by far too large. The estimates made by various western bodies and authorities are notoriously different, and for example in the case of Romania the estimate of its 1980 GNP ranges from 52 to 103 billion US\$.

Selecting the available data on Romania's GDP or GNP, various exchange rates and deflators, we obtained 7 alternative results for GNP and loss ratio (Georgescu and Pomonis, 2007). In this context, GDP or GNP ranged from 21.557 to 34.126 billion US \$ and thus, depending on the reference GNP values, we have:

- the direct loss to GDP or GNP ratio in 1977 could range from 4.9% to 7.8%;
- the total loss to GDP or GNP ratio in 1977 could range from 6.0% to 9.5%;

Using the total possible loss estimated by the authors (US\$ 4.5433 billion) and the alternatives of GNP, the total possible loss ratio to GDP or GNP in 1977 could range between 13.3% and 21.1%. Such values are considerably closer to the strong negative impact that was felt by the entire economy and society for more that a decade following the 1977 earthquake and the late seventies oil crisis, until the political system's collapse in late 1989 and even later on.

6. LESSONS OF 1977 DISASTER FOR SEISMIC RISK REDUCTION STRATEGIES

All published and recently recovered loss and impact data proves that the 1977 earthquake was a great disaster that affected numerous citizens, destroyed and damaged a significant share of the residential and non-residential building stock of Romania, adding strain to the economy and future prospect. This disaster concurred with the 1970's floods to contribute towards the very difficult economic and social situation of the 1980's in Romania.

The 1977 earthquake provided a great scientific laboratory, based on unique and valuable lessons in seismological and engineering terms. But later on the official actions were mostly concerned with other projects and neglected the potential for disaster from future earthquakes. With the knowledge of today, we may have many reasons to believe that Romania's 1977 regime possibly reported a smaller damage extent and impact because:

- the authorities were not sufficiently prepared to gather data and investigate the loss in all aspects; what was at hand was the direct loss on buildings and infrastructure in social-economic and industry sectors and only some indirect losses; the request for data from the local authorities was mainly focused on such items;
- the calculation of loss or replacement costs relied on conventional average apartment areas and fixed costs for repair and strengthening, that were grossly under-estimated and unrealistic; later on, it was common knowledge that contractors worked at a loss for such time consuming works; the costs were not for upgrading the damaged buildings but to bring their strength to the situation as it had been before the earthquake;
- a greater reported damage and loss would have been considered by the leaders of that period as an embarrassment, reports about huge losses could reduce the country's credit worthiness and place in doubt its ability to pay foreign debts and any weakness could have been exploited by some countries seeking to control or change the regime;
- admitting a major loss and impact would have tarnished Romania's image .

These hitherto newly analyzed files data sources give detailed damage data for 19 affected counties plus Bucharest City. The territorial loss was heavy in many counties as percentages of damage indicate both in physical units and values, and we were able to evaluate them here for the first time. In terms of disaster management, there is a striking difference between the huge damage caused to over 20 counties and the subsequent funds allocated to rehabilitation and strengthening. In July 1977, highest officials enforced the rule of limited repair and strengthening by local interventions for cosmetic purposes to "reach the initial safety level".

In physical terms, we know that there are hidden, neglected or un-repaired damages which represent the roots of future cumulative structural vulnerability, a bitter heritage from 1940 and 1977 for today's society, which may possibly suffer and pay for a large disaster in years to come. Thus, the impact of the 1977 earthquake is still a threat to Romania's future development prospects.

In terms of economics, the present paper is a contribution to a better impact assessment, since, according to these our recent estimations, we have reached a new insight on losses and the range of direct loss to GDP or GNP ratio in 1977 that could have been from 4.9 to 7.8%, while the range of total loss to GDP or GNP ratio in 1977 could have been from 6.0% to 9.5%. Adding further indirect losses that were unaccounted at the time brings the range of total possible loss ratio to GDP or GNP in 1977 to between 13.3% and 21.1%, predictor of a heavy impact. A better re-evaluation of past earthquake losses, including territorial extent of losses as well as the loss to GNP ratio, require access to more data and archives which with time will provide new insights.

According to the present knowledge at hand, many international analysts referred to the 1977 earthquake in studies on East European economies and their first international concern about the 1977 disaster's impact was related to Romania's capacity to pay its debts and secure its economic growth (Jackson, 1977, cited in Burakow, 1980). Some negative impact was immediately visible, while other had a period of "incubation", depending on internal and international situation. In order to be able to pay its foreign debts, a very efficient economy was necessary, but five years after 1977, under the combined effect of the earthquake, floods, the sudden increase of international interest rates and due to its own economy's systemic weakness, Romania was faced with an economic crisis considered by the cited analysts as "deep" and in a "profound stagnation, with painful consequences in social terms". Retrospective studies in later years stated clearly that the 1977 earthquake greatly contributed to the serious economic crisis that started in Romania in 1979 and lasted at least until the end of the 1990's of Romania's economy (Deletant, 2002; Deletant and Ionescu, 2004).

The recurrence cycle of great Vrancea earthquakes represents a warning and strategies must take it into account with due consideration. The accelerated strengthening and/or replacement of vulnerable buildings are a main task. A system of loss investigation and data collection must be prepared in advance for the next Vrancea earthquake. In this context, Romania's EU integration and the new Romanian Earthquake Design Code based on Eurocode requirements, on earthquake recurrence intervals of 100 and 475 years return period must be tackled with due concern.

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