

# Seismic Risk and/or Real Estate Risk for the Bucharest Heritage Buildings

**D. Lungu, C. Arion**

*Technical University of Civil Engineering, Bucharest*



## **SUMMARY:**

With about 2 millions inhabitants and more than 110,000 buildings Bucharest can be ranked as the megacity having the highest seismic risk in Europe due to (i) “occurrences of earthquakes originating repeatedly from the same (Vrancea) source” (Ch. Richter, 1977) (ii) soft soil condition in Bucharest characterized by long predominant period ( $1.4 \div 1.6s$ ) of ground vibration during strong Vrancea earthquakes and (iii) high fragility of tall reinforced concrete buildings built in Bucharest before WWII and even before the 1977 Vrancea earthquake disaster. It is emphasized that the price of  $1m^2$  terrain/land in historic center of Bucharest, as well as in its green residential areas, “encourage” a high rate of demolition of historic low-rise masonry structures in so called protected areas of the city.

*Keywords: earthquakes, Vrancea, damages, protection, heritage buildings*

## **1. INTRODUCTION**

The Vrancea region, located where the Carpathians Mountains Arch bends, at about 130km epicentral distance from Bucharest, is a source of subcrustal seismic activity, which affects more than 2/3 of the territory of Romania and an important part of the territories of Republic of Moldova, Bulgaria and Ukraine. The city is located in the Romanian Plain, between the Danube and the Carpathian Mountains, in the meadow area of two rivers, Colentina and Dambovită, which cross the city from NW to SE.

Bucharest is the capital city of Romania and the main administrative, economic and cultural center of the country. The first written record of the city comes from XVth century. Placed in a space of confluence of civilizations, Bucharest evolved by assimilating European and Oriental influences, displaying a natural capacity of integration that supported its vocation for a city between the Eastern and Western worlds.

## **2. BUILDING DAMAGE DURING MAJOR HISTORICAL VRANCEA EARTHQUAKES**

### **2.1. 1802 Earthquake**

The 26 Oct 1802 earthquake ( $M_w = 7.9$ ) is considered to be the strongest Vrancea subcrustal event; there is no precise information on causalities but some information on damages. During the 1802 earthquake many bell towers and towers of churches felt down and several churches were destroyed included St. Spiridon Church and Cotroceni monastery in Bucharest and the Monastery in Valeni, Figure 1 (left). Half of Coltea tower in Bucharest collapsed and the remaining part was seriously damaged; most of wealthy residences were heavily damaged and part of them collapsed. At Brasov, many chimneys felt down and houses and churches were damaged. The earthquake was felt in Transylvania (Sibiu, Sighisoara) and Banat (Timisoara). The earthquake was felt in Poland, Bulgaria, Turkey and Russia. In Cernauti some houses were damaged. In Lvov, Armenian church was cracked and the bells ring alone.

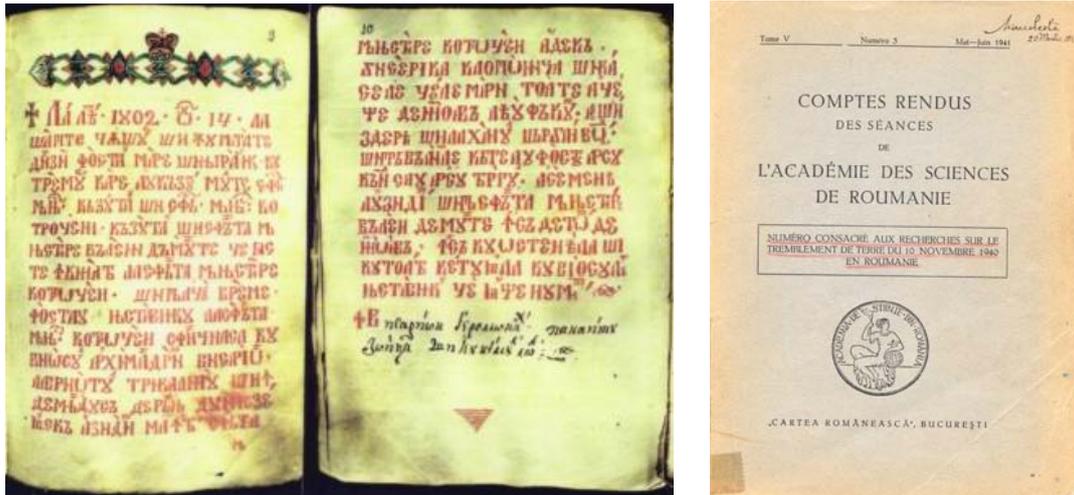


Figure 1. Chronicle of Monastery Valeni, Southern Carpathians (left) and Comptes Rendus des Séances de l'Academie des Sciences de Roumanie, 1941 (right)

## 2.2. 1829 Earthquake

“Wednesday night [...] a strong earthquake happened in our capital, [...] no house in Bucharest remained without damages; all walls were cracked and some cases felt down; roofs and chimneys were destroyed”, Curierul Român, Bucuresci, No.15/27 Nov 1829. During the earthquake of 26 Nov. 1829 ( $M_w = 7.3$ ), Bucharest suffered the most, documents indicating that 115 houses become unsafe and 15 of them were being heavily damaged and later demolished. At Campina a church collapsed. In Sibiu and Iasi many walls were cracked. The earthquake was felt on a large area: Transylvania, Banat, Bulgaria, Poland and Ukraine.

## 2.3. 1838 Earthquake

The following description of the effects of 1838 earthquake ( $M_w = 7.5$ ) effects in Bucharest is given in the book "Voyage dans la Russie Méridionale et la Crimée par la Hongrie, la Valachie et la Moldavie" par M. A. de Démidoff, Illustré par Raffet, E. Bourdin, éditeur Paris. 1841 & 1854, page 144: “Chaque année, le sol de la Valachie est ébranlé par deux ou trois secousses de tremblement de terre plus ou moins sensibles; mais, malheureusement, on a à noter, tous les huit ou dix ans, quelque atteinte réellement désastreuse de ce fléau. On conserve encore le souvenir du tremblement de terre de 1802, qui renversa la tour du monastère de Koltza; de celui de 1829, qui ébranla fortement la plupart des édifices de Bukharest. Depuis que ces lignes sont écrites, une secousse plus violente que toutes celles dont le souvenir attriste encore le pays, a pensé engloutir Bukharest. Tout à coup, le 11-23 janvier 1838, c'était le soir, la ville s'ébranle; les plus solides monuments chancellent; plusieurs maisons s'écroulent; toutes son endommagées, et, dans tout ces ravages, plusieurs hommes perdent la vie.” The description is based on the work of Gustav Schuller who was at that time in Bucharest.

The engineer Gustav Schuller, counselor of the Great Duque of Saxa, has been asked by Romanian authorities to make an investigation in the epicentral area. He indicated a maximum intensity IX in the area of Vrancea mountains, Focsani and Ramnicu Sarat where many villages were completely destroyed. Schuller concludes: “all the stone masonry buildings were heavily damaged and some of them especially the churches and other large buildings become unusable”.

In Bucharest, the Police report mentioned: 8 deaths, 14 injured and 36 collapsed buildings. Many other buildings (especially the larger ones among which was the Royal Palace) were heavily damaged.

The earthquake was felt on an extended area in: Ukraine, Poland, Bulgaria and up to Constantinople and to North of Italy.

## 2.4. 1940 Earthquake

“The November 10, 1940 earthquake ( $M_w = 7.7$ ) put damages all around Romania and throw the people in mourning”, Comptes Rendus des Séances de l’Académie des Sciences de Roumanie, 1941, Figure1 (right). In Bucharest the most significant loss was the complete collapse of RC framed Carlton building, the highest RC building (47m, 12 storeys) in Romania at that moment. Until Nov 24, 136 people were found dead in the rubble of that building. Several high-rise RC buildings in Bucharest were very severely damaged: Belvedere, Wilson, Lengyel, Pherekide, Brosteni, Galasescu. Other important heritage buildings in Bucharest suffered important damage: Palace of Justice, Romanian Atheneum, CEC Bank Palace, Postal Palace.

Masonry buildings located in Chisinau, Republic of Moldova have been very severely damaged, according to the photographic information provided by the Seismologicikii Institut Academii Nauk, CCCR, Moskow 15.02.1941.

Two zones of maximum seismic intensity were identified according to the actual structural damage: one was the epicentral area of Focsani and the second one was located at the North of Bucharest. In those areas the seismic intensity was over VIII, close to IX, on Mercalli-Sieberg scale. In Panciu, near Focsani no building was standing after the earthquake (Timpul newspaper of 12 Nov.1940). Since the earthquake was a deep event (about 140km depth) it has been felt on about 2 millions square kilometers i.e. to the East: in Odessa, Cracovia, Moscow; to the North: up to Saint Petersburg; to the West: up to Tissa river and to the South: up to Istanbul.

## 2.5. 1977 Earthquake

The March 4, 1977 ( $M_w=7.5$ , depth  $h= 94$ km) was the most destructive earthquake in the history of Romania, epicentral distance to Bucharest of the main shock was about 100km. This earthquake:

- killed 1,578 people including 1,424 in Bucharest;
- injured 11,221 people including 7,598 in Bucharest and 3,723 in the rest of the country;
- destroyed or seriously damaged 33,000 housing units in high-rise apartment flats and conventional type dwellings (35,000 families, more than 200,000 persons homeless);
- caused lesser damage to 182,000 other dwellings;
- destroyed 374 kindergartens, nurseries, and schools and badly damaged 1,992 others;
- destroyed 6 university buildings and damaged 60 others;
- destroyed 11 hospitals and damaged 2,288 others hospitals and 220 polyclinics;
- damaged almost 400 cultural institutions (theatre, museums, etc.);
- damaged 763 factories;
- directly affected over 200,000 people. (Fattal, Simiu, Culver, 1977).

Famous international experts dispatched in Romania in the aftermath of the earthquake reported as follows: “The unusual nature of the ground motion and the extent and distribution of the structural damage have important bearing on earthquake engineering efforts in the United States” Jennings & Blume, NRC&EERI, Washington. “It was felt on an area of 1.3 million squared kilometers and caused damage over an area of about 80000 km<sup>2</sup> within which the most frequently occurring intensity did not exceed VII (MM). Much of the damage was caused to old multi-storey reinforced concrete buildings of 6-12 storeys. These structures have a fundamental period of the order of 0.7-1.6 s, which places them on the ascending branch of the Bucharest response acceleration spectrum. Progressive damage during the earthquake should have caused a lengthening of their period and an increase in the lateral forces acting on them. In contrast, rigid structures of large panel or frame construction with shear wall, of the same height, as well as 1-3 storey masonry dwellings, suffered little damage” (Ambraseys, N.N., 1977).

The earthquake has been recorded in Bucharest by a SMAC-B Japanese instrument and further digitized and processed by the Observational Committee of Strong Motion Earthquake of the Building Research Institute, Ministry of Construction of Japan, January, 1978 (254 pages Report).



(i) Typical total collapse of pre-war tall reinforced concrete buildings



(i) Wilson building built in '30s

(ii) Lizeanu building, built in '60s

(ii) Collapse of the building soft story at the ground level

**Figure 2.** Total (i) and partial (ii) collapse of the Bucharest RC tall buildings in 1977 earthquake

### 3. VULNERABILITY OF BUILDINGS IN CENTRAL BUCHAREST

#### 3.1. Reasons of Vulnerability

The explanation for the location in the city centre of the most fragile or vulnerable RC tall buildings in Bucharest as well as of 29 (from 32) tall RC buildings collapsed during the 1977 comes from the Plan of Urban Development of the city of Bucharest issued in 1935 by the Municipality of Bucharest. The Plan recommends the city center for the tallest buildings within the city i.e. for buildings having 6-7 full storeys plus 2-3 setback storeys (roof height of the building smaller or equal to the street width!). The lack of structure horizontal and vertical regularity, soft ground floor due to commercial use of the floor (no infilled masonry walls), accumulated damage during the 1940 earthquake, low strength concrete (mean compressive strength  $100 \div 200 \text{ daN/cm}^2$ ) and the level seismic design knowledge at the time when old tall RC buildings has been built clearly explain the collapse of buildings in the center of Bucharest. Presently, more than 120 tall RC buildings built before WWII were randomly identified by authorities and structural engineers as “seismic risk class 1” buildings, i.e. buildings supposed to probably collapse or to be very severely damaged during the next earthquake larger than or similar

1977 one, Figure 3. The number of fragile high-rise RC buildings in the city centre of Bucharest is certainly larger than the existing number of identified buildings having "seismic risk class 1". Many of those vulnerable buildings in the city centre are still not yet identified.

Unfortunately even today, the lessons learnt in 1977 were still incompletely understood. Examples of those unlearned lessons are given below.

Lesson 1: " A systematic evaluation should be made of all buildings in Bucharest erected prior to the adoption of earthquake design requirements and a hazard abatement plan should be developed," G. Fattal, E. Simiu and Ch. Culver, 1977;

Lesson 2: " Tentative provisions for consolidation solutions would preferably be developed urgently", Japan International Cooperation Agency, June 1977;

Lesson 3: "...Bucharest is sited on deep alluvium.... Much of the damage was due to soil amplification associated with deep layers of silty clay, loess...Such sites would provide sufficient chances of dangerous amplifications in the shaking of such buildings," H. Tiedemann, 1992;

Lesson 4: "Bucharest had been microzoned as part of UNESCO Balkan Project, with microzones denoting three levels of risk. The worst destruction occurred in the lowest- risk microzone," G. Berg, B. Bolt, M. Sozen, Ch. Rojahn, 1980;

Lesson 5: "Ground motion spectrum should be provided corresponding to each soil condition. A considerable number of strong motion seismographs will be required for the above purpose," Japan International Cooperation Agency, June 1977.

On March 30, 1977 the national strategy for strengthening the buildings damaged by the 1977 earthquake was established by the authorities in the letter to the Municipality of Bucharest of the General Inspector for Construction of Romania as follows: "The retrofitting of buildings must provide: (i) For the old buildings - the same resistance the have before 1940 earthquake; (ii) For the new buildings - the same resistance the have when they were designed." The above Governmental Order was further explained in the letter to the Technical University of Civil Engineering, Bucharest from General Inspector for Construction of Romania and General Director of Central Institute for Research Design and Coordination for Construction, July 11, 1977, as follows: "Retrofitting of the buildings damaged by the 1977 earthquake will consist of strict local repairing of damaged elements. Additional measures for seismic protection are not allowed." The post 1977 earthquake strategy for repairing damaged buildings has proved as a regrettable mistake.

### 3.2 Seismic Risk Reduction Strategy and Programs

The contemporary national programs for seismic risk reduction in Romania are focusing the following three objectives: (i) Strengthening of fragile buildings in Bucharest, (ii) Upgrading the code for seismic design of buildings and structures and (iii) Seismic instrumentation of Romania.

In Bucharest less than 20 % of building stock has been built before World War II and more than 50% after the 1977 event. Currently, the present list of buildings which have been included in Class 1 of seismic risk at the Ministry of Development contains almost 400 entries / addresses which could be grouped as it follows (per cent of the total buildings which undergone technical evaluation:

(i) Tall buildings	$\geq$ GF + 9F	under 3%
	$\geq$ GF + 7F	16%
(ii) Low rise buildings	$\leq$ GF + 4F	57%
	$\leq$ GF + 1F	17%

After 12 years from the start-up of the building strengthening program for the Bucharest vulnerable buildings included in Class 1 of seismic risk less than 16 buildings has been completely retrofitted! from the initial number of 127 entries on the list- buildings over GF + 4F. It is also emphasized that from the 127 tall RC vulnerable buildings, 19 are located on Calea Victoriei and Magheru/ Bălcescu central boulevards, Figure 3. Most of them are considered city architectural heritage.



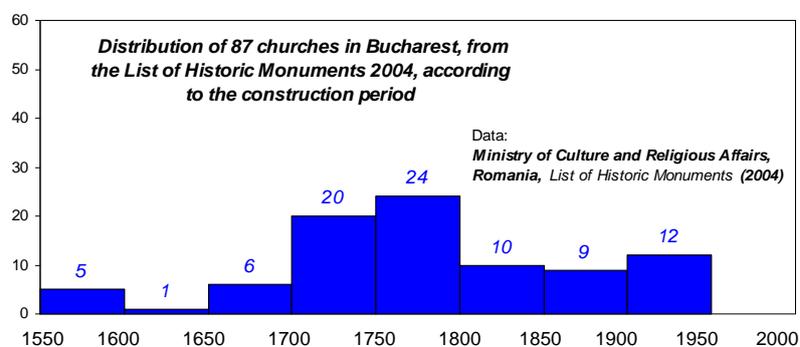
**Figure 3.** Architectural heritage tall buildings in Bucharest: RC buildings built from 1920 to 1940 in city center

The *Historical Monuments List* prepared by the *INMI, National Institute for Historical Monuments*, contains more than 25 cultural heritage palaces in Bucharest. From those, the several "seismic risk class 1" palaces were considered for priority strengthening: (i) Multistory steel structures: *Ministry of Transport, Constructions and Tourism*; (ii) Multistory reinforced concrete structures: *Romanian Government Palace* (under strengthening) and *City Hall of Sector 1* (under strengthening), Bucharest; (iii) Combined masonry and RC buildings: *Royal Palace i.e. National Museum of Art of Romania* (central building) etc. Only the *Palace of Justice* and *Telephone Palace* are now fully retrofitted, Fig. 4.



**Figure 4.** Retrofitting of the Palace of Justice - left (2006) and Telephone Palace - right (2002)

There are more than 200 orthodox churches in Bucharest and from those almost half are listed as architectural heritage, Figure 5. Most of the old churches still need structural strengthening and immediate rehabilitation. In the case of seismic upgrading of architectural heritage buildings, the central role of the state (or the church) has to be replaced by new partnership models with private sector and international donors and banks.



**Figure 5.** Distribution by age of the churches listed as architectural heritage

The actual concept "Seismic risk class 1 building" (which in fact describes "the seismic vulnerability class 1 buildings") must be changed soon according to the seismic risk matrix concept in Table 3.1.

**Table 3.1.** Seismic Risk Matrix indicating seismic risk classes (1, 2 and 3)

Seismic vulnerability/ fragility class	Importance & exposure class			
	I Essential facilities	II Hazardous buildings	III General buildings	IV Minor buildings
1	1	1	1&2	3
2	1&2	2	3	3
3	3			

## 4. THE CHALLENGE OF CONSERVATION OF BUCHAREST HERITAGE BUILDINGS

### 4.1. Introduction

Unfortunately for the cultural, historic, architectural and urban development of Bucharest, it is nowadays proved that the most important factors contributing to the disappearance – by self intended – destruction and demolition - of the beautiful buildings in the so called “protected areas” of Bucharest are the very deliberate architectural ambitions and, above all, the speculations on the real estate market going on at this time. The applicable legislation in force on protection of the historic monuments, on protection of buildings located in so called „protected urban areas” is finally leading to a negligible protection for those buildings.

The present day picture of Bucharest with (i) over-night demolitions of historic buildings which have not undergone seismic damages but which are “located in” downtown areas of the capital, or in elegant and non-polluted areas, and with (ii) sky scrapers which emerge at random and with no logic, although approved by the local and central authorities, all over the city, including the protection areas of historic monuments, is alarming and indicates the utter destruction of old Bucharest, the gravity of which might by far exceed the destruction undergone during the communist time.

The examination of the information made available for the buildings in Bucharest reveals the following conclusions:

- (i) The initial purpose of the technical and seismic assessment program of the buildings in Bucharest that were damaged during the earthquakes in 1940, 1977, 1986 and 1990, was to make a Priority List for strengthening and to insure the inhabitants' security with respect to the buildings showing serious seismic structural damage;
- (ii) Over the recent years, the list of seismically vulnerable buildings was updated with a very large number of low buildings, with only a few levels, generally having masonry or mixed (RC + masonry) structure and boards sometimes made of wood or metallic profiles and brick bolts. Such buildings could be included in the same seismic vulnerability class as the tall ones - those which collapsed in 1977 – but they cannot be definitively regarded as part of the seismic risk class 1 buildings for the mere reason that, considering the seismic history of 1977, they can generate in case of a major earthquake totally different human, economic and structural consequences from those caused by the collapse of the multi-leveled concrete buildings collapsed on March, 4th, 1977.
- (iii) Since more than 50% of the list of buildings in Bucharest falling under Class no. 1 of seismic risk are low buildings, below GF + 4F (17 % are buildings of GF and GF + 1F) we can infer that the initial purpose of the priority list for seismic strengthening has been altered and deviated to other intentions.

In conclusion, the „red spot” (i.e. seismic risk class 1 building spot) also signifies an „invitation” to eliminate many seismic risk class 1 buildings located in the central areas of the capital or in residential neighbourhoods in the northern area of the city (where 1 m<sup>2</sup> of land costs 3000 - 6000 Euro / m<sup>2</sup>!), disregarding completely the primary meaning: priority for seismic strengthening and security. The deliberate use of the symbol „class no. 1 of seismic risk” in order to demolish old buildings may result into the extermination of historic buildings of beautiful architecture which become very „attractive” for real estate speculations intended to offer free lands for future investment in tall buildings (3 to 8 levels above the general historic buildings height of the area/neighbourhood).

## 4.2 Real Estate risk examples

### 4.2.1. Impressive historic monuments demolished due to listing under class 1 of seismic risk

The tall RC structure of the former Ministry of Industry (MICM) has been demolished in 2007 due to seismic fragility of its RC framed structure. The building was the most impressive Art Deco building in Bucharest listed as Historic Monument.



**Figure 6.** MICM building, Calea Victoriei, Bucharest

### 4.2.2. Industrial buildings burnt and damaged, located on large areas of land

Asan Mill, built in 1853, is the first steam mill in Romania. It is an industrial architectural monument under category A, the List of Historic Monuments, code B-II-m-A-19692. The building is made of masonry walls with wooden boards. The mill was set on fire on May 14th, 2008 for a thorough and rapid extermination of the wooden boards and roof ridge. The masonry walls show signs of local degradation of bearing walls, deliberately caused by man, Figure 7.



**Figure 7.** Present-day destruction for “encouraging” self-collapse of the Asan Mill (*Moara lui Asan*), industrial heritage in Bucharest

### 4.2.3. Insertion implant of the tall building in the protected vicinity of historic monuments

„Saint Joseph” Cathedral in Bucharest was started in 1875 and finished in 1884, during the reign of the King Charles I<sup>st</sup>. The famous architect, Dr.Friedrich Schmidt from Vienna, planned the Cathedral. The company Mayer from Munich made the paintings and stained glasses of the Cathedral, while the altar was sculpted in Rome. The tall building under construction next to the cathedral is 4Under Ground + Ground Floor + 18Floors, total height: 75m, and floor area: 1059mp, Figure 8.

The procedures of permits and developing the city planning dossier, location and erection of the tall building at the address: general Berthelot no.11-15, – commenced in 1999 and (ii) the circumstances surrounding the start-up of the construction work – in 2006- has been generating controversial discussions. Justice is following to give a resolution with respect to the legitimacy of the construction. The huge building near the Cathedral St Joseph is contempt to the city planning common sense and a mockery in the vicinity of the religious historic monument represents an urban planning mistake.



**Figure 8.** „Saint Joseph” Cathedral, in central Bucharest

#### 4.2.4. Buildings subject to demolition / demolished located in so-called "protected urban areas"

Visarion 8, building was finished in 1911, and the urban renewal plan for Lascar Catargiu Blvd., between Piata Romana (the Roman Square) and Piata Victoriei (Victory Square), was implemented in the period 1895 – 1899, in the French Academy spirit, according to design delivered by architect I.D. Berindei. The building is also part of the protected area of Dinu Lipatti House, 12 Lascăr Catargiu Blvs., a historic monument, the List of Historic Monuments 2004, entry no. 615/B-II-m-B-18330. The building is located in a "protected area" yet, it has benefited from no protection at all. The roof burnt at the beginning of 2007 and man, to the present state of utter ruin, has systematically damaged the building, Figure 9. The „Collapse Hazard” sign placed on the facade of the building in March 2007 made a clear statement with respect to the destined end of that elegant building from the very heart of Bucharest. The application to declare the building a historic monument filed by the National Institute for Historic Monuments (no.351/23.03.2008) was rejected by the National Commission for Historic Monuments. Unfortunately, existing law on protected areas in Romania cannot legally prevent the demolition of the buildings located in such areas.



**Figure 9.** Bucharest heritage building in the city center intentionally prepared for demolition

#### 4.2.5. The advertise on the facades of buildings

The degradation of the general appearance of the city by the advertising posted on the facade of historic buildings located in "protected urban area" might be observed in Figure 10. The main facade of such buildings is severely mutilated. Unfortunately the Romanian legislation is not so restrictive. An excerpt from the *Law 554/20 "For preservation of the aesthetic appearance of the capital and other localities"* is: marking or posting on the walls, on the facades of buildings under public or private property, on historic and architectural monuments, and on any other type of buildings of unauthorized inscriptions [...] shall be fined a minimum 120 to maximum 600 euro and shall be liable to cover the expenses required to return the respective building to the aesthetic appearance.



**Figure 10.** Façade of the G. Enescu 27, historical building

The visual content of Figure 6 to Figure 10, presenting typical situations of aggression against the built-on heritage of Bucharest calls for an urgent amendment of the legislation on protection and the real estate policy on demolition of buildings-historic monuments or buildings located in „protected areas” in Romania.

## CONCLUSIONS

The future urban development of Bucharest cannot be achieved by demolition of heritage buildings or skyscraper insertion in the low-rise heritage buildings areas. The Bucharest capital urgently needs the support of the population and, moreover, a new political strategy of central and local administrations to preserve, repair and develop the city for the benefit of its inhabitants and for illustrating its historic value and European identity.

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