SEISMIC EVENTS IN MODERN GREECE. FROM THESSALONIKI (1978) TO KEFALONIA (2014).

A. D. Oikonomou\textsuperscript{1} and G. Zagora\textsuperscript{2}

ABSTRACT

This project aims to explore the measures of prevention in pre-earthquake stage and the response procedures during and after a destructive seismic event in the modern urban environment. During the 1978 Thessaloniki earthquake there were no Response Systems for seismic events. There was only the Seismic Code of 1978 for the constructions and the "On Policy Design of Emergency Response" Law, which contained the response mode by the Military in case of earthquakes during war period. After the Thessaloniki Earthquake, the responded bodies were formed and the post-earthquake management procedures were implemented in the Country. By 2014 both seismic and management legislation have been evolved, so the response of the State was more effective and the population was properly alerted and informed. When the Kefalonia Earthquake (2014) happened, the three phases of the Earthquake Management Cycle were already formed in Greece. Prevention includes the formulation of the Earthquake Planning and Protection Organization and the 2000 Seismic Code. Emergency includes the General Secretariat of Civil Protection, the General Plan of “Xenocrates”, and the Earthquake Damaged Buildings Compensation Service. Earthquake Damaged Buildings Compensation Service was fully responsible for the Compensation, the Reconstruction and the Rehabilitation of the affected area. The Earthquake Management Cycle is analyzed both in the Thessaloniki earthquake (1978) and the Kefalonia earthquake (2014), as well as with the evolution of the phases of the Management Cycle during a period of 36 years in Greece. Interesting conclusions have been derived from the comparison of the two events.

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This project aims to explore the measures of prevention in pre-earthquake stage and the response procedures during and after a destructive seismic event in the modern urban environment. During the 1978 Thessaloniki earthquake there were no Response Systems for seismic events. There was only the Seismic Code of 1978 for the constructions and the “On Policy Design of Emergency Response” Law, which contained the response mode by the Military in case of earthquakes during war period. After the Thessaloniki Earthquake, the responded bodies were formed and the post-earthquake management procedures were implemented in the Country. By 2014 both seismic and management legislation have been evolved, so the response of the State was more effective and the population was properly alerted and informed. When the Kefalonia Earthquake (2014) happened, the three phases of the Earthquake Management Cycle were already formed in Greece. Prevention includes the formulation of the Earthquake Planning and Protection Organization and the 2000 Seismic Code. Emergency includes the General Secretariat of Civil Protection, the General Plan of “Xenocrates”, and the Earthquake Damaged Buildings Compensation Service. Earthquake Damaged Buildings Compensation Service was fully responsible for the Compensation, the Reconstruction and the Rehabilitation of the affected area. The Earthquake Management Cycle is analyzed both in the Thessaloniki earthquake (1978) and the Kefalonia earthquake (2014), as well as with the evolution of the phases of the Management Cycle during a period of 36 years in Greece. Interesting conclusions have been derived from the comparison of the two events.

\textbf{Introduction}

The procedures of Prevention, Response and Recovery did not appear from the beginning in their present form. As time went by, the State began to reform, resulting the present one. Based on this, the following research, studies the evolution of the Earthquake Management in Greece by choosing two historical earthquakes: the 1978 Thessaloniki Earthquake and the 2014 Kefalonia Earthquake. These earthquakes were chosen because they occurred in urban areas, their magnitudes were similar and the period between them allows the study of evolution of Disaster Management procedures in Greece. Study on the evolution of earthquakes management processes at national level has not ever been performed. Nevertheless, comparative case studies have been carried out on how earthquakes were managed, one of them is the Master Thesis of Stephanou E. “Comparative Study of Izmit Earthquake (Turkey - 1999) and L’AQUILA

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Earthquake (Italy -2009) on the Management of Emergency” where it is being studied the way in which the authorities faced the critical period of the first weeks after the event when they offered assistance. The paper’s main purpose is to compare the appropriate authorities’ way of reaction in both case studies and to draw conclusions for the emergency management that can be traced in Greece, a country which also has a major experience from earthquakes [1]. Another study was conducted by Gziki E. in the Bachelor Thesis “Athens Earthquake 1981 and 1999. Comparative Analysis and Conclusions from the Conduct of Construction in Two Seismic Events” in which is analyzed the evolution of the management of two earthquakes in the same city within 18 years [2]. The study by Zagora G. in the Master Thesis “Inspection and Reconstruction Procedures after an Earthquake. Comparative Case Studies of the 2008 Andravida Earthquake (Greece) and the 2009 L’ Aquila Earthquake (Italy)” focuses on the different inspection and reconstruction procedures between Greece and Italy using two earthquakes that occurred a year apart from each other [3]. Worldwide similar study has been carried out by Wilson and Oyola-Yemaiel in “The evolution of emergency management and the advancement towards a profession in the United States and Florida” where the process of professionalization in the United States and Florida is examined. The research explores how emergency management organizations are modifying in order to develop the capacity to prepare for, respond to, recover from, and mitigate disaster events more effectively [4]. These above studies deal with a particular part of the management of earthquakes where the present paper applies a holistic approach of the earthquake crisis management.

The 1978 Thessaloniki Earthquake (1978.20.06, M=6.5)

The 1978 Thessaloniki Earthquake constitutes the cornerstone for the creation of structures which would be responsible for the Earthquake Management in Greece.

The earthquake took place at the second largest city of the country which had a population of 871,580 inhabitants based on the census of citizens of 1981. This census was chosen because it was more recent to the earthquake. The total number of buildings in the city of Thessaloniki was 352,354 [5]. The Greek legislation in 1978 included, as far as the management of earthquake disasters is concerned, the 1959 Seismic Code, on the basis of which the Greek buildings were built and the legislative order L.O. 17 “About Emergency Planning Policy” (Government Gazette 236/A/2.9.74) for the reaction of the army in case of war and the emergency confrontation in periods of peace [6].

The relative seismic quietness that prevailed in Greece from 1955 up to 1978 in combination with the introduction of the 1959 Seismic Code, had as a consequence the general complacency and the wrong estimation that the buildings with reinforced concrete frame have finally resolved the problem of seismic risk. Contradictory opinions were noticed in the Academic Society. The complacency was so intense that the 1959 Seismic Code, in a period of internationally crucial scientific developments, remained unchangeable for about 25 years and buildings were rebuilt by reinforced concrete to over 80% of the country's urban areas [7]. No other measures of Prevention were applied since no organized institutions for the management of the earthquake phenomenon were established.

The Thessaloniki earthquake caused 50 deaths and 220 injuries. About 800,000 people were left
homeless either because their homes had been destroyed or because they were afraid to use them. Besides the human losses there were also large-scale material damages. Extensive damages were detected to the city historical monuments (Rotonda, Axeiropoihto e.t.c.) due to the aggravation of damage already existed decades or centuries ago. Damages to utility networks were very limited or even non-existent. Similar damages occurred across all the affected area and particularly in the area near the epicenter of the earthquake, where urban areas were not included.

The earthquake caused also the collapse of the eight-storey building on Hippodromiou Street where 39 people died (including the constructor of the building) and cracks on the reinforced concrete elements and columns on the ground floor of many multi-storey buildings. An old two-storey building, housing a footwear craft also collapsed. There were no casualties due to the fact that after the earthquake the owners had kept the craft closed and had removed their machinery and merchandise. Also five buildings collapsed in the city of Lagada [8]. The damages recorded in relation to the magnitude of the earthquake were limited, but the extent to which they were observed was excessive.

The psychological impact on the population was disproportionately high due to the complete lack of the State readiness for crisis management and led to a complete disorganization of the economic and social life of the city. The panic caused to the residents was also intensified by the fact that their access to information was minimal as the main source of information was the newspapers, which had restrictions on the time of printing the morning edition. It was ascertained that part of the press infused the events, expressing the view that a major and catholic disaster would be expected in Thessaloniki, resulting the panic of the residents. The problem of poor awareness has caused a number of non-scientific explanations for the earthquake, for example that the earth was going to open in the Volvi region, and from the opening girls would come out with red tongue who were asking “to drink people” and that the Day of Reckoning was coming. Another theory was that since the opening of the earth (a common fault) flames began to emerge, a volcano would be created resulting universal destruction [8].

The aforementioned emergency plan of Civil Defense was proven inapplicable. The rescuers were not mobilized immediately due to the lack of human resources. Citizens and State realized that although the buildings of Greek cities were built by reinforced concrete and based on the 1959 Seismic Code, they were not immune to earthquakes. There were neither available materials (lumber-scaffolding), and human resources for substandard, nor action plan for post-crisis response. There was no institutional framework to give political leadership and to the Services the basis and legitimacy for quick and effective action. In addition, the existed plans were confidential. Despite the fact that the Greek State was unprepared to deal with the crisis, activation was immediate, after the first shock. Having the unwavering support of the faculties of the Civil Engineers and Geophysics of Aristotle University of Thessaloniki as well as the support of the Technical Chamber of Greece, the State organized a system which included care of the victims, characterization of buildings, estimation of damages, repairs and reinforcement of buildings, restoration of the monuments that had been damaged and financial support for the affected people. At the same time, State proceeded to long-term actions by creating or strengthening scientific and administrative infrastructures in order to reduce the seismic risk.

During the Response, responsibility for the reaction of the State was assumed by the Prime
Minister, in cooperation with the Police, the Army and the Technical Chamber of Greece. It was the first effort of coordinated management, which led to its overall successful management, but this fact does not refute the deficiencies and the mistakes that were made. The institutional post-earthquake action framework which was applied remains almost unchanged until today. The administrative institutions that continue to be the core of post-earthquake mobilization of the State have been formed on the occasion of this specific earthquake.

The responsibility for the management of the crisis was given by the Government to the Minister of Public Works, who immediately set up a consultative committee and, at the same time, he reorganized the operational capacity of the Ministry of Environment Physical Planning and Public Works in Central Macedonia. This rearrangement caused the movement of human resources to the Special Service that was set up by the Ministry of Environment Physical Planning and Public Works in Northern Greece (later Earthquake Damaged Buildings Compensation Service of Northern Greece). The whole effort was supported by the Technical Chamber of Greece, which mobilized its members with various ways on a voluntary basis. The problems that had to be faced under unbearable pressure and without any preparatory work were the rescue and care of the citizens, the assessment of the buildings’ damages, the necessary substandard and demolitions, the repairs and aids to be done, the restoration of the monuments, the existence of funding, the creation of an appropriate institutional framework for post-earthquake interventions, the creation of Service Implementation Structures and the treatment of temporary housing in tents, of feeding and of medical care issues, subjects under the authority of the Ministry of Health and Welfare, the military and the Local Governments (Municipality and Prefecture).

Engineering committees had already been set up on the second day after the earthquake, but the organization became better and the inspection of all the buildings (per sector), according to the police department, started systematically on June, 24. First Degree and Second Degree Inspection committees were formed by Civil Engineers under the supervision of the Seismology Management Division for Building Control. During inspection, engineers completed a form relatively easy to use with building and damage data due to the earthquake. At the entrance of each building, the engineers posted a green sign to the buildings which could be inhabited, a yellow sign to those that needed repairs and an orange sign to the buildings with serious damages or to those that re-inspection was considered necessary. Second Degree Inspection committees were responsible for the re-inspection. The buildings were demolished after the inspection of a three-member committee and a Demolition Protocol was issued or a later attestation that it was built of loose materials or that it had an excessive cost of repair [9]. The affected areas, the earthquake epicenter and the seismic faults are presented on Figure 1. The geographical distribution of the damaged buildings is not accessible due to personal privacy of citizens.
The State assumed the overall responsibility for assessing the damages for reasons of public security. On June 24, 1978, a four-member panel of experts was set up to examine whether the legal requirements and the anti-seismic regulations were respected when building the Hippodromiou Street building, as well as later interventions in the load-bearing structure and columns of the ground floor [8]. After extensive scrutiny, it was considered that the apartment building of Hippodromiou Street was constructed without respecting the Anti-seismic Regulations.

Inspection of buildings belonging to Public Sector was carried out by engineers from the relevant Technical Services. Inspections extended to all buildings in the affected area (Table 1). The Inspection was qualitative and aimed to the protection of citizens from partial or total collapse from aftershocks since the main objective was to consolidate the sense of public security. The buildings and the constructions are coloured classified as:

- The strength of the building was not reduced and it could be directly inhabited (green).
- The overall strength of the building, other than specific elements or parts, has not been reduced. It could be inhabited by isolation of these dangerous parts if they existed (yellow).
- The building had to be examined by a Second Decree Inspection committee or the building was dangerous and had to be isolated (orange).

<table>
<thead>
<tr>
<th>Colour Marking</th>
<th>Buildings</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green</td>
<td>46,446</td>
<td>73.8%</td>
</tr>
<tr>
<td>Yellow</td>
<td>12,823</td>
<td>20.4%</td>
</tr>
<tr>
<td>Orange</td>
<td>3,648</td>
<td>5.8%</td>
</tr>
</tbody>
</table>
Given the low quality of the reinforced concrete frame of multi-storey buildings, due to low concrete strength and poor reinforcement, it is estimated that the structural response, despite the magnitude of the earthquake, was impressively good. This behavior was attributed to the high quality of infills (well-built brickworks), fact that was confirmed by extensive research programs of the Reinforced Concrete Laboratory of A.U.TH.

Finally, other surveys of the same laboratory showed that the territorial profile in different areas of the city played an important role in the topographical distribution of the high damages, while various parameters such as the number of floors or the existence of piers influenced the extent of damages to the structural frame of buildings.

The cost of restoring the buildings reached the amount of 1.0 – 1.2 billion euro, without including the cost of opening new roads, of household and of indirect losses due to disorganization of the economic life of the city and of the wider region [9].

In 1979 the 867 Law (Government Gazette 24/A/07.02.1979) was published which ratified, amended, and supplemented the Legislative Act which had been in force since July 28,1978 having as an issue “About Recovery of Damages from the 1978 earthquakes in the region of Northern Greece etc. and the regulation of other issues”. This specific Law defined that repairs of the damages in all the buildings would be done by granting non-interest loans and free contribution (financial aid) by the Government. Specific funding for preserved buildings was foreseen. Restoration work was carried out under the responsibility of the citizens and under the control of a competent authority which was established by the legislative act, on July 28, 1978 “About recovery of damages from the 1978 earthquakes in the region of Northern Greece etc. and the regulation of other similar issues”, i.e. the Earthquake Damaged Buildings Compensation Service of Northern Greece (Y.A.S.B.E.). All the inspection procedures, the terms for non-interest loans and the State financial aid for the damaged buildings were defined according to the type of construction, use and ownership status. For the applied research of Technical Seismology, the 867/79 Law foresaw the establishment of the Institute of Engineering Seismology and Earthquake Engineering (I.T.S.A.K.) based in Thessaloniki [11].

The 1978 Thessaloniki Earthquake constituted the reason for the creation of such institutions as Y.A.S.B.E. and I.T.S.A.K., and later because of the 1981 Corinth Earthquake, the Earthquake Damaged Buildings Compensation Service (now Natural Disasters Damaged Buildings Compensation General Division) (Y.A.S.) and Earthquake Planning and Protection Organization (E.P.P.O.) were created. The legislative order L.O. “About Emergency Planning Policy” enacted the security of the National Defense in periods of war and the Nation’s readiness to respond to emergency situations in periods of peace through prevention and mobilization of political forces and different sources of Greece.

The 2014 Kefalonia Earthquake (2014.26.01, M=5.8)

The 2014 Kefalonia Earthquake constitutes a recent event in which the structures and bodies
responsible for the Earthquake Management were already formed.

The legislation of Greece in 2014 Kefalonia Earthquake included the 2000 Seismic Code [12]. The Earthquake Management Services applicable in 2014 in Greece were the General Secretariat of Civil Protection, the Earthquake Planning and Protection Organization and the Natural Disasters Damaged Buildings Compensation General Division. Finally, the following paragraphs will also analyze the inspection procedures, recovery and reconstruction.

The 2000 Seismic Code concerns the design of structures against earthquakes. It is pointed out that the Code does not cover projects for which partial or complete earthquake insulation is premeditated. Additional provisions related to individual materials are included. According to the law 3013/2002, General Secretariat of Civil Protection (G.S.C.P.) aims to protect lives, health and property of citizens from natural and man-made disasters that cause emergency situations during times of peace. In the same context, care of material and cultural goods, natural resources and infrastructures of the country are included, with the aim of minimizing the impact of disasters. "Xenocratis" is a General Civil Protection Plan for the purpose of developing a system for effective response to disastrous phenomena for the protection of life, health and property of citizens, as well as for the protection of natural environment. It is the basic planning framework, which is responsible for assigning the design and drafting, based on different risk, specialized projects to the relevant Ministries [13].

The First Degree Inspection on the earthquake-stricken area began on the day of the earthquake, by engineers who staffed the local bodies. From the next day of the earthquake on January 27, 2014, inspections begun intensively. A total of 300 employees from the Ministry of Infrastructures, Transport and Networks and other Services were deployed for inspections and administrative support work. During the First Degree Inspection (Table 2), a total of 2,841 inspections were carried out either by owners request or by performing “door to door” inspections in specific areas and villages after the first estimations by the Local Authorities. 55.2% of the First Degree Inspection was completed almost fourteen days later, on February 10, 2014. Based on the census of citizens of 2011 the population of the affected areas in Kefalonia was 31,747 and the population of the affected areas in Ithaki was 3,131. The census of 2011 was chosen because it was more recent in the events of the earthquake. The total number of buildings in the prefecture of Kefalonia was 24,304 and of Ithaki was 3,120, of which 2,841 was inspected [14]. The results of the First Degree Inspection (Table 2) and the Second Degree Inspection (Table 3) are presented below.

<table>
<thead>
<tr>
<th>Type of Damages</th>
<th>Buildings</th>
<th>Percentage %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fit for Habitation (suitable to use)</td>
<td>1,568</td>
<td>55%</td>
</tr>
<tr>
<td>Not fit for Habitation (temporarily not suitable to use)</td>
<td>1,273</td>
<td>45%</td>
</tr>
<tr>
<td>Total</td>
<td>2,841</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 2. Results of the First Degree Inspection in the affected areas [8]

Immediately after the end of the First Degree Inspection, the Second Degree Inspection (Table 3) started on February 11, 2014 and it was completed by February 28, 2014. At the same time as the
Second Degree Inspection was initiated, information was given to the interested owners about inspection and compensation procedures.

Table 3. Results of the Second Degree Inspection in the affected areas [8]

<table>
<thead>
<tr>
<th>Colour Marking</th>
<th>Buildings</th>
<th>Percentage %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green</td>
<td>1,280</td>
<td>45.7%</td>
</tr>
<tr>
<td>Yellow</td>
<td>1,321</td>
<td>47.1%</td>
</tr>
<tr>
<td>Red</td>
<td>203</td>
<td>7.2%</td>
</tr>
<tr>
<td>Total</td>
<td>2,804</td>
<td>100%</td>
</tr>
</tbody>
</table>

The affected areas, the earthquake epicenter and the seismic fault are presented on Figure 2. The geographical distribution of the damaged buildings is not accessible due to personal privacy of citizens.

Significant were the damages on the island’s road network and along the main port. Damages from the earthquake also occurred to the ships that dug in the harbor due to their movement to the pier. In order to repair the damages, a budget of 58,540,000 euro was set up to cover buildings that could be repaired (“yellow” or “green” with damages).

Conclusions

The 1978 Thessaloniki and the 2014 Kefalonia Earthquakes have similar magnitudes and the building stock was affected in respectively the same proportion.

The 1978 Thessaloniki Earthquake left almost 800,000 people homeless. On the other hand, at the 2014 Kefalonia Earthquake, a ship was chartered for the immediate temporary housing and was used for 3 months.
The population awareness has also evolved rapidly. As mentioned above, in the 1978 Thessaloniki Earthquake, the citizens did not know how to react in case of an earthquake and what the results would be, so this led to misinterpretations and panic. On the contrary, in the 2014 Kefalonia Earthquake citizens knew how to react so there were no casualties and the panic injuries were very limited.

In the state domain of Response, in 2014 institutionalized bodies were put into operation directly, following specific and standardized procedures. However, there has been overestimation of needs resulting in oversupply of human and material resources.

At the same time, bodies and a suitable plan to deal with the earthquakes were already created. This is illustrated on the way buildings were inspected. In 1978, the First Degree Inspection categorized the buildings into three categories (green, yellow and orange) and the Second Degree Inspection verified the results of the First Degree Inspection. In 2014 the First Degree Inspection characterized the buildings as “fit for habitation” and “not fit for habitation”. The Second Degree Inspection deals with the buildings that were classified as “not fit for habitation” by the First Degree Inspection and classifies them in three categories (green, yellow, red), so an overall damage control can be achieved and restoration to be followed. This modification of the procedure allowed a more rapid characterization of the structural damages.

In the 36 years that came between the 1978 earthquake in Thessaloniki and the 2014 earthquake in Kefalonia, we can observe the various differentiation that have been formed. In the 1978 Thessaloniki Earthquake, there were no organizations and bodies charged with the responsibility of carrying out Disaster Management in Greece.

The 1978 Thessaloniki Earthquake marked the beginning of a Seismic Plan formation for Greece and launched long-term actions that shaped the current framework of seismic protection. After the earthquake, the bodies created which were responsible for the implementation of the Disaster Management, from the stage of Prevention up to the stage of Recovery. All these bodies have the same responsibilities until today and they were the Services that were active during the 2014 Kefalonia Earthquake.

Having established the basis for seismic protection since 1978, the earthquake management of Kefalonia was more organized. Each institution has done its work, so the impact of the earthquake has been directly managed. This is also evident in the direct reaction of the institutions and in the way of management, which was now based on already specific procedures. In the Kefalonia earthquake, in 2014, the necessary Preparation and Prevention existed.

The evolution of earthquake management structures in Greece has helped to provide citizens with better information, immediate and co-ordinated intervention at the time of emergency, and to remedy the impact of the earthquake.

Although through the years Prevention, Response and Recovery procedures have been improved this does not confute the fact that there is still room for improvement. Some suggestions for improvement are:
- electronic recording of buildings inspection with coordinate audits
- staff training to deal more effectively with emergency
- the use of stimulation of the seismic risk
- creating a communal home for the earthquake victims

References


11. Government Gazette On the amendment of the Act of Legislative Content of the President of the Republic of 28.09.1978 "on the restoration of damage caused by the 1978 earthquakes in Northern Greece, etc., and the regulation of other relevant issues". No. 24, Issue 1, Athens, 1979

