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Emergency planning for the municipality of Kos, Kos Island, Greece

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ABSTRACT: The island of Kos is located in the southeastern Aegean Sea. Earthquakes and associated phenomena such as tsunamis have been recorded in the region since the antiquity with the latest catastrophic earthquake being that of 1933, with a magnitude of 6.6 R. that destroyed the city of Kos claiming the lives of 178 people. Based on the Civil Protection frame that applies in Greece, all the available scientific and technical data for the municipality of Kos were collected and analyzed in order to conduct an earthquake and a tsunami emergency plan. The proposed plan includes a contingency plan for the Local Authorities, emergency maps as well as guidelines for emergency drills and public information.

1 INTRODUCTION

1.1 *Study area*

The Eastern Mediterranean is a region exhibiting high seismicity due to the Hellenic Arc and trench system. The island of Kos is located in southeastern Aegean Sea and belongs to the island chain of Dodecanese, Greece. The municipality of Kos, located at the northeastern part of the island, is a modern city of 17.890 residents, it includes the main port of the island and during the summer period represents an international tourist centre.

Based on the existing Civil Protection framework that applies in Greece, all the available scientific—technical data for the city of Kos were analyzed in order to identify the natural hazards that may pose a threat to the city, to conduct a contingency planning at city services level (actions of prevention-preparedness, immediate response and recovery for each service) for the identified hazards and to conduct a proposed emergency plan at a city level in agreement with the Civil Protection Secretariat manual for emergency planning.

1.2 *Existing legislation*

The existing Civil Protection framework that applies in Greece is based on the Civil Protection Law and the Revised National Emergency plan under the code name "Xenokratis". According to the Civil Protection law, the aim is summarized as "the protection of life, health and property of citizens during peacetime emergencies triggered by natural and manmade hazards". In brief: (i) the Civil protection framework and definitions are introduced and (ii) the general coordination bodies and means of Civil protection that will be activated—mobilized during an emergency as well as their responsibilities at a national, prefectural and local level, are described.

The aim of the revised National Emergency plan "Xenokratis" is to introduce a generalized frame of successful management of disastrous phenomena, the protection of life, health and property of citizens and the protection of the natural environment. The plan represents the foundations for "planning and acting" of the state mechanism at all levels of administration for the management of emergencies that result from the manifestation of hazards. It also determines the involved services as well as the authorities that will coordinate Civil Protection at all levels.

The plan assigns specific responsibilities to the Local Authorities regarding the management of natural and technological hazards. More specifically, the Municipalities:

- Have to arrange for the necessary Civil Protection resources and organization in order to be capable for the application of effective actions of Civil Protection and for the conduction of relative contingency plans.
- Are responsible for the coordination and supervision of the actions for each Civil Protection stage (prevention, preparedness, immediate response, recovery).
- Have to be equipped with the necessary means needed for the response and coordination during a peacetime emergency.
- Ought to constitute a Local Civil Protection Coordination council.
- Are responsible for the determination of assembly areas for the affected and for all the necessary arrangements for their accommodation.

1.3 *Earthquake and tsunami hazard*

The seismic hazard for the island of Kos is existent and is located on land and in the submarine region around the island (Fig. 1). The principal faults on land have a potential to trigger an earthquake of the order of 5.5 to 6 R magnitude. Regarding the seismic hazard in the submarine region, it is located mainly in the region between Kos and Pserimos and in the region south of Kos where a large scale composite fault zone has been recorded with a potential to trigger an earthquake of the order of 7 R magnitude. This zone represents the primary source of seismic hazard and is responsible for many disasters of the past, (Papanikolaou et al., 1998).

The seismicity of the island during historical times is summarized in Table 1, ranging from the older earthquake record that was made by Thucydides in 411 B.C. to the most recent in 1933.

The right hand column of the table includes the earthquake induced secondary phenomena that were recorded. More specifically such phenomena are manifested during the earthquake and many times are responsible for damages of a greater extent than the damages triggered by the earthquake itself. For the city of Kos, poor geotechnical conditions have favored the manifestation of such phenomena.

For the island of Kos, there are historical records for three tsunamis that stroke the island—at 556 A.D. 1570 and 1672 A.D.—related to strong earthquakes that took place in the region, (Papadopoulos et al., 2007). The exact areas that were affected and the wave heights are not known. However, historical sources provide significant information for the regions that were affected and the extent of the disasters. For example, regarding the 556 A.D.

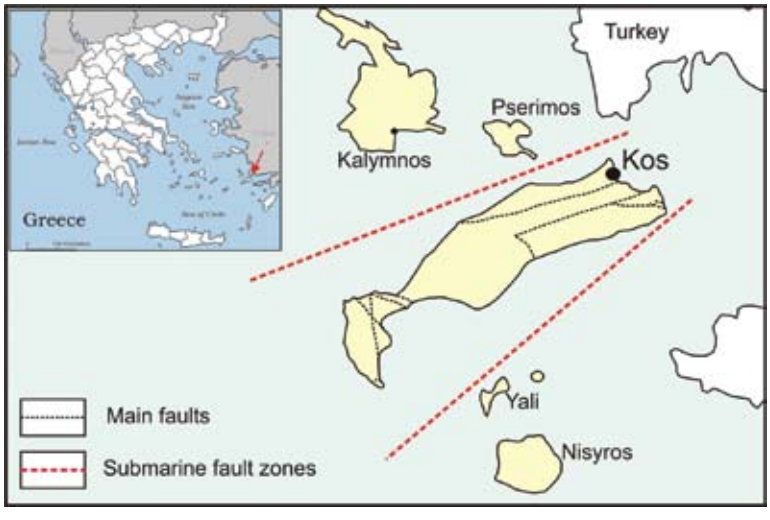

Figure 1. Principal faults on Kos Island and surrounding submarine fault zones.

tsunami, the Byzantine scholar Agathias (536–582 A.D.) was sailing to the northern part of the island when the disastrous earthquake stroke and he gave a detailed description of the tsunami that followed and the damages it caused to the city of Kos, (Zaraftis, 2005).

The tsunami hazard is existent not only for the city of Kos but for the whole island for the following reasons:

- Intense seismicity of the broader region of the Dodecanese.
- Intense seismic activity of the composite submarine fault zone south of Kos.
- The mild morphology that dominates the island.
- The high morphological submarine dip values that dominate to the north and to the south of the island.
- The historical data that provide information on at least three tsunami events and give a description of the total destruction of the city of Kos by the earthquake and the tsunami in 556 A.D.

Therefore, it was considered that the tsunami hazard had to be included in the emergency planning for the city of Kos.

2 EMERGENCY PLANS

2.1 *Contingency planning*

After the identification of the potential hazards, the Contingency and Emergency planning for the Municipality of Kos was conducted. The plan involved proposed contingency planning and Emergency actions for the local civil protection office, the local civil protection coordination council, the municipality services and the municipality agencies for all 4 stages of Civil Protection. In addition, contingency plan actions were proposed for each identified

Table 1. Historical earthquake disasters for the Island of Kos.

Year	Earthquake magnitute	Earthquake intensity	Regions affected	Earthquake associated phenomena
411 B.C.	7.0 R	IX	Kos town was destroyed (Papazachos 1989, Zaraftis, 2005)	Ground ruptures
6 B.C.	–	–	A large part of the town of Kos was destroyed (Zaraftis, 2005)	The town of Kos subsided
142 A.D.	7.0 R	X	Large scale disasters to Kos and Rhodes (Papazachos, 1989)	Tsunami with an inundation of many km inland at Rhodes. Towns at Kos, Serifos and Simi islands were destroyed.
556 A.D.	7.0 R	X	The ancient market of Kos town collapsed and Asklipeio was permanently abandoned (Zaraftis, 2005)	Tsunami hit the coast and town. Subsidence of at least one meter was recorded. Water turned saline. Many casualties.
1926	5,4 R	–	Most of the construtions of Antimachia were destroyed—two casualties (Papazachos, 1989)	–
1933	6,6 R	IX	Almost all Kos town collapsed. 178 casualties. The earthquake hit Kos and Nisiros island.The villages of Antimachia, Asfendiou and Pyli were totally or partly destroyed. (Papazachos, 1989)	One meter subsidence

hazard, guidelines for the creation of emergency response teams were given and the necessary equipment and voluntary organizations were proposed in order for the Local Authorities to practice successfully the Civil Protection within the city.

2.2 *Emergency plan for the seismic hazard*

An emergency plan for seismic hazard is directly related to the identification of suitable outdoor shelters in order to cover the needs created after the manifestation of an earthquake and during the aftershocks period. The categories of shelters needed as determined by the Earthquake Planning and Protection organization are assembly areas, tent camp areas, first aid facilities, relocation areas for critical services and areas for groups of people with special needs, (Delladetsimas et al., 1994).

In order to identify the appropriate areas for these uses, the existing land use was recorded according to present use identifying schools, public buildings, archaeological sites that are not included in the planning since they are under the authority of the Ministry of Culture and special terms of use apply and finally public areas, including squares, parks, playgrounds, courts, open parking areas etc. These public areas were examined in terms of suitability for use as assembly areas, tent camp areas etc. and in terms of distance from the coastline. As a future earthquake might include earthquake induced secondary phenomena, it was suggested that the public areas and streets included in the emergency plan are located at a reasonably safe distance from the coastal zone.

Based on the location of schools and public buildings, assembly areas were initially proposed, located away from the coastal zone (Fig. 2). After the determination of assembly areas, the tent camp areas were selected. The Municipality has already started the configuration of a tent camp area, with capacity to shelter 400 people that was included in the plan. However, it was necessary to propose a second area, next to the tent camp under construction. These areas are also suggested to be used for the relocation of critical services and as first aid facilities. It should be noted that the facilities of two Youth centers have been proposed as shelters for groups of people with special needs.

After the identification of the appropriate areas there was a selection of primary and secondary roads in order to form a road network that will ensure easy and direct access to the selected areas and the town centre by the emergency response teams. The use of coastal roads was avoided since they might be damaged by small scale earthquake associated phenomena.

Figure 2. Earthquake emergency map for the city of Kos.

Figure 3. Tsunami emergency map for the city of Kos.

2.3 *Emergency plan for the tsunami hazard*

As far as the Tsunami hazard is concerned, the recurrence of a catastrophic phenomenon similar to the one triggered by the earthquake of 556 A.D. in our days will have inestimable catastrophic consequences on the city of Kos and the surrounding settlements that are under development along the coastal zone. The vulnerability of the city is characterized as high due to:

- The mild morphological relief that dominates the city plan, (altitudes lower than 10 m and at locations even below the sea level as recorded in the northwestern part of the city).
- The location of public services, touristic development and related activities along the coastal zone resulting in concentration of citizens and visitors in an area that can be characterized as hazardous.

Emergency planning for tsunami hazard is directly related to the selection of suitable evacuation routes. Usually, such routes follow existing roads that develop vertically to the direction of the shoreline and lead to areas that are located in higher and safer altitudes. Based on the practices applied on an international level, as safe are characterized areas located higher than the 10 meter contour that in the case of the study area runs through the border of the city plan. Based on the existing city plan the evacuation routes that are summarized in Figure 3 were proposed.

These selected routes guarantee the direct evacuation of the population from the coastal lowland areas to higher altitude safe areas. At this point it should be mentioned that the evacuation was recommended to be carried out on foot and not by the use of vehicles as these roads might suffer damages by earthquake induced secondary phenomena or be blocked by building collapses etc. The traffic jam that will result by the use of vehicles will decelerate the evacuation process rather than facilitate it. The tent camp area under construction is located higher than the 10 m contour and could be considered as a safe assembly and tent camp area.

2.4 *Emergency preparedness drills and public information*

Following the conduction of an emergency plan it was advised that the Local Authorities should proceed to emergency preparedness drills in order to test: (i) the preparedness of the Local Authorities, the involved agencies, rescue teams, volunteers and population and

(ii) the applicability of the emergency plan, identifying potential weaknesses and flaws aiming towards its optimization. It was suggested that the emergency preparedness drills should be realized in frequent time intervals (e.g. once or twice a year) and to include exercises at Local Authorities level.

A significant part of the emergency planning is the information of the public. Through this study, in order to increase the awareness of the public, it was proposed that the residents and visitors should be informed in detail on the potential hazards and the self-protection guidelines. The emergency plan should be published informing the public about the proposed assembly areas, the tent camp areas and the evacuation routes. It should be stressed out that the evacuation process is encouraged to be carried out on foot and that the use of vehicles is not recommended. Moreover, it was proposed that Public information should be realized through:

- Leaflets that briefly list the potential hazards and the protection guidelines.
- Appropriate signage for assembly and tent camp areas as well as for hazardous areas and evacuation routes.
- Information signs at key location throughout the city presenting the emergency plan maps.

Finally, as the island of Kos represent a tourist destination and its economy in a considerable extent is based on tourism, it was proposed that the Municipality in co-operation with the local Tourism Organization, the local Hotel Association and the travel agencies should commit to the visitors information for the possible hazards that might pose a threat during their visit to the island.

3 CONCLUSIONS

Through this study, two principal natural hazards were identified for the city of Kos, the seismic hazard and the tsunami hazard as an earthquake associated phenomenon. Historical records are indicative of the damages that a future earthquake and tsunami may cause to the modern city of Kos. The vulnerability of the city to the tsunami hazard is high regarding the mild morphology that dominates and the concentration of city services and touristic development near the coastline. The proposed emergency plan will contribute significantly to the Civil Protection of the city, however it has to be stressed that further research on the seismic hazard and the tsunami hazard should be conducted in order to determine in detail the vulnerability and estimate the potential risk.

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