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School Buildings and Antiseismic Planning. The Example of Grevena - Kozani Earthquake (W. Macedonia, Greece) of May 13, 1995.

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Introduction

The indisputable fact that the Hellenic territory is characterized by high seismicity calls for accurate and effective earthquake protection planning, at least as far as the human constructions are concerned. When it comes to buildings housing large numbers of people, and especially the youths, as is the case of school buildings, this need becomes even more urgent.

The so far accumulated experience on the distribution of seismic activity around the Hellenic territory has shown that even there are confirmed high seismicity certain areas, where the constructions are built to meet higher standards of design, this measure should be expanded to theoretically more stable areas. This has been the lesson learnt from the recent earthquake at Grevena-Kozani, not to mention cases outside Greece, as the Maastricht and Kobe earthquakes, etc., all of which were areas that known destructive earthquakes used to rather sparse, if existing at all.

The earthquake of Grevena-Kozani (Ms = 6.6) occurred at an area considered aseismic (Papazachos 1990, Papazachos et al 1995) at 11.47 local time. Its epicentre was at 40.16 N, 21.67 E and the focus lay at a depth of approximately 10 km. The shock took everybody by surprise (including the scientific community and the state) and there would have been a considerable death toll, had it not been for the fact that it was Saturday and the schools and all the civil services were closed, and the most of the people were outdoors, farming or shopping; in the case that the shock took place on a weekday, it is obvious that the death toll would be overwhelmingly high. Besides, a foreshock that occurred some minutes before the main one disturbed the residents, who sought refuge in the open air.

Distribution of school buildings damage

Using this earthquake as the case study, an attempt will be made to determine the factors that played a significant part on the distribution of the damage of school buildings. The pleistoseismal area has numerous small villages and communities, where the school buildings are mainly old constructions, housing one or two classrooms. Most of them collapsed or were seriously damaged (Fig. 1).

It is noted here that the overall distribution of the damage in the school buildings follows that of the other constructions. Thus, out of 30 villages where damage 17, at 6 cases the school buildings collapsed, 3 suffered extensive damage and all the others were lightly damaged (Carydis et al 1995, Lekkas et al 1995).

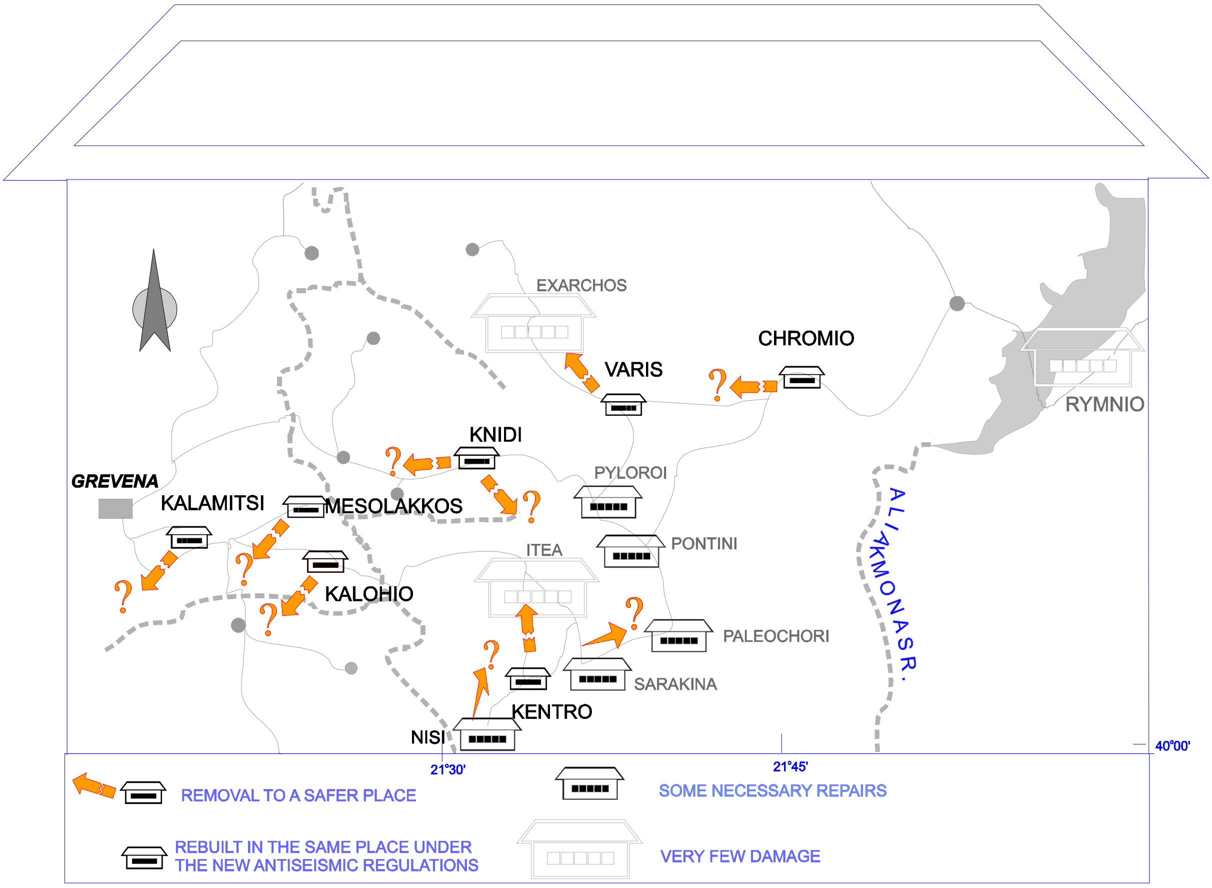

Fig. 1: The distribution of the school buildings damage and the synoptic proposals.

The factors that were taken into account for the evaluation of damage distribution of the shool buildings were the following:

- The type of construction
- The foundation soil
- The neighbouring with active or neotectonic faults
- The morphology and the slope stability
- The existence of seismic fractures
- The occurrence of landslides, rockfalls or subsidence phenomena

Table I summarises all the above mentioned factors. Conserning the didstribution of the school buildings damage, the following observations can be made:

- The type of construction played an important part, as it has been confirmed that at the very few cases that the school buildings withstood the shock, it was when they were new constructions. At the worst cases, these new constructions suffered light damage.

- Given that the majority of the school buildings were old, stone-built ones, the sample examined can be judged as statistically homogenous, it may be left out and the other contribution of each of the other factors in the damage distribution can be calculated.

TABLE I

TABLE SUMMARISING THE GEOTECHNICAL AND SEISMOTECTONIC CONDITIONS OF SCHOOL BUILDINGS WITHIN THE PLIOSEISMAL AREA

VILLAGE NAME	DAMAGES	MORPHOLOGY	GEOTECHNICAL CONDITIONS	FAULT ZONES - SEISMIC FRACTURES	LANDSLIDES ROCKFALLS	SYNOPTIC PROPOSAL
RYMNIO	Few	Advantageous morphological conditions	Moderate geotechnical conditions	Adjacent to Serbia fault zone	Some small landslides	The school could stay at the same location but it is is suggested to built a new one, or to reinforce the existing, because of the nearby active fault zone
CHROMIO	Collapsed	Advantageous	Very bad geotechnical conditions	No seismic fractures	Some landslides	The school should be removed to a safer site together with the village
KNIDI	Collapsed	Advantageous morphological conditions	Very bad geotechnical conditions	Some fractures, probably seismic	Local subsidence	1st solution: The school must be removed to safer site. 2nd solution: The school can be rebuilt in the same place taking into account the New Antis. Regulations.
VARIS	Collapsed	Advantageous morphological conditions	Very bad geotechnical conditions	Adjacent to Chromion - Varis fault zone	Local subsidence	The school must be rebuilt using the New Antiseismic Regulations
EXARHOS	Very few	Advantageous	Moderate geotechnical conditions	No	No	For preventive reasons the school must be reinforced or re-established
KALAMITSI	Partial collapse	Not advantageous	Very Bad geotechnical conditions	No seismic	Landslides	The new school must be built under the New Antiseismic Regulations
MESSOLAKOS	Collapsed	Moderate morphological cond.	Very bad geotechnical conditions	No	No landslides	The new school must be built under the New Antiseismic Regulations
KALOCHION	Collapsed	Negative	Very bad geotechnical conditions	No	Landslides	The new school must be built under the New Antiseismic Regulations
ITEA	Very few	Very good	Moderate geotechnical conditions	No	Local subsidence	The school will stay at the same place with some necessary repairs

- The foundation soil, as can be seen in TABLE I, was the most important factor in the damage distribution. The school buildings were founded on two types of formations. The former is Plio-Pleistocene loose conglomerates and red soils, and the latter is the Miocene molassic formation, comprising consolidated conglomerates, sandstones and marls (Mavridis & Kelepertzis 1993). Foundation on the former meant severe damage, while foundation on the latter meant reduced destruction, regardless the morphologic conditions.

- The morphology, as it is expressed through the distribution of mean slopes, was equally an important, but not a decisive factor. This is because even when the relief was relatively smooth, there were cases of increased damage, while at areas of intense relief the damage was occasionally small.

- The occurrence of neotectonic structures and seismic fractures (Pavlides et al 1995) was significant, as regards the distribution and extent of damage.

Based on all the above, it is thought purposeful once more to underline the fact that, as far as proper earthquake protection planning is concerned and mainly with regards to the school buildings, both in the region of Grevena - Kozani and in the rest of the Hellenic territory, the following must be borne in mind:

- Very careful selection of the foundation soil.
- Potential occurrence of destructive phenomena (landslides, settling, etc.).
- The occurrence of active neotectonic structures.
- The type of construction.

References

Carydis,G., Holevas,K., Lekkas,E. & Papadopoulos,T. (1995): The Grevena (Central-North Greece) Earthquake Series of May 13, 1995. EERI Spec. Earth. Rep., Vol. 29, Nb 6, 1-4.

Lekkas,E.L., Lozios,S.G., Fountoulis,I.G., Adamopoulou,E.I. & Kranis,H.D. (1995): Investigation - Correlation of the geodynamic hazards at the earthquake stricken areas of Kozani - Grevena: Proposals for safe reconstruction, Applied research Project, Athens. 1995.

Mavridis,A. & Kelepertzis,A. (1993): Geological map of Greece, scale 1/50.000, "Knidi" Sheet, I.G.M.E. Publ.

Papazachos,B.C. (1990). Seismicity of the Aegean and surrounding area. *Tectonophysics*, 178, 287-308.

Papazachos, B.C and twelve others (1995): The physical generation process of the Kozani-Grevena earthquake of 13 May 1995 (Ms=6.6) and the ensuing earthquake sequence. Publication No. 4, 1995, Aristotle University of Thessaloniki.

Pavlides,S.B., Zouros,N.C., Chatzipetros,A.A., Kostopoulos,D.S. and Mountrakis,D.M. (1995): The 13 May Western Macedonia, Greece (Kozani Grevena) earthquake; preliminary results. *Terra Nova*, 7, 544-549.