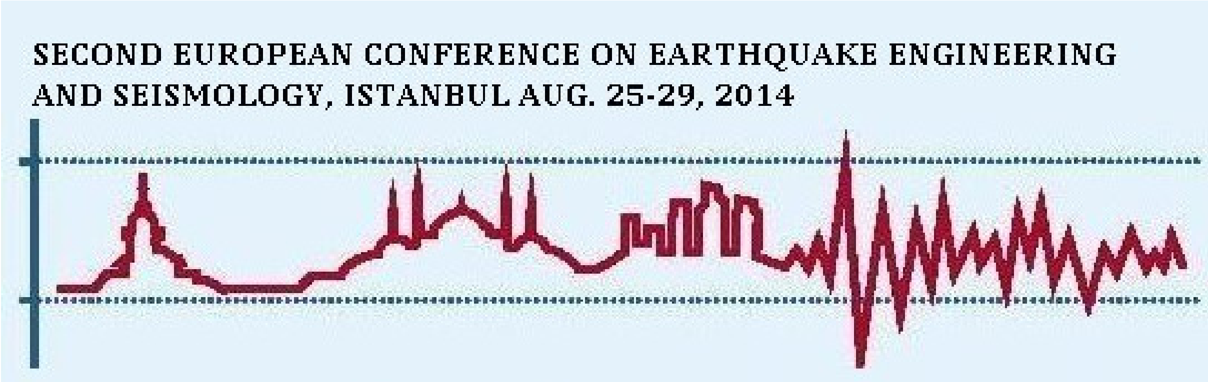

A PROPOSAL FOR ACCELEROMETRIC STATION VALIDATION PROCEDURES : APPLICATION TO REPRESENTATIVE SITES IN CRETE (GREECE)

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ABSTRACT

In the present research effort, fourteen representative sites of the strong motion accelerometric network of Crete Island in Greece were investigated in order to establish a reliable site characterization and the eventual classification of the soil conditions into the respective types prescribed in Eurocode 8. Various approaches of different complexity were applied, and comparisons among the results of the various procedures are presented. Additional investigations are proposed for the evaluation of the seismic vulnerability of the buildings that house the stations, as well as for the preliminary assessment of the effect of the dynamic response of the building on the recordings of the accelerograph at its base. Towards this aim, a multiple-stage building inspection methodology (including a first-stage Rapid Visual Screening procedure) was developed and is herein presented in detail. Thus, the whole research effort leads to a comprehensive validation of both the site conditions at each accelerometric station, as well as of the seismic vulnerability of the respective structures and their effect on the earthquake recordings.

INTRODUCTION

Real free field recordings are very useful for design engineers, and can improve the seismic input motions prescribed in seismic codes (e.g. Eurocode 8 - EC8). An essential issue for the proper use of the recordings of any accelerometric network is the proper validation of the soil conditions at each station site and their eventual classification according to the respective soil types prescribed in the

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codes. Thus, in the framework of a joint Hellenic-EU funded research project ("*GEOCHARACTERIZATION*"), fourteen representative sites of the accelerometric network of Crete Island - that operates within the frame of the national Hellenic Accelerometric Network (HAN) - were selected in order to improve the understanding of the relation between the near surface geology (as defined from geotechnical mapping at the appropriate scale) and the seismic properties shear wave velocity (v_s) and its variation with depth from in-situ geophysical measurements. Each approach is used independently in order to define the soil category prescribed in the Eurocodes (EC8), and any observed differences in the obtained results help in a better understanding the limitations of each approach. Various geological, geotechnical and geophysical investigations have been combined to provide accurately, or even with its corresponding uncertainty, the ground type. Ground type characterization based on small and large-scale mapping is defined and further compared with geophysical results. The detailed large scale engineering geological mapping around the strong motion stations of Crete provides crucial information on the ground type/soil category of the foundation formations. These data are enriched by geophysical surveys where different types of geophysical methods have been applied to provide a high level of refinement in the earth model. These results are to be further maximized by targeted geotechnical drills, regarding the geo-characterization of the sites.

Other important issues which are also internationally open to research is the assessment of the seismic vulnerability of the buildings that house the stations of the accelerometric network, as well as the evaluation of the effect of the dynamic response of the building during an earthquake on the recordings of the accelerograph at its base. For the validation of the structures that house the recording stations, a specialized multiple-stage methodology was developed by the EPPO-ITSAK earthquake research engineering team, based on their long experience on pre- and post- earthquake structural assessment procedures. The first stage of the proposed procedure is based on the pre-earthquake seismic vulnerability assessment methodology proposed by EPPO (2001) and adopted on a national level in Greece. The methodology has been significantly modified/enhanced for the needs of the present research effort in order to allow for a more detailed classification of the structural system of the inspected structures, as well as for the collection of data on structural properties that have an important effect on the recordings by the accelerometric stations that are housed in the station buildings. The selected data can be straightforwardly incorporated in a database that will allow for the assessment of the seismic vulnerability of the inspected station buildings, as well as a primary assessment of their effect on the recorded ground excitations.

The proposed investigation procedures lead to a comprehensive validation of the site conditions at the stations of an accelerometric strong-motion network, as well as of the seismic vulnerability of the structures housing the sensors and the effect of the dynamic response of the buildings on the earthquake recordings. Some preliminary results of the application of the proposed methodology during the still ongoing research effort are presented and discussed.

SITE CHARACTERIZATION FOR THE STRONG MOTION SITES

In order to estimate the site soil conditions for each site of accelerometric stations and to classify them according to the ground types prescribed in EC8 three different approaches have been followed. The first two are based on geological mapping in two different scales, small (1:50000) and large (1:5000) and the third one on geophysical measurements in order to reveal the time-averaged shear wave velocity of the first 30 m (known as v_{s30}).

The area of study and the stations of HAN in Crete Island are presented in Figure 1. The different type of geological/geophysical data available is shown with different color. The epicenters of the earthquake data used in this study are also shown.

The large scale engineering geological mapping around the HAN strong motion sites proved that the common practice of allowing the use of medium scale geological maps (eg the IGME maps of 1:50.000 scale) for the geocharacterization of the sites is not always precise. At several sites, new certain or probable faults were identified very close to the stations. These data appointed new targets for the geophysical research and the site response as the location and the orientation of the tectonic elements set new perspectives on the models referring to the propagation of the seismic waves.

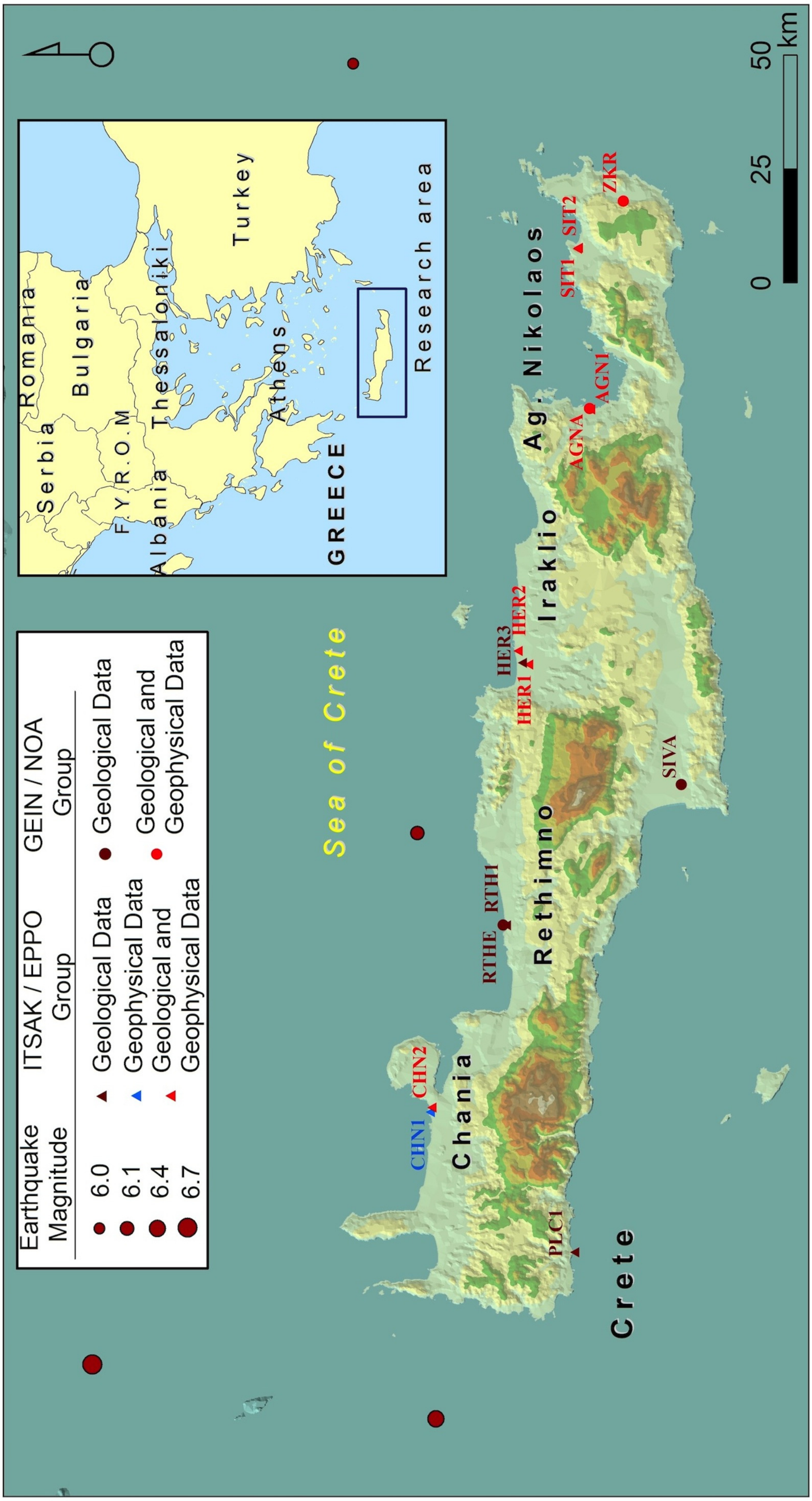

Figure 1. The distribution of the HAN stations in Crete. The triangles and circles indicate the ITSAK/EPPO and the GEIN/NOA strong motion instruments, respectively. Circles of magenta color with a black outline indicate the epicenters of the earthquake events recorded.

Table 1. The foundation formations according to the medium scale geological maps of IGME and the large-scale maps composed within the framework of the current study. The corresponding ground type/soil categories are presented. The ground type and the corresponding v_{s30} values as a result of the geophysical prospecting are also shown. With red color we denote foundation formations or soil categories that change from one ground type categorization method to the other.

Station	Medium scale maps		Large scale maps		Geophysical Results	
	Station foundation formations	Ground-type	Station foundation formations	Ground-type	v_{S30}	Ground-type
CHN1					903	A
CHN2	Loose marly sandstones	C	Stiff marly conglomerate and marly Limestones	A	578	B
PLC1	Loose alluvial deposits	D	Loose alluvial deposits	D		
RTH1	Clayey marls	B	Clayey marls	B		
RTHE	Limestones and dolomites	A	Limestones and dolomites	A		
HER1	Marls	B	Marls	B	378	B
HER2	Marls	B	Recent and historic deposits	D	413	B
HER3	Coastal loose sands	D (or S_2)	Marls	B		
SIVA	Conglomerates, sandstones and marls	B	Marls and Marly sandstones	B		
AGN1	Limestones and dolomites	A	Loose alluvial deposits over limestones	E	476	B
AGNA	Marly conglomerate	A	Marly conglomerate	A	476	B
SIT1	Marls	B	Marls	B	416	B
SIT2	Loose alluvial deposits	D	Loose alluvial deposits	D	242	C
ZKR	Phyllites	A	Overthrusted limestones	A	871	A

Additionally, the engineering geological mapping revealed variations altering the ground-type/soil-category of the foundation formations (Table 1). In particular, substantial variations were observed at the CHN2, HER2, HER3, and AGN1 stations. The disagreement on the type of the foundation formations does not imply that these maps are of bad quality. On the contrary it is a reasonable disagreement imposed by the combined complexity of the geological structure and the low scale of the IGME maps.

A comprehensive series of geophysical seismic testing, including MASW and MAM (Park et al., 1999; Louie 2001) testing was completed in December 2012, in order to determine the v_s profiles at nine strong motion stations in Crete. The Rayleigh wave phase velocity as a function of frequency (i.e. the Dispersion Curve) has been calculated for each site. For v_s inversion of the dispersion curves, we used the Neighborhood algorithm (Whatelet, 2005), which is available from the open source software geopsy (http://www.geopsy.org). Inversions were performed using as input five model scenarios with increasing number of layers starting from one uniform layer over half-space, up to five-layer over half-space. The ensemble of models calculated that follow the lowest misfit where further evaluated based on the Akaike criteria estimate (Savvaidis et al., 2009; Di Giulio et al., 2012) and the 'best' parameterization was selected in order to calculate the v_s profile for each site and from that the corresponding v_{s30}. A detailed presentation of all calculated earth models along with the large-scale mapping is presented in Savvaidis et al. (2014).

Comparing the Category Type defined based on geophysical data, with the one defined based on the large scale mapping two very interesting findings come out. Firstly, on sites with Neogene rock-like geological formations, such as marly conglomerates, the calculated v_{s30} values downgrade the ground type from A to B (Table 1 - CHN2 and AGNA). So, the ground-type/soil-category of these formations must not be overestimated although they appear on site like rock formations. The second finding concerns the sites with shallow depth, less than 10m, loose to medium dense deposits (HER2, AGN1, SIT2). According to EC8 and based on the description of the stratigraphic profile the ground type is underestimated. As presented in table 1 the category estimated by the geophysical data is upgraded to upper categories (to B for HER2 and AGN1 from D and E respectively, and to C from D for SIT2) depending on the shear wave velocity of the underlay formations.

ASSESSMENT OF SEISMIC VULNERABILITY OF THE BUILDING HOUSING THE STATION AND ITS EFFECT ON THE RECORDINGS

In several cases, the sensors of a strong motion accelerometric network are installed at the basement of existing buildings, due to several reasons (safety, access to power and internet/ethernet connection etc), resulting in conditions that can not be considered as 'free-field'. The influence of the dynamic response of the building on the recorded earthquake excitation by the accelerograph at its base is an internationally acknowledged issue that is still open to research. Another equally important issue is the evaluation of the seismic vulnerability of the building, since it will give an indication of its potential behaviour during a strong event and will indicate the potential need of strengthening interventions. In this context, it is essential to have a thorough knowledge of several structural properties of the building that define its dynamic properties and its seismic vulnerability (e.g. dimensions, number of storeys, structural system, foundation type, soil type, structural irregularities etc). In the case of an accelerometric network of national or even local scale, which comprises a large number of buildings, one of the most economically feasible methodologies for their mass assessment is based on a Rapid Visual Screening (RVS) procedure. As the name implies, the assessment is based on a visual inspection of the buildings by a team of inspectors, at least one of which must be a qualified civil engineer. The advantage of the methodology is the relatively small time span necessary for the inspection of each building (typically half a day on field and one to two days of office work). The collected data thus allow the creation of a data base with a general "profile" for each building, which contains all the essential information for a primary assessment of its seismic vulnerability, as well as its potential influence on the recorded response at its base. Another advantage is the fact that the methodology finally ends up in assigning to each inspected building a quantitative measure (a single structural score) of its potential seismic vulnerability. Such information can hence be used in order to draw useful information of the overall potential seismic behaviour of the inspected station housing buildings, and to prioritize second-stage, more detailed inspections of the more critical ones. The economic feasibility of the RVS methodology has been acknowledged in Greece, which adopted it from similarly proposed approaches in the US (FEMA 1992) - and after proper adaption of the US methodologies to Greek building practices - as the first of a three-stage methodology for the assessment of the seismic vulnerability of public buildings (EPPO 2000).

Based on previous experience of members of the research team on vulnerability assessment of existing buildings (Stylianides et al. 2003a, 2003b, Karakostas et al. 2008, 2009), a data collection form has been custom-designed for the needs of the present research project. The form comprises six sections. In each Data Collection Form space is provided for a code (ID) number, unique for each building, that helps in linking all data pertinent to this particular building (Data Collection Form, Photo and drawing of the building etc.)

ΓΕΩΤΕΧΝΙΚΟΣ ΧΑΡΑΚΤΗΡΙΣΜΟΣ ΕΠΙΛΕΓΜΕΝΩΝ ΘΕΣΕΩΝ ΣΤΗΝ ΚΡΗΤΗ ΜΕ ΤΗΝ ΣΥΝΔΥΑΣΤΙΚΗ ΧΡΗΣΗ ΓΕΩΦΥΣΙΚΩΝ ΚΑΙ ΓΕΩΤΕΧΝΙΚΩΝ ΜΕΘΟΔΩΝ

CODE NO.:

SECTION A: IDENTITY DATA OF BUILDING

1.	PREFECTURE:			
2a.	MUNICIPALITY:	2b. TOWN :		
3.	ADDRESS :			
		ZIP:	Tel. :	
4.	BUILDING COORDINATES :			
5.	5a. BUILDING COMPLEX:		5b. BUILDG. :	
6a.	BUILDING USE :			
6b.	USAGE CODE (*000-000-000*) :			
7.	USER ID :			
8.	OWNER ID :			
9.	SUPERVISING AUTHORITY :			
10.	INSPECTING AYTHORITY :			
11.	MAX NO OF PEOPLE IN BUILDING :	UP TO 10 ☐	10 – 100 ☐	> 100 ☐
12.	CONTACT INFO :			

SECTION B: TECHNICAL DATA OF BUILDING

13.	NO OF STOREYS:				
14.	NO OF BASEMENTS:				
15.	TYPICAL PLAN AREA:				
16.	TOTAL BUILT AREA :				
17.	YEAR OF CONSTRUCTION :				
18.	YEAR OF LATEST APPENDAGE:				
19.	DESIGN DRAWINGS AVAILABLE:	YES ELECTRONIC ☐	YES HARDCOPY ☐	NO ☐	
20.	WERE DESIGN DRAWINGS USED IN INSPECTION :	YES ☐		NO ☐	
21.	ARE DESIGN DRAWINGS AVAILABLE AT EPPO-ITSAK?	YES ELECTRONIC ☐	YES HARDCOPY ☐	NO ☐	

ΓΕΩΤΕΧΝΙΚΟΣ ΧΑΡΑΚΤΗΡΙΣΜΟΣ ΕΠΙΛΕΓΜΕΝΩΝ ΘΕΣΕΩΝ ΣΤΗΝ ΚΡΗΤΗ ΜΕ ΤΗΝ ΣΥΝΔΥΑΣΤΙΚΗ ΧΡΗΣΗ ΓΕΩΦΥΣΙΚΩΝ ΚΑΙ ΓΕΩΤΕΧΝΙΚΩΝ ΜΕΘΟΔΩΝ

22.	BUILDING OF CULTURAL IMPORTANCE :	YES ☐	NO ☐		
23.	WAS BUILDING REPAIRED / STRENGTHENED :	YES ☐	NO ☐		
24.	IF YES, WHY AND WHEN :				
25.	BUILDING IMPORTANCE ACCORDING TO EC8:	I ☐	II ☐	III ☐	IV ☐
26.	ADDITIONAL INFO/REMARKS :				

27.	INSPECTORS' ID:	
	1. NAME:	2. NAME:
	QUALIFICATION:	QUALIFICATION:
28.	INSPECTION DATE :	

USE ASTERISC (*) WHEN IN DOUBT OR GIVING PERSONAL ESTIMATION DUE TO LACK OF SUFFICIENT DATA

Figure 2. Data collection form : Sections A and B

In Section A of the Collection Form (Fig. 2), data pertaining to the identity of the investigated building are included. Space is provided for the address, usage and ownership of the building, as well as the maximum number of people expected to be gathered in it. Noteworthy is the refinement of field 5 into Building complex (5a) and building (5b) in order to better describe the particular station housing building if it belongs to a building complex. Also this refinement is useful for the case of a building with expansion/seismic joints that separate it into statically independent parts. In such a case, one separate Data Collection form is filled for each statically independent part, i.e. each part is treated as a separate building. Another noteworthy point is field 6b (usage code) which comprises a set of three, 3-digit code numbers that describe the use of the building from a general aspect (e.g. education – usage code A) to more specific ones (e.g. elementary school – usage code B and finally e.g. classrooms – usage code C). Section B (Fig. 2) pertains to technical data of the building, including information on number of storeys, typical floor area and total area, year of construction and latest appendage (if any), as well as information about the availability of blueprints/design data, if the building has been characterized as culturally important, and if any strengthening/repair interventions have ever taken place. Finally the building is assigned its (usage-dependant) importance according to Eurocode 8 and space is provided for any additional info that the inspectors would like to include.

Section C (Fig. 3) comprises seismological and geotechnical data, such as the seismic hazard zone according to current seismic code (Eurocode 8), as well as the seismic code according to which the building was designed.

The structural type of the building is defined in section D (Fig. 3). The structural types include reinforced concrete (RC), prefabricated (PF) Masonry (URM, UMDB, RM, SM) and steel (ST) load-bearing systems. In the guidelines of the Hellenic Ministry of Greek Works (EPPO, 2000), RC buildings are classified in three three categories (RCa, RCb, RCc), depending solely on the Greek seismic code according to which the inspected building was built. In the present research effort RC buildings are classified in seven different RC structural types (RC1 to RC7), depending on both the respective Greek seismic code, as well as on the specific characteristics of the load-bearing system of the building.

ΓΕΩΤΕΧΝΙΚΟΣ ΧΑΡΑΚΤΗΡΙΣΜΟΣ ΕΠΙΛΕΓΜΕΝΩΝ ΘΕΣΕΩΝ ΣΤΗΝ ΚΡΗΤΗ ΜΕ ΤΗΝ ΣΥΝΔΥΑΣΤΙΚΗ ΧΡΗΣΗ ΓΕΩΦΥΣΙΚΩΝ ΚΑΙ ΓΕΩΤΕΧΝΙΚΩΝ ΜΕΘΟΔΩΝ

SECTION C : SEISMOLOGICAL AND GEOTECHNICAL DATA OF AREA

29. Current seismic hazard zone according to EC8				
I ☐	II ☐	III ☐		
30. Seismic hazard zone at design year of the building				
Pre-1995	I ☐	II ☐	III ☐	
1995 -2003	I ☐	II ☐	III ☐	IV ☐
2004 - Today		I ☐	II ☐	III ☐
31. Ground type according to EC8				

A ☐	B ☐	C ☐	D ☐	E ☐	S1 ☐	S2 ☐
Unknown ground type ☐						

SECTION D : STRUCTURAL SYSTEM OF BUILDING

(D1) LOWER-LEVEL FLOOR (Basement ☐ / Ground floor ☐)

32. Structural type of lower-level floor (at contact with foundation) (See Table 1)						
RC1 ☐	RC2 ☐	RC3 ☐	RC4 ☐	RC5 ☐	RC6 ☐	RC7 ☐
PF1 ☐	PF2 ☐	WOOD ☐				
URM1 ☐	URM2 ☐	UMDB ☐	RM ☐	SM ☐		
ST1a ☐	ST1b ☐	ST2a ☐	ST2b ☐			

(D2) REMAINING HIGHER-LEVEL FLOORS

33 Structural type of remaining higher-level floors (See Table 1)						
RC1 ☐	RC2 ☐	RC3 ☐	RC4 ☐	RC5 ☐	RC6 ☐	RC7 ☐
PF1 ☐	PF2 ☐	WOOD ☐				
URM1 ☐	URM2 ☐	UMDB ☐	RM ☐	SM ☐		
ST1a ☐	ST1b ☐	ST2a ☐	ST2b ☐			

ΓΕΩΤΕΧΝΙΚΟΣ ΧΑΡΑΚΤΗΡΙΣΜΟΣ ΕΠΙΛΕΓΜΕΝΩΝ ΘΕΣΕΩΝ ΣΤΗΝ ΚΡΗΤΗ ΜΕ ΤΗΝ ΣΥΝΔΥΑΣΤΙΚΗ ΧΡΗΣΗ ΓΕΩΦΥΣΙΚΩΝ ΚΑΙ ΓΕΩΤΕΧΝΙΚΩΝ ΜΕΘΟΔΩΝ

SECTION E : BUILDING VULNERABILITY DATA

(Mark with X the positive answers to the following questions)

34.	No Seismic Code applied	☐
35.	Building's importance has changed due to modification of use	☐
36.	Previous seismic damage (not properly repaired)	☐
37.	Poor condition due to inadequate maintenance / poor detailing	☐
38.	Possibility of pounding with adjacent buildings	☐
39.	Soft storey	☐
40.	Irregular distribution of brick infill walls in plan (for RC type)	☐
41.	High-rise building	☐
42.	Vertical irregularities	☐
43.	Horizontal irregularities	☐
44.	Possibility of torsion	☐
45.	Short columns	☐
46.	EXTRA FIELD1	
47.	EXTRA FIELD2	
48.	FINAL STRUCTURAL SCORE (RVS methodology)	

:

SECTION F :FACTORS AFFECTING RECORDS

(Mark with X the positive answers to the following questions)

49.	Building of significant size/mass	☐
50.	Foundation type	
	FOOTING ☐ STRIPED ☐ GEN SLAB ☐ OTHER SWALLOW ☐	
	PILES ☐ MICROPILES ☐ OTHER DEEP ☐ UNKNOWN ☐	
51.	Adjacent areas are densely built	☐
52.	EXTRA FIELD3	
53	EXTRA FIELD4	
54	EXTRA FIELD5	

Figure 3. Data collection form : Sections C, D, E and F

	STRUCTURAL TYPE		STRUCTURAL CHARACTERISTICS	GREEK SEISMIC CODE
REINFORCED CONCRETE	RCa	RC1	Reinforced concrete frame system building	1959 Seismic Code 1954 R/C Code
		RC2	Reinforced concrete dual system building (columns and shear walls)	1959 Seismic Code 1954 R/C Code
		RC3	Reinforced concrete dual system building (columns and adequate shear walls – with area ≥ 0.2 % of total area of the higher floors – hence with no need for further seismic computations)	1959 Seismic Code 1954 R/C Code
	RCb	RC4	Reinforced concrete frame system building	1959 Seismic Code upgraded in 1985 1954 R/C Code
		RC5	Reinforced concrete dual system building (columns and shear walls)	1959 Seismic Code upgraded in 1985 1954 R/C Code
	RCc	RC6	Reinforced concrete frame system building	1995 New Seismic Code 1993 New R/C Code
		RC7	Reinforced concrete dual system building (columns and shear walls)	1995 New Seismic Code 1993 New R/C Code
PREFABRICATED	PF1	PF1	Prefabricated reinforced concrete frame system building	
	PF2	PF2	Prefabricated reinforced concrete shear wall system building	
MASONRY	URM	URM1	Unreinforced masonry buildings, mainly from stone blocks, with wooden roof and without R/C belts or horizontal diaphragms.	
		URM2	Unreinforced masonry buildings, with R/C horizontal diaphragms (floor slabs).	
	UMDB	UMDB	Unreinforced masonry buildings, mainly from stone blocks, with R/C belts and R/C horizontal diaphragms (floor slabs).	
	RM	RM	Reinforced masonry buildings (with horizontal and vertical rebars), mainly from contemporary masonry blocks, with R/C horizontal diaphragms and possibly additional R/C belts.	
	SM	SM	Unreinforced masonry buildings, repaired and strengthened with R/C belts and horizontal diaphragms, and appropriately founded one- or two-sided R/C jacketing of masonry walls.	
	Notes: 1. Belts are horizontal and vertical R/C elements, strongly connected to the walls, with rigid junctions, designed according to contemporary know-how and code provisions for confined masonry. 2. Horizontal diaphragms are continuous R/C slabs, with no significant openings, strongly connected to the walls and to any horizontal and vertical belt system.			
STEEL STRUCTURES		ST1a	Single storey industrial steel buildings	1959 Seismic Code, DIN 1050 (or alternate foreign code)
		ST1b		1995 New Seismic Code Eurocode 3
		ST2a	Multi-storey industrial buildings with space steel frames and/or vertical steel bracing.	1959 Seismic Code, DIN 1050 (or alternate foreign code)
		ST2b		1995 New Seismic Code Eurocode 3
	Note: Steel buildings with R/C shear walls or/and cores are to be treated as the corresponding R/C shear wall buildings.			

(a)

BUILD. COMPLEX:	BUILD.:	
		CODE
SPACE FOR PHOTOGRAPH		
SPACE FOR DRAWING		
SCALE		
REMARKS:		INSP. DATE

(b)

Figure 4. (a) Structural type classification used in the *GEOCHARACTERISATION* program (b) Additional sheet for photos and drawings

A similar refinement has been implemented for unreinforced masonry buildings (URM), classifying them into two subcategories (URM1 and URM2), depending on the existence or not of horizontal diaphragms. The structural type classification used in the present research effort is presented in Fig. 4a, together with the classification proposed by EPPO. It should be noted that the EPPO classification is less detailed since it addresses the inspection of a very large number of public buildings in the whole Greek territory, and a more detailed classification would render the whole effort economically unfeasible. On the other hand, detailed approaches have been implemented in the framework of research programs dealing with rapid visual screening of a less vast number buildings in specific urban areas in Greece (Stylianides 2003a,b, Karakostas et al. 2008, 2009).

In Section E (Fig. 3), data pertaining to factors affecting the seismic vulnerability of the inspected building are included. This is one of the most important sections of the Data Collection form (along with section D), and special care should be given by the inspectors about the data they fill in. The layout of the section and the vulnerability factors included are identical to those provided in OASP's Data Collection form. The data in Section E include information about the following possible issues:

- The inspected building was not built according to any seismic code (i.e. built prior to the first Greek Seismic Code issued in 1959, or with no seismic code provisions)
- The building's importance, according to the Greek Seismic Code has increased, due to change of use and / or the expected seismic hazard
- The building suffered damage to its load-bearing system from past earthquakes and no repair was done based on a repair study
- Poor condition due to inadequate maintenance / poor detailing (e.g. low quality concrete, exposed and/or corroded steel reinforcement, low-strength adobe in masonry buildings, cracks due to settlement etc)
- Possibility of pounding with adjacent buildings (adjacent buildings with inadequate seismic gap, with different floor heights, significant stiffness difference etc.)
- The existence of a "soft storey", i.e. a storey with significantly reduced stiffness or strength compared to the rest building storeys (i.e. the existence of soft storey on ground floor, or a shop without brick infill walls in a RC building etc.)
- For RC buildings, the irregular distribution of brick infill walls (brick infill walls almost symmetrically placed in plan on each floor and for the whole height of the building are deemed as regularly distributed, otherwise they should be regarded as irregularly distributed).
- High-rise building. Prefabricated and masonry buildings with more than two storeys. Reinforced concrete buildings with more than five storeys.
- Vertical irregularities. Buildings with set-back upper storeys with area less than 70% of the remaining storeys.
- Horizontal irregularities. Buildings irregular in plan (e.g. L, E, T and Π shaped, elongated buildings etc.)
- Possibility of torsion. For reinforced concrete buildings, in which the distribution of vertical load-bearing elements in plan is not symmetrical.
- Short columns. Columns in RC buildings which have been designed with the assumption of full-storey height functionality, but which, due to later additions of infill walls up to a certain height, have an active length significantly smaller than that of the story height.
- Two extra fields provided for possible inclusion of further factors in the future

As already described above, the RVS methodology makes use of a scoring system to assess the seismic vulnerability (strictly speaking risk) of each inspected building. Basic structural scores are provided for each structural type, followed by score modifiers that correspond to different seismic hazard and vulnerability factors, which have been recorded in the Data Collection form. The sum of the Basic structural score of a building and the score modifiers that pertain to it lead to a final structural score S, for which a field has been provided in Section E of the data forms. A higher structural score typically corresponds to better seismic performance. A detailed description of the continuous updating of the RVS methodology and the respective scoring procedure up to their present state, falls out of the scope of the present paper and can be found in previous publications of members of the research team (Karakostas et al. 2008, 2009).

Section F (Fig. 3) addresses the issue of the effect of the housing building's dynamic response to the recordings of the accelerograph at its base. This is a complex issue that normally needs detailed and sophisticated case-by-case investigation efforts, however at a first-stage investigation one can note the existence or not of several factors which are known to play an enhanced role, such as the overall size and mass of the housing building, its foundation type, location of the station in a densely built environment (in which case adjacent buildings can also affect the recordings), the position of the accelerograph in relation to the center of rotation of the building etc. Extra fields are provided in the section for the inclusion of further relevant factors.

Finally, the data collection forms are complemented with extra sheets (Fig. 4b) in which space is provided for photos of the inspected building, a map of its location, drawings of a typical floor and a height cross-section of the building, as well as a plan of the building basement in which the location of the installed accelerograph will be marked. All data sheets, photos and drawings will be in electronic form, so that they can be easily incorporated and accessed from the GIS database which will be created for the needs of the current project.

The data collection forms will be used for on-site inspections of the buildings housing the stations at fourteen representative sites of the Hellenic accelerometric station in Greece, which have been selected as a case study for the *GEOCHARACTERIZATION* research project. The collected data can contribute to create an adequate 'structural profile' for each station building, which will allow an experienced engineer to have a primary assessment of its seismic vulnerability and its effect on the recorded response, and thus help him decide for the prioritization of more detailed, second-stage investigations and potential strengthening measures. These second-stage investigations can typically be applied only to the most vulnerable buildings, since they are both time-consuming and costly, involving the development of reliable finite element models of the buildings based on as-built drawings or thorough on-site measurements, investigations of the actual condition of the structural system and steel reinforcement through destructive or non-destructive testing, reliable evaluation of the soil type and its mechanical properties etc.

It should be noted that the research project is still under way, and more detailed results of the application of the proposed methodology will be published after the completion of on-site investigations of the buildings of the stations selected within the project.

CONCLUSIONS

In the present study a comprehensive set of procedures have been applied for the validation of fourteen representative sites of the strong motion accelerometric network of Crete Island in Greece. In order to estimate the site soil conditions for each site of accelerometric stations and to classify them according to the ground types prescribed in EC8 three different approaches have been followed. The first two were based on geological mapping in two different scales, small (1:50000) and large (1:5000) and the third one on geophysical measurements in order to estimate the v_{s30} shear wave velocity at each site. Comparing the results of the investigations, it is found that, as expected, significant variations on the soil category can be observed, depending on the scale of the available geological maps. Furthermore, comparison with more accurate results from geophysical measurements reveals that use even of large-scale maps, can lead to significant over- or underestimation of the soil type at a station site. For a comprehensive validation of the network stations, it is also necessary to assess the seismic vulnerability of the buildings that house the stations, as well as to evaluate the effect of the building's response on the recorded excitation at its base. A multi-stage building investigation methodology is proposed, and a detailed presentation is given of the proposed first-stage rapid visual screening (RVS) procedure. The results of the RVS investigations lead to a quantification of the seismic vulnerability of each inspected building, allowing the prioritization for more detailed, second-stage inspections. The methodology foresees that all data sheets, photos and drawings will be in electronic form, so that they can be easily incorporated and accessed from a GIS database which will contain a comprehensive 'structural profile' of each building that can be used for future investigations beyond the scope of the current research effort.

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