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SEISMIC RISK ASSESSMENT OF NICOSIA, CYPRUS

Christis CHRYSOSTOMOU [1], Ted ALGERMISSEN[2], Albert ROGERS[3], Themos DEMETRIOU[4]

SUMMARY

This report presents the results of a seismic risk assessment study for the city of Nicosia, Cyprus. The study was conducted with the support of the Bi-communal Development Programme, which is funded by USAID and UNDP and is executed by UNOPS. The study area consisted of 223 square kilometers covering the southern portion of the Nicosia urban area. The number of buildings is about 50,000 with a footprint and total area of about 12 million and 22 million square meters, respectively. The objectives of this study were a) to develop an inventory of buildings within the study area, b) to establish the vulnerability of these buildings to various levels of earthquake ground shaking, and c) to estimate the maximum possible earthquake losses that might occur in the study area (catastrophe potential) and average annual earthquake loss. An innovation of this project was that the plan area of the buildings was digitized from satellite images of 1m resolution. The vulnerability of the buildings was obtained by using the European Macroseismic Scale 98 (EMS 98) that classifies earthquake damage into vulnerability classes for various types of structures and various grades of damage. The cost of replacement for the various classes of buildings and different grades of damage was estimated using the descriptions of actual damage in the EMS 98, which compared well with actual data from earthquakes that have occurred in Cyprus. Vulnerability curves for various building classes were defined, which are presented along with the spatial distribution of damage in the study area for various intensities. A reasonable average annual loss of $2.3 million per year, or about 0.016 percent of the total replacement cost of all buildings in the study area, was estimated. For a range of EMS 98 intensities from V to X, occurring throughout the study area, the estimated losses in replacement costs range from $800,000 to $2,700,000,000. The maximum replacement cost losses in a single large damaging earthquake affecting the study area range from $300,000,000 to $1,000,000,000, depending upon the location and magnitude of the earthquake assumed.

INTRODUCTION

One of the principal objectives of the Bi-communal Development Programme (BDP) sponsored study of earthquake hazard and risk in Cyprus was the simulation of future earthquake losses in the Nicosia Study Area, which covered both the north and south urban areas of Nicosia. In this paper Nicosia Study Area means the 223 square kilometers covering the south portion of the Nicosia urban area. The simulation of

[1] Lecturer, Higher Technical Institute, Nicosia, Cyprus. Email: christis@spidernet.com.cy
[2] GeoRisk Associates, Inc., Golden, CO, USA. Email: stageorisk@aol.com
[3] GeoRisk Associates, Inc., Golden, CO, USA. Email:albertrogers@att.net
[4] President, Technical Chamber of Cyprus, Nicosia, Cyprus. Email: t.demetriou@cytanet.com.cy

earthquake losses is the principal basis for the development and implementation of a wide range of planning, zoning, and building ideas that should provide Nicosia with greater safety protection and lower economic losses in the event of a future earthquake that might affect the city. A key and important question that arises in the planning and development of an urban area is: "If earthquakes present a risk of economic loss to the Nicosia area, what are the characteristics and extent of the losses that might occur?" While seismic hazard studies of urban areas are increasingly common, it is not so common to apply hazard results to estimate future earthquake losses. Without the estimation of the nature and extent of future losses, it is more difficult to improve emergency relief measures, land use planning, and the seismic provisions of building code in order to mitigate the effects of possible future earthquake losses.

Earthquake loss (risk) assessment consists of three elements: a) an inventory; b) vulnerability relationships; and, c) an earthquake hazard model. Inventory is defined as the geographical distribution and description of things at risk that are included in the study. Vulnerability is defined as the relationships between the hazard assessment and the inventory that result in losses. Vulnerabilities may be developed for anything at risk (buildings, lifelines, population, etc), although, in practice, vulnerability may be an exceedingly difficult parameter to determine. The earthquake hazard model or models used depends on the kind of risk simulation or assessment required. In the following sections of the paper the above three elements as have been developed for this study are presented.

INVENTORY OF BUILDINGS

The important considerations for inventory development to be used for loss estimation are: a) definition of classes of buildings representative of the built environment; b) development of a method that isolates the parameters of the inventoried items that are important in the determination of earthquake damage; c) selection of an inventory technique that can be accomplished in the time available and which still provides the parameters important in loss estimation.

Classes of buildings

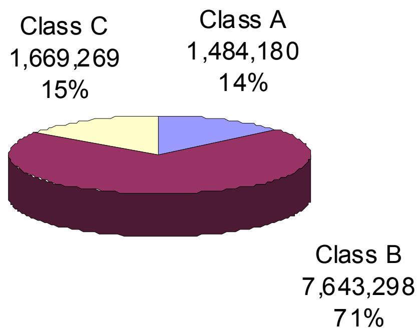
Three building classes were identified and defined as: Class A – traditional buildings made of adobe, stone or unreinforced brick; Class B – one and two story reinforced concrete frame structures; and, Class C – reinforced concrete structures with heights greater than two stories.

The above three classes include almost all of the structural types found in the Nicosia Study Area. Excluded from this study are government buildings, large industrial – commercial steel frame buildings, national monuments, and historical and religious buildings. An especially important feature of the above building classification is that it fits very well into the classification of buildings used in the "European Macroseismic Scale 1998 – EMS-98" [1], and they could be therefore assigned into a vulnerability category according to EMS-98.

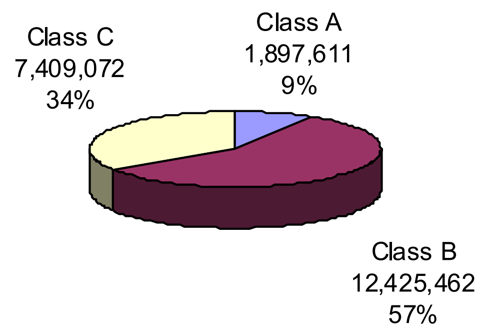
Methodology for obtaining the inventory

A relatively new technique for inventory development was used for the inventory assembled for this project. Satellite photography with a resolution of slightly better than one meter was obtained for the Nicosia Study Area. The photographs were used in the field at a scale of 1:5000 to identify buildings and separate the buildings into the three classes. For field study purposes, the Nicosia Study Area was broken into one kilometer grid squares, which were further subdivided into one hundred sub-grid squares. The inventory was assembled in each of the one kilometer squares. An important additional tool available with the satellite photography was that the number and footprint area of every building was digitized and tabulated for each square kilometer of the study area. Overlays showing the outline of each building were available for each photograph.

A drive-through observation of the buildings was conducted for each square kilometer of the study area by four teams consisting of two engineers each. Estimates of the percentage of Class A, Class B and Class C buildings, together with the estimates of the building heights in the three building classes, were tabulated for each square kilometer of the study area. The percentages of each building class in each square kilometer and the known total footprint areas of buildings in each square kilometer formed the basis for the inventory. The end result of the inventory was the distribution of the total floor space for each of the three classes of construction for each square kilometer of the study area. The number of buildings is about 50,000 with a footprint and total area of about 12 million and 22 million square meters, respectively. The footprint and total area for each building class are shown in Figure 1.



(a)



(b)

Figure 1. (a) Footprint area (m^2) per building class, (b) Total area (m^2) per building class

VULNERABILITY

Vulnerability defined for this study, is the percentage cost of replacement of buildings in each of the three classes of construction, identified above, for levels of damage specified in the EMS-98. In order to arrive at these figures the replacement cost per square meter for each of the five Grades of damage specified in EMS-98 were first obtained for each building class. Then, based on the detailed description of the expected level of damage for each intensity, the percentage cost of replacement of buildings in each of the three classes was estimated. The procedures followed to establish the vulnerability of the building stock are explained below.

Replacement cost

Two methodologies were followed to establish the replacement cost for each building class for each grade of damage. In the first, a search was made in the archives of the Cyprus Earthquake Rehabilitation Service, which contained files of buildings damaged by the earthquakes of 1995, 1996 and 1999 that occurred in Cyprus. From this search a number of buildings were identified as conforming to the EMS-98 description of damage levels. The estimate of replacement value made by the Earthquake Rehabilitation Service engineers was divided by the area of the building to obtain a normalized replacement cost per square meter. In the second methodology, a "typical" building was postulated for each of the building classes and damage was described for various parts of the building to conform to the descriptions of the EMS-98 damage levels. By pricing these damage descriptions a replacement value for the damage was reached, which was then divided by the building floor area to get a normalized replacement cost per square meter. The results of the two approaches are presented in graphical form in

Figures 2 and 3. The replacement cost is reported in Cyprus pounds. The dollar values reported in the rest of the paper are based on a conversion rate of 1.67 dollars per Cyprus pound which was valid for the period of the study. Comparison of the two approaches shows that they give very close results.

It should be noted that in deriving the costs of replacements there was no typical case of collapse in the earthquakes considered and thus estimates of Grade 5 damage were based on a market replacement value assessment for the case of actual earthquake data, i.e. CY£350 per square meter ($583) for traditional buildings and CY£400 per square meter ($667) for concrete frame construction. Estimates according to the descriptions in the EMS-98 were based on the replacement value of the postulated components of the "typical" building. In addition, only one concrete frame building that suffered more than Grade 3 damage was found in the actual earthquake data. It was taken as Grade 4 damage although it was felt that it was more of a borderline case.

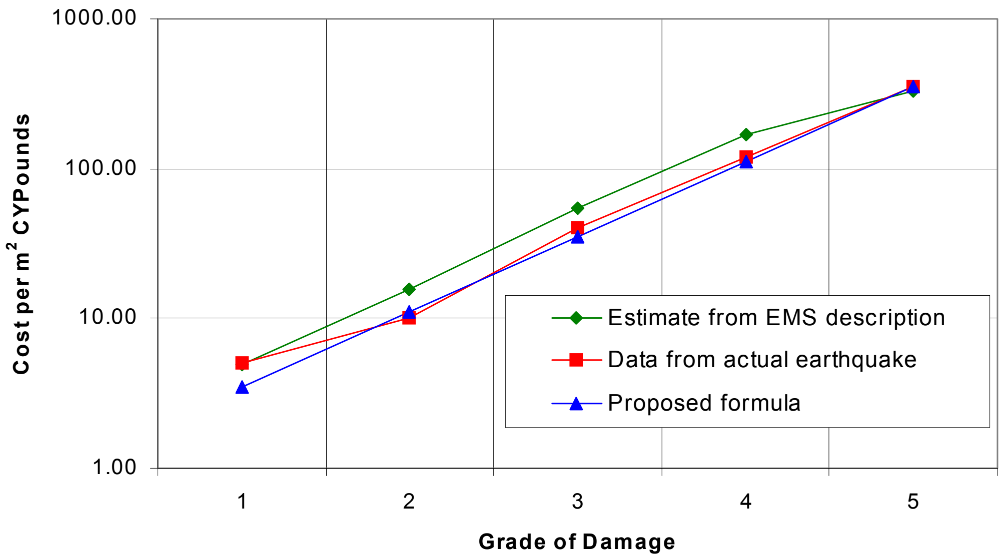


Figure 2. Cost of replacement for Class A buildings

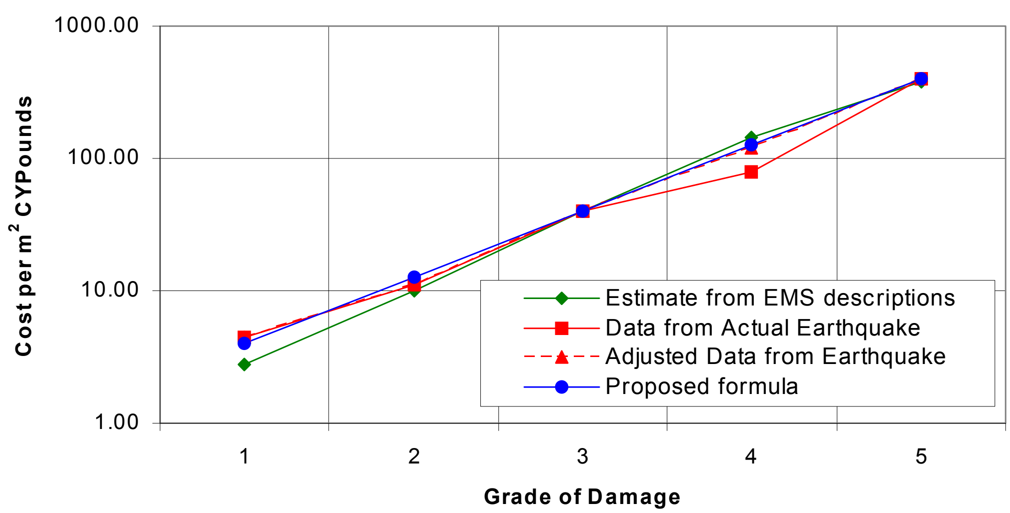


Figure 3 Cost of replacement for Class B and C buildings

Based on the results of this study, two formulae are proposed for calculating the cost of replacement: for traditional buildings $C = 1.85 \times 10^{G/2}$, and for concrete frame buildings $C = 2.10 \times 10^{G/2}$, where C is the cost of replacement per square meter in US dollars and G the damage Grade as defined in EMS-98 (1 to 5).

Damage factors

In the EMS-98, building damage begins to appear at intensity degree V and continues through degree XII (total destruction). From a practical point of view, for the Nicosia Study Area it was necessary to evaluate damage only for degrees V through X, since degrees above X were estimated as not being realistically possible for Nicosia. Nevertheless, the damage for intensity degree XI is also reported.

The first step in obtaining the damage factors was to relate the building classes defined to the vulnerability classes specified in EMS-98. After comparing the EMS-98 descriptions with the building stock of Nicosia it was decided that 20% of Class A buildings be assigned to Vulnerability Class A and 80% to Vulnerability Class B, 40% of Class B buildings to Vulnerability Class C and 60% to Vulnerability Class D, while 60% of Class C buildings be assigned to Vulnerability Class C and 40% to Vulnerability Class D. Since the accuracy of this assignment depends on subjective judgment, a sensitivity study was performed to investigate the effects of the variation of these percentages, which has shown that the final results are not affected to a great degree.

Average values were taken for the definitions "few" (0 to 15% was taken to mean 7.5%), "many" (15 to 55% was taken to mean 35%) and "most" (more than 55% was taken to mean 77.5%) used by the EMS-98 to define the Grade of damage for each intensity and vulnerability class. Based on the descriptions a table was generated (Table 1) which shows the percentages of buildings in each vulnerability class expected to suffer the specified grade of damage. It should be noted that the numbers in bold are not specified by the EMS-98 scale, but they were calculated to reach 100%. The only problem with this approach appears in the last row of Table 1 for Vulnerability Class C in which a negative percentage is obtained for no damage. This does not affect the results of this study since no such case was encountered.

Using the relationships established as explained above and the damage description for each intensity in the EMS-98, the cost of replacement relationships were developed, which are shown in Figure 4. The total replacement values for the three classes of buildings were estimated as follows: for Class A $1,106,939,532, for Class B $8,283,641,625 and for Class C $4,939,381,149. Using these figures and the data in Figure 4, the "damage factors", which means the percentage cost of repair (for each degree of intensity) required to return a structure to its pre-earthquake condition, were calculated. These are listed in Table 2 and plotted in Figure 5.

Table 1. Damage descriptor per grade of damage and vulnerability class.

VULNE-RABILI-TY CLASS	NO DAMAGE	DAMAGE DESCRIPTOR AND MEAN(%)				
		GRADE 1	**GRADE 2**	**GRADE 3**	**GRADE 4**	**GRADE 5**
A	92.5%	7.5% (Few)	-	-	-	-
B	92.5%	7.5% (Few)	-	-	-	-
C	100.0%	-	-	-	-	-
D	100.0%	-	-	-	-	-
A	57.5%	35%(Many)	7.5% (Few)	-	-	-
B	57.5%	35%(Many)	7.5% (Few)	-	-	-
C	92.5%	7.5% (Few)	-	-	-	-
D	100.0%	-	-	-	-	-
A	0.0%	-	**57.5%**	35%(Many)	7.5% (Few)	-
B	0.0%	**57.5%**	35%(Many)	7.5% (Few)	-	-
C	57.5%	**35%**	7.5% (Few)	-	-	-
D	92.5%	7.5% (Few)	-	-	-	-
A	0.0%	-	-	**57.5%**	35%(Many)	7.5% (Few)
B	0.0%	-	**57.5%**	35%(Many)	7.5% (Few)	-
C	0.0%	**57.5%**	35%(Many)	7.5% (Few)	-	-
D	57.5%	**35%**	7.5% (Few)	-	-	-
A	0.0%	-	-	-	**65%**	35%(Many)
B	0.0%	-	-	**57.5%**	35%(Many)	7.5% (Few)
C	0.0%	-	**57.5%**	35%(Many)	7.5% (Few)	-
D	0.0%	**57.5%**	35%(Many)	7.5% (Few)	-	-
E	57.5%	**35%**	7.5% (Few)	-	-	-
A	0.0%	-	-	-	**22.5%**	77.5%(Most)
B	0.0%	-	-	-	65%	35%(Many)
C	0.0%	-	-	**57.5%**	35%(Many)	7.5% (Few)
D	0.0%	-	**57.5%**	35%(Many)	7.5% (Few)	-
E	0.0%	**57.5%**	35%(Many)	7.5% (Few)	-	-
F	57.5%	**35%**	7.5% (Few)	-	-	-
A	0.0%	-	-	-	-	**100%**
B	0.0%	-	-	-	**22.5%**	77.5%(Most)
C	**-12.5%**	-	-	-	77.5%(Most)	35%(Many)
D	0.0%	-	-	**57.5%**	35%(Many)	7.5% (Few)
E	0.0%	-	**57.5%**	35%(Many)	7.5% (Few)	-
F	0.0%	**57.5%**	35%(Many)	7.5% (Few)	-	-

Table 2. Damage factors (fractional part of replacement cost) for the study area

Damage factors for various Building Classes at specific Earthquake Intensity							
	European Macroseismic Scale Intensity						
	V	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**
Class A	0.08%	0.59%	3.48%	11.02%	30.60%	61.42%	87.70%
Class B		0.03%	0.28%	1.30%	4.47%	14.31%	38.46%
Class C		0.05%	0.38%	1.66%	5.51%	17.66%	45.51%

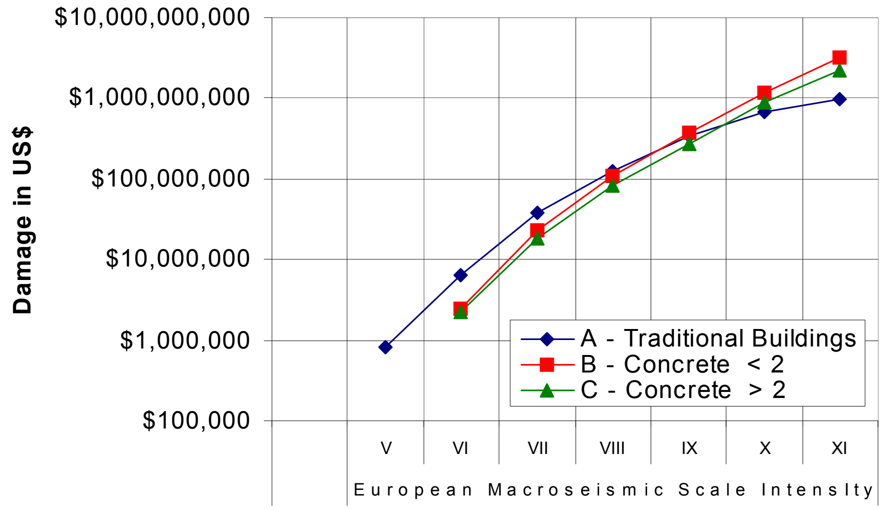


Figure 4. Cost of replacement per building class

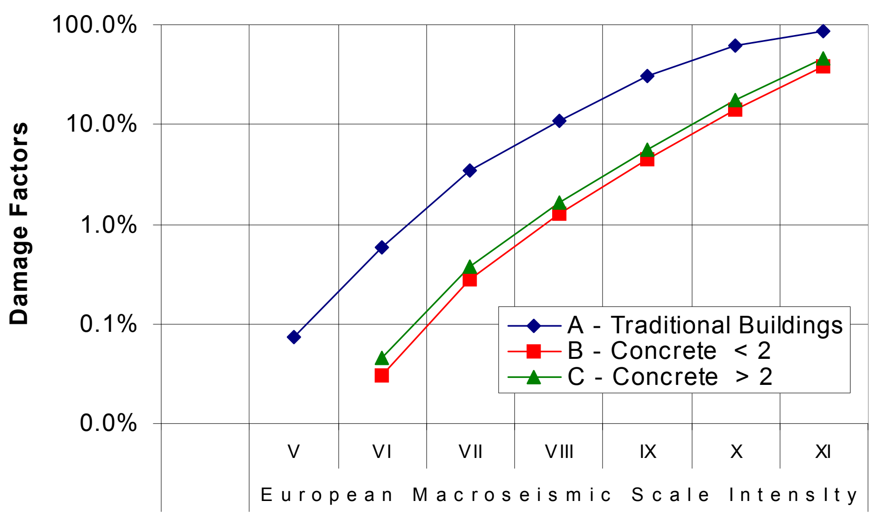


Figure 5. Damage factors of building classes for various intensities

Distribution of damage according to class of building

It can be observed from Figure 5 that there is a logarithmic relationship between the damage factors and the earthquake intensities. Class A buildings, which are the most vulnerable of all the classes, suffer damage for all intensities with the largest damage factor of 88% occurring at intensity XI. The damage factors for Classes B and C are about the same, with the ones for Class C being slightly larger. At intensity XI the damage factors are 39% and 46% for Classes B and C, respectively.

Although Class A buildings will suffer most of the damage, the cost of replacement for the other classes is much larger in higher intensities. This is obvious from the pie-charts in Figure 6 each of which represents the apportionment of damage among the three classes for a given intensity. Class A buildings are shown in blue, Class B in red and Class C in yellow. At low intensity levels the majority of damage is concentrated in traditional buildings. As intensity increases, concrete buildings increase their share of damage. Thus, at Intensity V the damage is exclusively among traditional buildings while at intensities VIII through X damage is evenly distributed among the three building classes. At intensity XI, half of the total damage comes from Class B buildings (concrete frame, one or two storeys) while damage from Class A (traditional buildings) is barely one sixth of the total.

Figure 6. Distribution of damage according to Class of building for various intensities

Geographic distribution of damage

Geographic distributions of damage for each building Class were also plotted for the Nicosia Area and are shown in Figures 7, 8 and 9. In these figures it is clear that the distribution of damage is reflecting the distribution of building types. Thus, traditional buildings present damage concentration in city centers and old village neighborhoods (Figure 7) while low rise buildings display a more evenly distributed damage pattern (Figure 8). Strong concentration of damage, mainly in the Nicosia City center, is also displayed by the plot for the high rise buildings (Figure 9). All the Figures were obtained for Intensity VIII and using the same scale dot of ten million US dollars for comparison purposes.

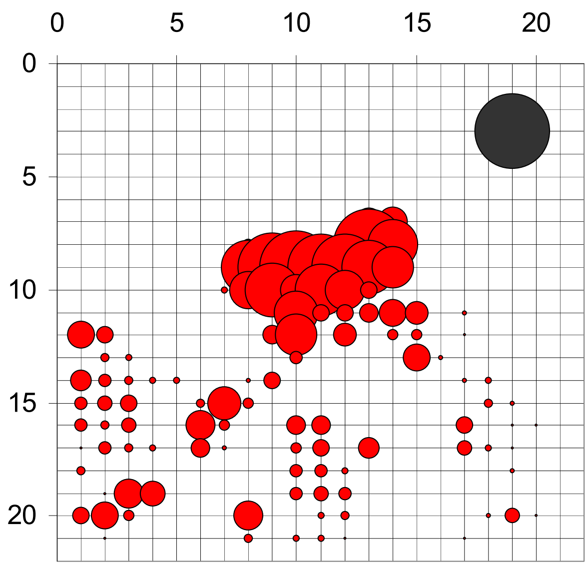


Figure 7. Class A damage distribution

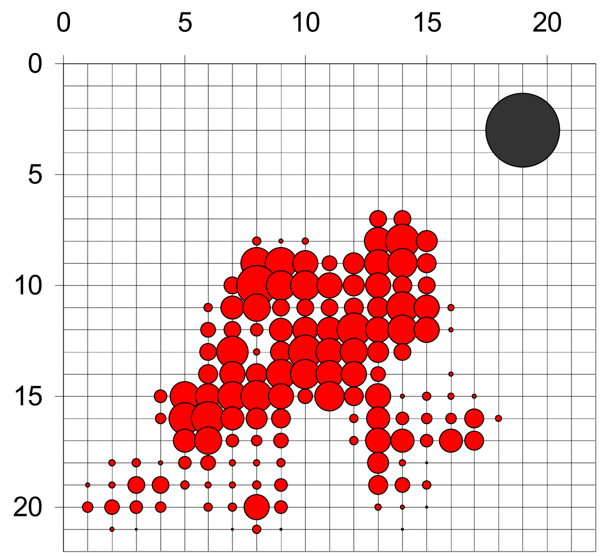


Figure 8. Class B damage distribution

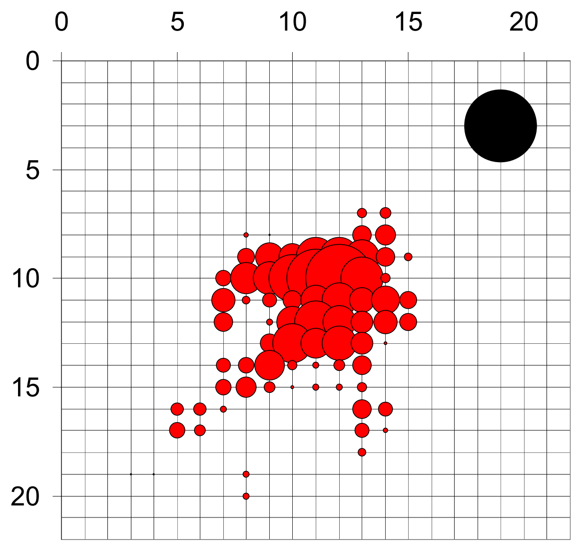


Figure 9. Class C damage distribution

LOSS ESTIMATES

Objective

The overall objectives of this loss study were to provide a general idea of the total replacement cost of the inventory developed, to present the losses that might be expected if the city experiences intensities V through X, and to estimate the possible future earthquake losses to Nicosia using two useful measures of loss: a) the maximum (catastrophe) earthquake losses that might affect the city over a long period of time; and b) the average annual earthquake losses that the city may experience when considering losses sustained over a long period of time.

Replacement value of the inventory at risk

Table 3 summarizes the replacement value of the three building classes studied in this report. It should be understood that the dollar values in Table 3 represent a special definition of value. The replacement values in Table 3 and elsewhere throughout this report do not include the land value beneath each building. They represent the cost of repairing damage to structures and not the cost of constructing a new building of modern design where the building damaged may be modern or obsolete. This type of building valuation is called the cost of repairing in kind.

The values in Table 3, and other tables, represent the replacement cost as it existed at the time of the inventory development in mid-2002.

Table 3. Replacement costs by class of construction

Class of Construction	Replacement Cost dollars ($)
A	1,106,939,532
B	8,283,641,625
C	4,939,381,149
Total	14,329,962,306

Distribution of losses for various levels of intensity

Table 4 presents the earthquake losses if Nicosia experiences intensities of V through X uniformly throughout the city. It represents a departure point for the assessment of losses using any possible scenario earthquakes simulation.

Table 4. Distribution of losses by intensity

Intensity (EMS-98)	Loss, dollars ($)
V	830,204
VI	11,191,200
VII	79,792,586
VIII	310,988,923
IX	981,172,186
X	2,737,447,300

Maximum (catastrophe) potential losses

Estimates of the maximum earthquake losses were developed by calculating the losses associated with large earthquakes that might possibly occur and affect Nicosia. The earthquakes selected for loss simulation are of slightly larger magnitude than are known in the historical record. Two earthquakes were selected for loss simulation: a) a magnitude Ms=8.0 offshore South of Cyprus and b) a magnitude Ms=6.5 earthquake that might occur anyplace within Nicosia. The location and characteristics of these two earthquakes are listed in Table 5. The magnitude Ms=8.0 earthquake was located off the South shore of Cyprus based on the historical seismicity of Cyprus. The seismicity of Cyprus is greatest offshore to the South of the island and earthquakes as large as magnitude Ms=7.0 – 7.25 are known to have occurred historically. However it should be noted that magnitudes of earthquakes occurring prior to about 1900 are only know approximately, and are based on the distributions of damage on Cyprus and effects throughout the eastern Mediterranean. The simulation of the effects of this Ms=8.0 earthquake is meant to be representative of the largest earthquakes that might reasonably occur in the diffuse crustal boundary area between the African and Eurasian plates present off the South coast of Cyprus. A recent review of the seismicity of Cyprus is given by Rogers and Algermissen [2].

Table 5. Maximum (catastrophe) potential loss estimates

Earthquake Location	Magnitude (Ms)	Distance from Nicosia	Intensity in Nicosia	Losses in dollars($)
34.30° N. lat.; 33.00° E. long.	8.0	85 – 113 km.	VIII	310,988,923
Anywhere in the Nicosia Study Area	6.5	Within the study area	IX	981,172,186

A moderate (Ms=6.5) earthquake that might occur within Nicosia was selected on the basis of the results of geological studies in Nicosia. Several faulting events ranging in age from Holocene to Quaternary and older have been identified on faults within Nicosia (Harrison [3]). No historical earthquakes of magnitude Ms = 6.5 or greater are known to have occurred within Nicosia, but the Holocene faulting discovered in Nicosia that has associated surface faulting of the order of 10-15 km suggests that an earthquake with Ms=6.5 occurred in Nicosia at least once within the past 10,000 years. Thus, an Ms = 6.5 magnitude event within the study area is simulated as a maximum magnitude earthquake that might occur in the study area over a long period of time. The exact location of the epicenter of the simulated earthquake in Nicosia is not critical since magnitude-intensity relationships indicate that an intensity of IX (EMS-98) would be associated with such an earthquake, and this intensity would occur over the entire city.

Average annual losses and results

The damage that would be associated with earthquakes in the historical record in the time period 1303AD to the present that affected Nicosia causing intensities of V or greater in the Nicosia area were modeled. Table 6 summarizes the occurrences of intensity VIII over the period 1303 through 2001, intensity VII over the time interval 1480-2001, intensity VI over the time interval 1845-2001, and intensity V over the time interval 1894-2001. Intensities greater than VIII are not known to have occurred historically in Nicosia. The intensities in these time intervals are assumed to be completely reported. For each of these time intervals, the average annual rates of occurrence of intensities V through VIII were calculated. These results are shown in Table 6. The losses associated with these simulations formed one model for the determination of the estimates of the long term average annual earthquake loss in Nicosia. Accounts of earthquake effects in Cyprus extend back for at least the last 2000 years. The most complete studies of earthquake effects and seismicity are those of Ambraseys [4,5,6]. He presents accounts of earthquake effects and observed damage, but does not assign intensities. The EMS-98 intensities assigned here are based principally on our interpretation of Ambraseys [4,5,6] and Solomi's [7] accounts of damage and other earthquake effects.

Table 6. Historical earthquakes resulting in Intensity V (EMS - 98 Intensity Scale) or greater in Nicosia for the period 1303 AD – 2001 AD. Summary of results

Intensity	No. of Times Observed	Historical Time Interval Considered	Time Interval (Years)	Rate per Year	Average Return Period (Years)
VIII	3	1303-2001	698	0.0043	233
VII	4	1480-2001	521	0.0077	130
VI	8	1845-2001	156	0.0513	20
V	13	1894-2001	107	0.1215	8

Table 7 lists the average annual losses simulated using the historical record of earthquake effects in Nicosia over the past 698-107 years (Model 1), as already discussed. The average annual loss in this model ($2,624,020/year) represents about 0.0183 percent loss per year of the total value of buildings in the study area.

Table 7. Average annual loss estimates (Model 1)

Intensity	Number of times observed	Time interval (years)	Losses/yr dollars ($)
VIII	3	698	1,336,629
VII	4	521	612,611
VI	8	156	573,914
V	13	107	100,866
Total			2,624,020

Table 8 represents the result of a second simulation for average annual loss (model 2). This model is called the "lower bound" model because it assumes that all of the intensity assignments for ground shaking in the study obtained from the historical record of earthquakes are too large (are in error) by one intensity degree. Damage data from historical earthquakes are always less than complete, and are frequently exaggerated (particularly in accounts of ancient earthquakes), some of the intensity assignments may be too high. Since it is almost certain that all of the intensity assignments are not in error by one intensity degree, this model surely represents a lower bound to possible future losses. The $474,444 annual loss represents only 0.0033 percent of the total value of buildings at risk, or 18 percent of the annual losses found in the first model discussed.

Table 8. Average annual loss (lower bound estimate, Model 2)

Intensity	Number of times observed	Time Interval	Losses/yr ($)
VII	3	698	342,948
VI	4	521	85,921
V	8	156	45,575
Total			474,444

Table 9 represents the third model used to simulate average annual loss. In this third model, intensities derived for earthquakes prior to 1894 are considered unreliable or incomplete. Only intensity observations for shocks in the past 108 years are used to establish the average annual rate of loss for the study area. Clearly, accounts of more recent earthquakes are more accurate than accounts of older shocks. The liability in using a shorter historical earthquake history to determine an average annual rate of shaking is that the interval may be too short to include large earthquakes with long return periods. This model contains no earthquakes causing intensity VIII in the study area, as intensity VIII has not been reported in Nicosia in the 20th century. This model produces an annual rate of loss of $1,984,374, or approximately 0.0138 percent of total value per year.

Table 9. Average annual loss estimates, shortened historical record (Model 3)

Intensity	Number of times observed	Time Interval	Losses/year ($)
VII	2	108	1,477,640
VI	4	108	414,489
V	12	108	92,245
Total			1,984,374

The three models discussed present three possible views of the average annual loss from earthquakes that might affect Nicosia. Many other seismicity models may be assembled using the inventory and vulnerability relationships developed in this paper. Model 3 gives a lower rate than Model 1 and is based on a shorter historical record of earthquakes. Some researchers, for example Ambraseys [6] believe that seismicity in the Cyprus area has been substantially lower since about 1900. This is reflected in the Model 3 results, which are based principally on 20th century seismicity and give a lower average annual loss. Model 1, which is based on a much longer historical record of earthquake ground motions, yields a larger average annual loss for the study area. Since the longer historical record used in Model 1 may be, at least for the lower intensities, incomplete, the average annual loss could be even higher than given in the three models. An average annual loss based on an average of the losses estimated in model 1 and model 3 with less weight being given to model 2, is about $2.3 million US dollars per year. A conservative annual loss, taking into account the preceding discussion, might be of the order of $4 million US dollars per year. These variations in the average annual loss based on different interpretations of the historical seismicity provide some information as to the level of uncertainty associated with variations in the seismicity assumptions only. The variations in the loss estimates are larger if uncertainties in the vulnerabilities and inventory are considered.

SUMMARY

The work reported here presents a number of results. The following are of special interest.

- A detailed inventory of nearly the total building stock in Nicosia has been assembled using high quality satellite photography.
- Vulnerability relationships for the three principal types of buildings have been developed making use of earthquake damage data available in Cyprus
- The replacement cost of Class A, B and C type buildings in Nicosia is about $14.329 billion US dollars.
- The earthquake losses in Nicosia associated with a magnitude 8.0 earthquake off the South shore of Cyprus is about 2.17 percent of total building value, or about $311 million US dollars.
- The loss in Nicosia associated with an Ms=6.5 earthquake that might occur in Nicosia is about 6.85 percent of value, or about $981 million US dollars.
- A reasonable average annual loss rate associated with future earthquakes that might cause damage in Nicosia is about 0.016 percent of the total value of Class A, B, and C buildings in Nicosia, or about $2.3 million US dollars.

The estimates of earthquake losses presented in this report provide significant information for earthquake disaster management and relief, land use planning and building code considerations. The risk assessments presented here are in general agreement with the known seismicity of the area and with risk estimates made in other parts of the world. Both the estimates of catastrophe potential and average annual loss provide important data which should be considered in any economic development planning undertaken.

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