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Abstract

Increased resilience is a strategic objective of the European strategy for disaster management, particularly concerning the protection urban areas. For the assessment of the seismic resilience of urban areas, three components are essential: a description of the hazard, an inventory of the exposed assets and an accurate estimation of their vulnerability. Exposure data have been collected during the national housing censuses and within the framework of research projects dealing with seismic risk or with the energy performance of buildings. These sources of information are reviewed with focus on the building characteristics of interest for seismic risk assessment and the space resolution. The inventories compiled within research projects contain data aggregated at the level of countries, which is not sufficient for seismic risk assessment. They were inferred from a variety of sources that present notable divergences and they do not account for the distribution of buildings in small geographical units, which is proven to influence the loss estimates. On the other hand, housing censuses cover the important building features for several countries and may be aggregated at the desired geographical areas. However, a significant effort is required to collect and elaborate the census data.

1. Introduction

Increased resilience is a strategic objective of the European strategy for disaster management¹, which calls for a qualitative shift from reacting to emergencies to a more proactive role of prevention and preparedness. Besides, prevention is more cost-effective and can be a driver for economic growth. Furthermore, the protection and refurbishment of urban areas deserves particular attention², owing to their potential for economic growth – 67 % of Europe’s GDP is generated in metropolitan areas – and energy efficiency in the transport and housing sector, as well as because of their high vulnerability to natural and man-made disasters.

In the global context, the recently adopted Sendai Framework (UNISDR 2015a) aims to prevent new and substantially reduce existing disaster risk and losses through, among other measures, the reduction of exposure and vulnerability. Across the world, the rapid and unplanned urbanisation together with the construction in hazard-prone areas are seen as aggravating factors as regards expected losses due to natural hazards.

The extent of the problem in Europe becomes evident in Fig. 1, which presents the results of a probabilistic risk model. The map depicts the expected average annual losses due to multiple hazards, in particular, earthquakes, floods, cyclones and tsunamis.

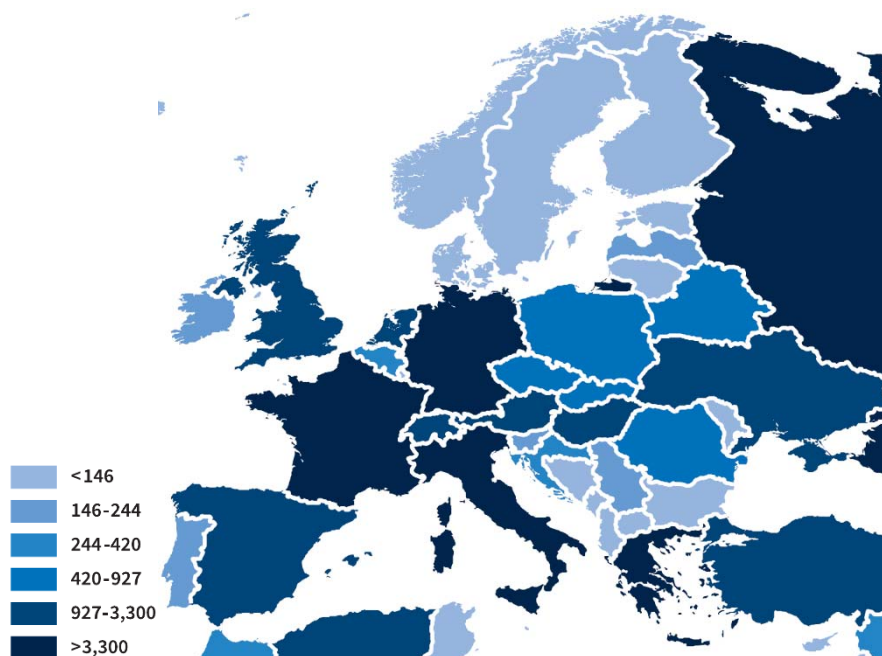


Fig. 1 Multi-hazard average annual loss in million \$, adapted from UNISDR (2015b)

Keeping the above in mind, the RESURBAN institutional project was launched at the Joint Research Centre. It deals with the resilience of the buildings in urban areas across the European Union, with focus on regions of moderate-to-high seismicity. The objective is to provide scientific support for decision-making as regards, at the first step, the seismic retrofit of existing buildings. The second stage of the project will examine the scope, synergies and conflicts in retrofitting the building stock for the dual purpose of improving

¹ Communication from the Commission to the European Parliament and the Council. Towards a stronger European disaster response: the role of civil protection and humanitarian assistance. COM(2010) 600 final

² Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. The urban dimension of EU policies – key features of an EU urban agenda. COM(2014) 490 final

their environmental and seismic performance, the former mainly related to energy consumption.

The project employs established probabilistic methods for the assessment of the earthquake risk. The fundamental components include the hazard, exposed assets and their vulnerability. The seismic hazard is described by the results of a recent study that is based on harmonised data across Europe (Woessner et al 2015). The – conditional on seismic intensity – probability of damage of buildings is described by fragility curves that are selected among those available in the technical literature according to a set of criteria, so as to better represent the building stock in different geographic regions (Maio 2015). Unfortunately, detailed and harmonised information on the exposed structures is still not widely available.

Exposure data have been collected for a number of individual cities around Europe, often at a high degree of geographic discretisation. Information on the building stock has been also collected within the framework of research projects aiming at the assessment of the energy performance of buildings, in this instance, aggregated at much larger areas with similar climatic conditions. Another significant source of detailed information on the building stock, albeit not fully harmonised across countries, are the national housing censuses. In this report, the above-mentioned databases are reviewed and compared in order to investigate their compatibility and to examine the possibility of making use of them in the framework of seismic risk assessment of large urban areas in Europe.

2. Requirements for building inventory

The building inventory should be compatible, on one hand with the data on the seismic hazard and on the other with the available fragility curves. As regards the hazard, the SHARE seismic map (Woessner et al 2015) has a high resolution, which will probably be scaled up. Fragility curves are developed either for individual structures or for classes thereof, which are characterised by the main attributes that are important for the seismic vulnerability of buildings. For risk analysis at large geographic areas it is only feasible to consider classes of the exposed assets, i.e. the buildings for the purpose of the RESURBAN project, and therefore a system for classification of buildings according to a set of underlying principles, or a taxonomy, is needed.

HAZUS (FEMA 2010) is a comprehensive tool for multi-risk analysis developed in the USA. With a view to seismic vulnerability, it foresees four main attributes for buildings: material (wood, steel, reinforced and precast concrete, reinforced and unreinforced masonry), structural lateral-load resisting system or (e.g. braced frames, reinforced concrete walls, type of floors in masonry buildings), height (low-, mid- and high-rise buildings) and seismic design level (high, moderate-, low- and pre-code design). The first three attributes are used to define a total of 36 building classes.

Similar classification systems were proposed in the frame of European research projects, with focus on the specifics of the European building stock. The most recent one reviewed previous work, detected some drawbacks and developed an expandable and collapsible taxonomy for buildings and other exposed assets. The modular SYNER-G taxonomy (Hancilar and Taucer 2013) makes use of main categories, organised in a hierarchical order, and of secondary ones. The main categories comprise the material, lateral force resisting mechanism, detailing, floor and roof system, seismic code level, etc. Secondary categories serve to expand the taxonomy in order to accommodate additional information, where it is available.

The INSPIRE Directive³ provides general rules aimed at the establishment of the infrastructure for spatial information in the European Community, for activities related to the environment. Datasets on the geographical location of buildings and the earthquake hazard are within the scope of INSPIRE. In addition, the thematic working group on buildings assigns key importance to buildings because of the requirements for safety (protection from risks), health (protection from noise and air pollution), the consumption of natural resources (heating, land, raw materials for construction) and also because of their historical and architectural value. Further to these areas, the building dataset is essential for a wider range of uses, as described in Fig. 2.

The INSPIRE building taxonomy is organised in schemes with increasing degree of detail. The simplest scheme includes information on the condition and date of construction, demolition and renovation, use, height and number of floors above ground, and number of dwellings and building units. The basic scheme can be extended to comprise the building footprint or the tri-dimensional prism made up of the walls and roofs. Similarly to the SYNER-G taxonomy and depending on the availability of information, the scheme may be further enriched³ with the construction and façade material, installations such as chimneys and balconies and the connection to utilities.

Among the building features discussed above, the construction material (steel, concrete and masonry are the most common in the seismic-prone regions of Europe) and period of construction, the latter used a proxy for the seismic code used for the design of the building, have a fundamental influence on the vulnerability of buildings. Moreover, the building height is also important, particularly for older construction, as higher buildings are in general more vulnerable to earthquakes.

³ Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE)

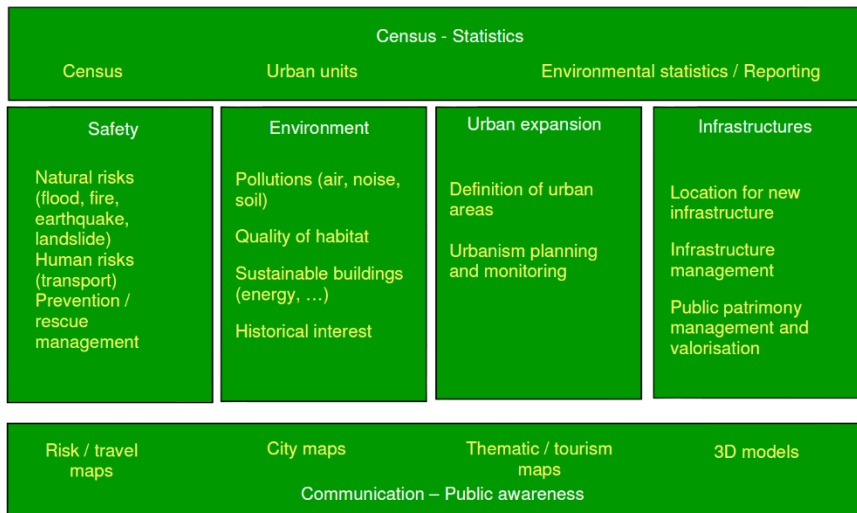


Fig. 2 Possible areas of use for the buildings theme in INSPIRE (TWG BU 2013)

In summary, the building inventory that serves the purpose of the RESURBAN project should comply with the following requirements:

- The taxonomy should account for the material, year of construction (in periods corresponding to different seismic codes – no/low-level, medium-level and high-level – possibly varying by country) and height or number of storeys (in classes corresponding to low-, mid- and high-rise buildings).
- The data need to be aggregated at local administrative, i.e. municipalities, or smaller units.

3. Review of databases of the European building stock

3.1 Introduction

There are three main sources of information on the European building stock. The first two were developed for research purposes, either regarding energy efficiency or seismic risk assessment. As anticipated, buildings have a high potential for improving the energy efficiency and therefore, there have been numerous research projects that collected data on buildings in different climatic zones across Europe. On the other hand, seismic risk assessment studies have been performed mainly for individual metropolitan areas. The third source of data are the national censuses that collect, at regular intervals, information on the building stock – albeit not completely harmonised across countries.

The review in the following focuses on the type of information collected and on the geographic resolution. It makes use of the nomenclature of territorial units for statistics (NUTS). This nomenclature is a hierarchical system for dividing the economic territory of the European Union and contains three main classes; NUTS 1 (major socio-economic regions, e.g. groups of administrative regions), NUTS 2 (basic regions for the application of regional policies) and NUTS 3 (small regions for specific diagnoses, e.g. provinces). Within the system of local administrative units (LAUs), LAU 1 roughly corresponds to cities and LAU 2 consists of municipalities or equivalent units.

Data are reported for buildings or conventional dwellings. The former are defined as permanent buildings that contain living quarters designed for habitation or conventional dwellings. The latter are structurally separate and independent premises at fixed locations, which are designed for permanent human habitation.

3.2 Data for seismic risk assessment

There are several works in literature concerning seismic risk assessment of cities or, less often, of larger regions that provide information on the local building stock. For instance, information on the height, age, structural type, etc. of more than 12.000 buildings in Potenza, Italy, was collected following the 1990 earthquake (Dolce et al 2006). This database showed that the ratio of RC and masonry buildings changes from 0.6 when considering the number of buildings to 2.0 when considering their volume. It was also confirmed that the majority of masonry buildings is situated in rural areas, whereas RC buildings are prevalent in urban ones.

The higher quality (and lower vulnerability) of buildings in urban areas as compared to rural ones was considered in a risk analysis study of the Catalonia region in Spain (Roca et al 2006). For this application, it was assumed that all residential buildings were of masonry and therefore data from the regional census were used as regards the height, age and location in urban or rural area.

Tyagunov et al (2006) performed seismic risk mapping of Germany using a commercial building inventory, which contained information on the year of construction, type and quality of the buildings in municipalities. The vulnerability of buildings was estimated based on the type only (i.e. farmhouse, single- or two-family house, row, terrace and multi-family house, block of flats and multi-storey buildings). The analysis was further simplified by grouping the municipalities in five classes, depending on their population, and assuming a distribution of the building types within each class, based on the observation that the vulnerability of buildings is higher in smaller rural municipalities as compared to larger urban ones.

Post-earthquake field investigations were used for the estimation of the expected losses in the Faial Island of Azores (Neves et al 2012). In the specific area of interest, all buildings are low-rise and the prevailing structural type is stone masonry buildings with

timber floor and roof. Therefore, the taxonomy of existing buildings was based on the construction material and the type of floor and roof.

In the framework of the Prompt Assessment of Global Earthquakes for Response (PAGER) system developed by the United States Geological Survey, a global building inventory has been compiled for the purpose of earthquake loss assessment and risk management (Jaiswal et al 2010). It is based on harmonised data from various sources, e.g. the World Housing Encyclopaedia, national census and research publications, that has been rated for quality ranging from high (data compiled from field visits or from local experts) through medium (general surveys not based on engineering standards) to low (non-engineering agencies that are not specifically meant for risk analysis) and harmful. The quality of data in the PAGER database for most of the high-seismicity countries in Europe is medium or high. The inventory provides estimates of the fractions of building types present in urban and rural regions of each country by their functional use (residential or non-residential). Building types refer to construction material, structural system, height and seismic design for reinforced concrete buildings (ductile or non-ductile).

A similar objective was pursued in the framework of the NERA European project (<http://www.nera-eu.org>). The housing census data in the European countries were reviewed for spotting the information that is useful for creating a building inventory for seismic risk assessment (Crowley et al 2012). It was observed that the information is not harmonised among the countries as regards the fundamental attributes, e.g. construction material, age, number of storeys, etc. The procedure adopted in NERA was to use the total number of buildings in the country and scale it down to cells with resolution of at least 30 arc seconds, through the population density. Some additional operations are needed when the census provided only the dwelling count.

The same procedure was adopted for the Global Exposure Database developed by the Global Earthquake Model (GEM) Foundation (Gamba 2014). The buildings database is structured at four different levels: i) country; ii) region, where statistics on the buildings are available at national or sub-national level; iii) local, where building counts are obtained by aggregating building level data and iv) building, with information on individual structures coming from ground surveys. Dwelling fractions (urban/rural and residential/non-residential) are provided at country and region level and may be used to compute the building fractions. The number of buildings belonging to different classes is foreseen at the local level.

3.3 Data for monitoring the energy performance of buildings

Europe-wide building inventories have been developed for monitoring and improving the energy performance of buildings. The Building Performance Institute Europe created a web data hub with statistical data on buildings across 30 European countries (<http://www.buildingsdata.eu>). A team of experts in each country extracted data from official statistics and studies and resorted to expert estimations in cases where official data were not available. The data of interest for seismic risk assessment that are accessible through the web portal, include the total number of buildings or dwellings in a given country by type (office, education, hospital, hotel/restaurant, sports, wholesale/retail, residential, other) and period of construction, the total floor area by age and building type and the energy consumption by building type.

The ENTRANZE project provides data, analysis and guidelines to promote the introduction of nearly zero energy buildings in the existing building stock in Europe (<http://www.entranze.eu>). Among the collected data that are available by means of an online tool, the percentage of dwellings by period of construction and by type of building (single- or multi-family) and the average floor area by type of building are useful for risk assessment studies. All data are available at country level. The databank was compiled

from several sources, including previous research projects, European and national statistics institutes as well as national authorities.

The EPISCOPE project focused on the energy refurbishment of houses in 20 European countries (<http://episcope.eu>). Among the collected information, data regarding the construction period (different classes are defined in each country) and the building type (single-family, terraced house, multi-family house and apartment block) may be useful for risk assessment of large geographic areas. The information was aggregated in climate zones that encompass several regions, i.e. NUTS 1 or higher.

The GE20 project defines geo-clusters across EU countries with a view to deploy the potential of energy efficient buildings (<http://www.geoclusters.eu>). Geo-clusters are wide trans-national areas with similar building typologies, climatic conditions, macroeconomic situation and regulatory framework. A web-based mapping tool was developed for the visualisation of data regarding inter alia the age of construction (given in number of buildings per km²) and use (residential or non residential) of buildings at NUTS3 level and in the large geo-clusters.

Within the IMPRO-Building project (Nemry et al 2008), data were collected from several sources and harmonised in order to define an appropriate building stock typology based on several aspects (e.g. population and residential area, building type, age, structure). The overall objective of the project was the analysis of the environmental improvement potentials of residential buildings. The database covered 25 member states of the European Union and defined 72 building types. It collected information on the number of buildings and dwellings by period of construction, material of the load-bearing structure, floors and roof, number of storeys, etc. Data are available for countries.

Table 1 presents a summary of the data that may be retrieved from the inventories compiled within projects dealing with the energy efficiency of buildings. It is noted that the available information is not sufficient for the fragility assessment of classes of buildings (construction material and number of storeys are not reported in most databanks), but may be used to estimate the current value of buildings and repair costs, based on the floor area. Recall also that data are available for NUTS3 or larger areas.

Table 1. Summary of data available from research projects on energy efficiency

Project	Material	Construction period	Nb. of floors	Use	Floor area	Units
BPIE		✓		✓	✓	buildings/dwellings
ENTRANZE		✓		✓	✓	dwellings
EPISCOPE		✓		✓	✓	buildings/dwellings
GE20		✓		✓		buildings
IMPRO-building	✓	✓	✓	✓		buildings/dwellings

3.4 National housing census

A population and housing census takes place every 10 years in the member states of the European Union and EFTA⁴. A major advantage of census data is that they are collected at the level of individual buildings and can therefore be aggregated – at a considerable effort – at NUTS 3 or LAU areas, which is the desired geographic resolution. Furthermore, it is possible to obtain the coordinates of the areas of interest for geo-referencing, which will greatly facilitate the calculations.

⁴ Iceland, Liechtenstein, Norway and Switzerland

The information that was collected during the 2011 census is reported in Fig. 3, as regards the construction material, number of floors and number of buildings or dwellings. The construction period is available in all countries and therefore not shown in the maps. The maps were produced by reviewing, where available, the census questionnaires, reports issued by the national statistical institutes and the information available on their websites. Note that all three types of data are available in the most seismic-prone areas, i.e. most of the Mediterranean and Balkan countries and many of the countries in central and central-east Europe. These countries may serve as a first case study, provided that data aggregated at local administrative units are obtained from the national statistics authorities.

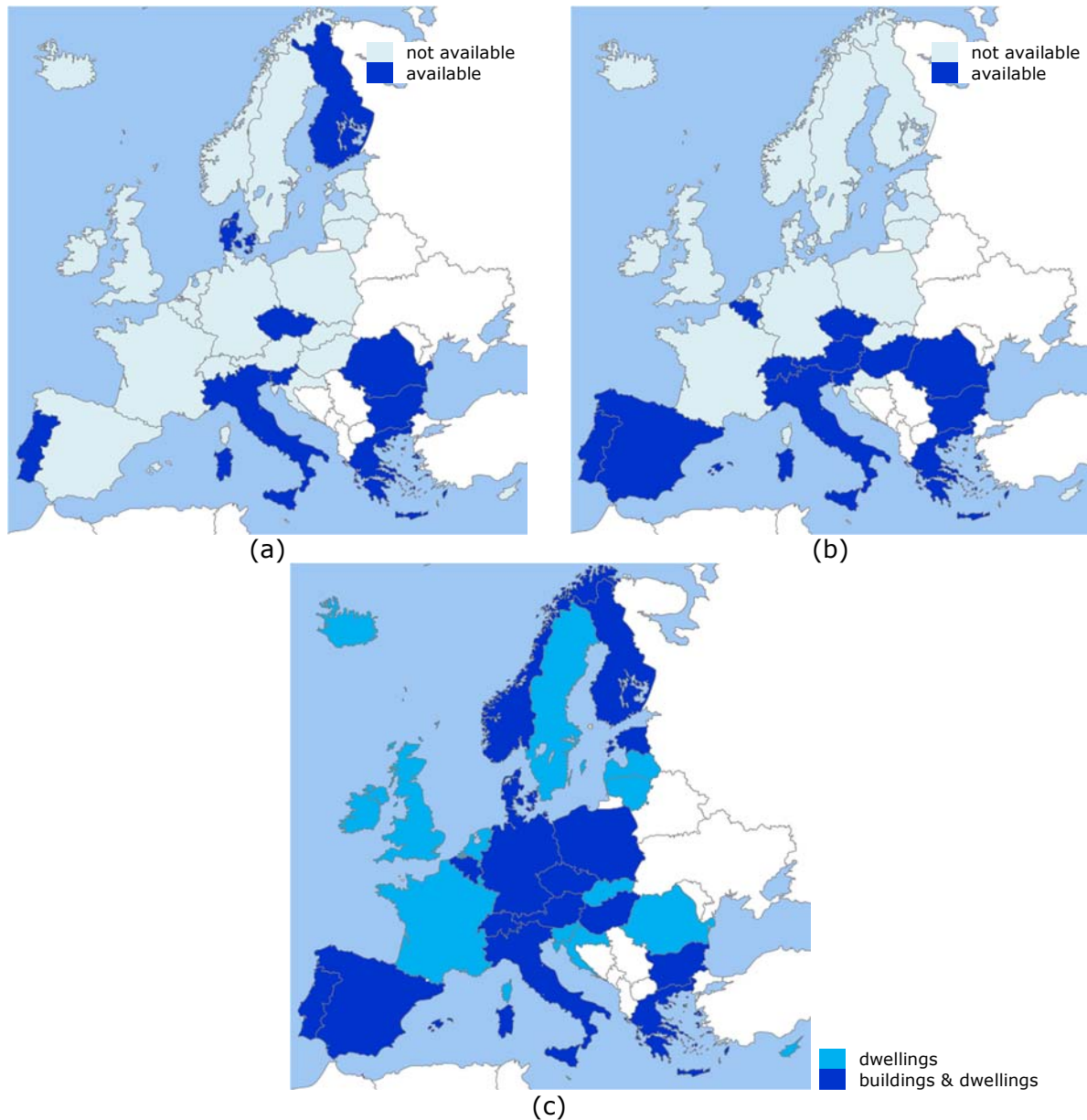


Fig. 3 Type of data collected at the 2011 census in the EU and EFTA member states: construction material (a), number of floors (b) and number of buildings or dwellings (c)

Aggregated data on dwellings from the 2011 census, prepared by the national statistical institutes using harmonised statistical definitions and classifications, are made available through the Eurostat Census Hub (<https://ec.europa.eu/CensusHub2>) for countries, NUTS 2, NUTS 3 and LAU 2 areas. All data are available for countries and the NUTS 2

class but are incomplete for smaller areas. They are provided in tables and can be combined in hypercubes. The attributes of interest for seismic risk assessment are the period of construction of the building and possibly the floor space and number of occupants of dwellings. The available hypercubes, e.g. number of dwellings by period of construction and type of building (residential buildings with one, two or more than three dwellings and non-residential ones), are not readily usable for seismic risk assessment studies.

Data on the main structural material (reinforced concrete or masonry) and age of buildings from the 2001 housing census in Italy were used for seismic risk assessment of Italy (Di Pasquale et al 2006). The available information for dwellings was converted to a distribution of buildings, using the census data for population and floor area. Expected losses were subsequently estimated for all the municipalities across the country.

During the 2010 house numbers survey in Italy, georeferenced information was collected, among others, about the period of construction, number of floors, material (masonry, reinforced concrete or other) structural type and conservation state (four levels, based on visual inspection of structural and non-structural elements) of individual buildings. These attributes were combined to produce a vulnerability index for each building that was later used to perform a seismic risk analysis (Corradi et al 2014). Furthermore, a case study for an urban centre identified some difficulties in combining the information for buildings and those for population, which come from different sources.

4. Comparison of data from different sources

It becomes evident from the previous sections that building inventories from different sources were developed for various uses and following a number of methodologies. In this section, selected datasets are compared in order to assess the consistency among them.

Steimen et al (2004) assessed an economic way of collecting data on the building stock from rapid visual observations in the city of Basel in Switzerland. The data recorded by three inspectors showed significant differences as regards the assignment to building typologies, mainly related to the construction material and structural system. The results of a simplified method for loss assessment were found to be sensitive to the building inventory and to modifications, based on engineering judgement, that were implemented to harmonise the data from different sources. As a matter of fact, differences up to 30 % were observed in the expected damage calculated for the different datasets. Lastly, it was pointed out that the distribution of building of each class varied remarkably among the examined city districts and this was propagated to the expected damage estimates.

Frassine and Giovinazzi (2004) compared the building data collected for the national census to those collected during a detailed study of the seismic risk for the city of Catania in Southern Italy. Among the data recorded for each building, Fig. 4 presents the fractions of masonry and RC buildings by period of construction. It is evident that the two datasets vary significantly across all building ages and both construction materials. Furthermore, it is not possible to identify any pattern in those differences and therefore to attempt to put in place some 'correction' procedure.

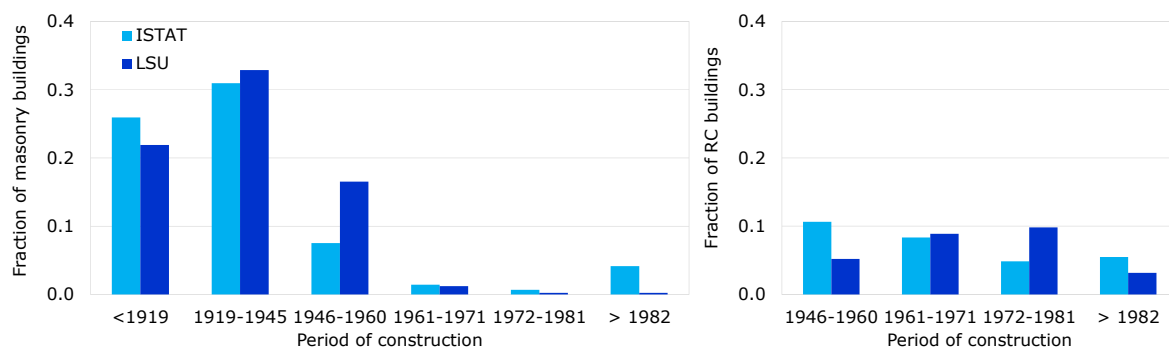


Fig. 4 Fraction of masonry and RC buildings in Catania from national census (ISTAT) and local inventory (LSU), data from Frassine and Giovinazzi (2004)

Spence et al (2012) developed a procedure for validating a common building inventory with the objective to assess how a homogenised Europe-wide database of buildings compares to detailed data collected from field surveys across (part of) a city. One validation method consists in the comparison of the relative proportions of RC and masonry buildings and in the estimation of the difference between the percentages of buildings of the same typology in the two databases. Another method focuses on a simplified calculation of the expected damage/loss for a given scenario. Both methods were used to compare the PAGER database to the building inventory developed within the NERA research project for a number of European cities and showed notable differences in the percentage of all building typologies and in the ratio of RC to masonry buildings. These inconsistencies were also reflected in the results of risk assessment, as confirmed in Table 2 that shows the percentage of buildings expected to reach or exceed a given damage level for an Intensity 8 scenario. It is interesting to observe how the use of the homogenised database may significantly under- or over-estimate the expected damage in different cities of the same country.

Table 2. Expected percentage of buildings above D3 damage level, based on the PAGER and NERA inventories (Spence et al 2012)

City	PAGER	NERA
Vienna (AU)	27	8
Grenoble (FR)	27	31
Pylos (GR)	16	21
Thessaloniki (GR)	16	4
Potenza province (IT)	27	35
Torre del Greco (IT)	27	18
Lisbon (PT)	1	21
Bucharest (RO)	37	22

As shown in Fig. 3(c), only the number of dwellings is available from the census in some countries. The building count, which is needed for seismic risk assessment, may be inferred if a reliable estimate of the number of dwellings per building is available. Fig. 5 presents this ratio for Greece, based on the data collected for the 2011 census (ELSTAT 2011) and on those reported in the BPIE databank (the latter are only available for a few periods of construction of the building). Apart from the lack of the complete time series, very good agreement is shown for the 1971-1980 and the 2001-2005 periods, but a large deviation for the buildings built between 1991 and 2000.

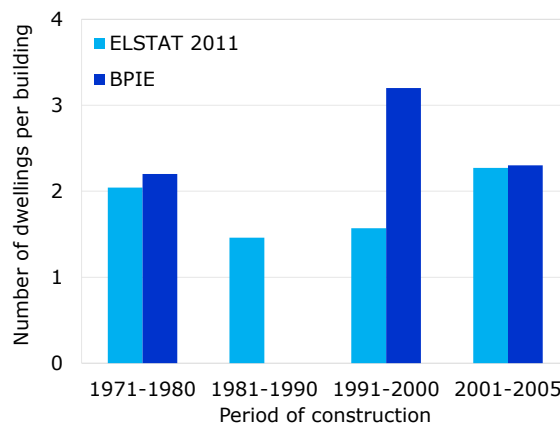


Fig. 5 Number of dwellings per building in Greece

The BPIE databank contains relevant data for a number of countries across Europe. There are on average two dwellings per building in all countries and this ratio remains practically constant in all construction periods. This is aggregated at country level and does not differentiate for instance between urban and rural areas, where a different ratio would be expected particularly for the most recent construction.

The fraction of dwellings per period of construction, as obtained from the Eurostat Census Hub and the BPIE database, is compared in the following. Overall, there is a quite good agreement for all countries and all construction periods, with differences less than 10% in the corresponding values of the two datasets. Fig. 6 shows examples of countries where significant divergence of the two data sources are observed.

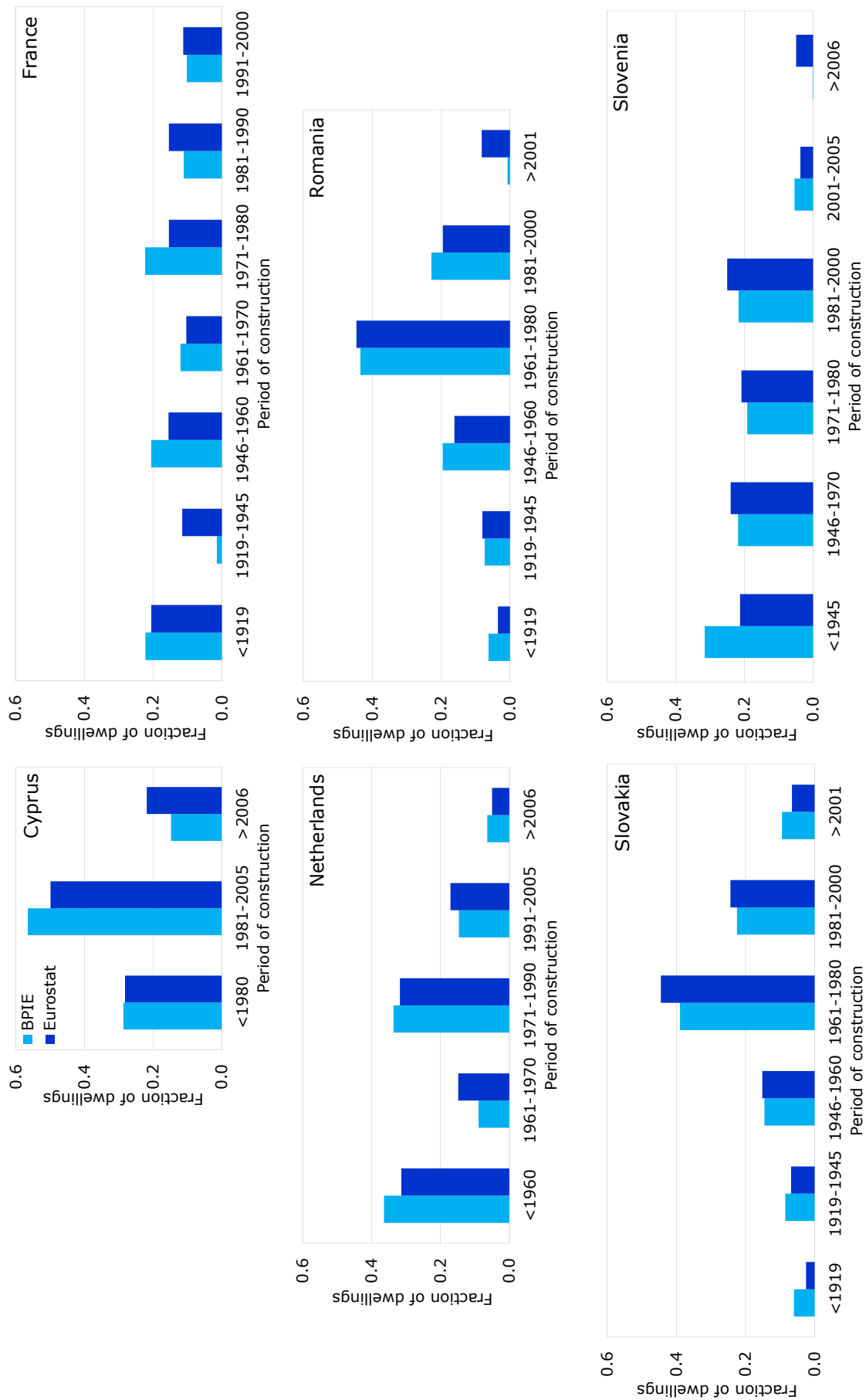


Fig. 6 Fraction of dwellings by period of construction from the Eurostat Census Hub and the BPIE database

Similar observations hold for the comparison of data from the ENTRANZE project and the Eurostat Census Hub, as shown Fig. 7. Further to the above comments, it is worth noting that the three databanks differ also in the total number of dwellings per country; the difference from the Census Hub values is on average 10 % and at extreme cases rises to 30 %.

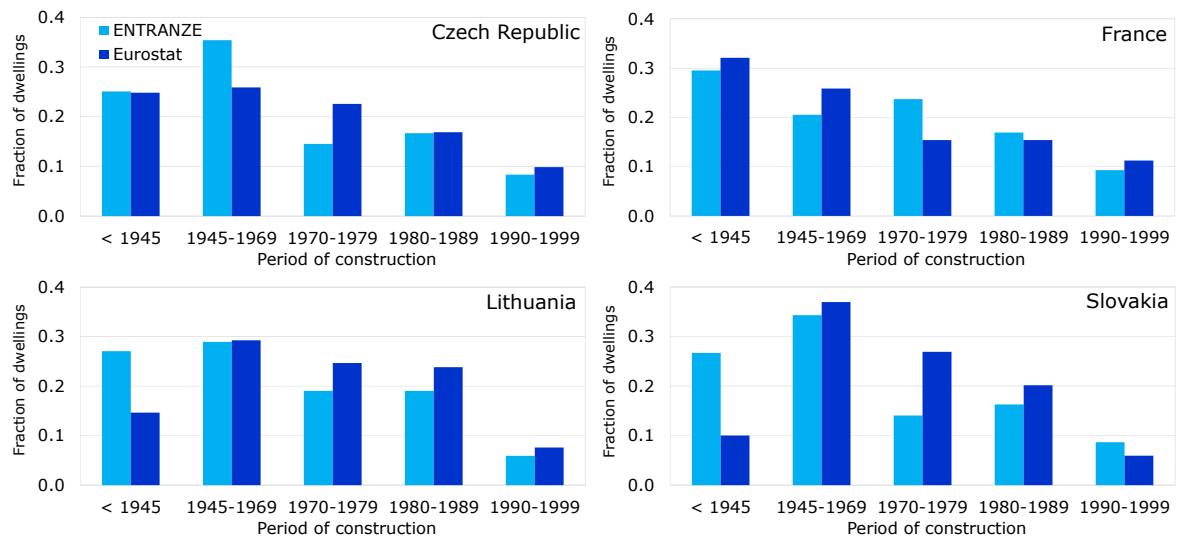


Fig. 7 Fraction of dwellings by period of construction from the Eurostat Census Hub and the ENTRANZE database

Finally, Fig. 8 compares the number of buildings in Greece by construction material, as reported in the results of the 2000 national building census (ELSTAT 2007) and the database compiled by Nemry et al (2008). A major difference is observed both in the total number of buildings, i.e. 4.1 million against 1.8 million, which cannot be attributed only to the different time periods covered by the two sources. Also as regards the construction material, the national census provides a more rational distribution of reinforced concrete and masonry buildings, whereas according to the database of Nemry et al (2008), reinforced concrete buildings account for only 1 % of the building stock.

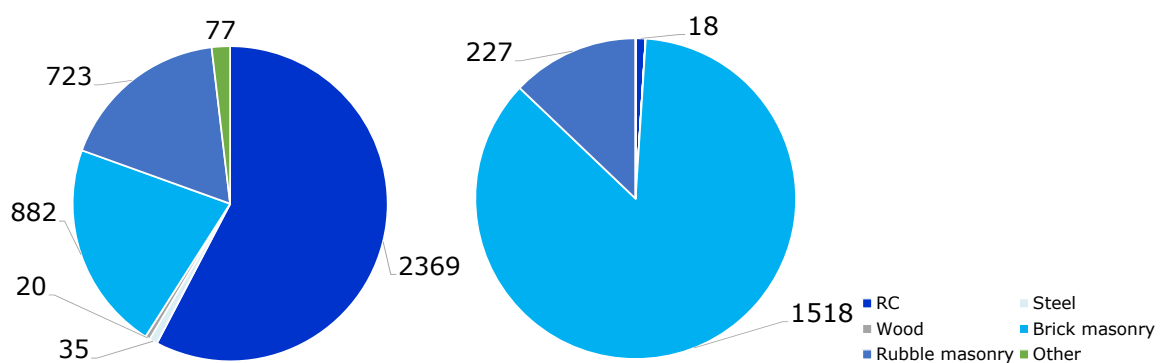


Fig. 8 Number of buildings ($\times 10^3$) in Greece by construction material, from the national census (left) and the Nemry et al (2008) database (right)

5. Conclusions

Three sources of building inventory data were reviewed, namely risk assessment research projects, studies focusing on the energy performance of buildings and national housing censuses. The objective of the review was to examine their aptness for use in a probabilistic seismic risk assessment of urban areas across the European Union. The databanks were individually assessed with regard to: i) the type of collected information and its compatibility with the taxonomy used for the development of fragility curves and ii) the geographic resolution and whether it matches the seismic hazard maps. Furthermore, databanks were compared to each other with a view to assess the quality of the collected data.

The inventories compiled in the frame of studies of the energy performance of buildings are not sufficient for seismic risk assessment, as they contain data aggregated at the level of countries or large administrative regions. Scaling down to smaller areas will likely introduce uncertainties in the loss estimation that are not easy to quantify. Besides, there are significant divergences in the data concerning important features of the buildings, for instance their age and the main construction material. These inventories however, contain useful information for the assessment of economic losses, such as the floor area, and for the future activities of the project that will investigate the synergies and conflicts of energy and structural retrofit of buildings.

The databanks created for seismic risk assessment comply fully with the required taxonomy of exposed buildings and the spatial variability of the seismic hazard. Furthermore, they accurately represent the building stock in the area of interest. Their main drawback is that they refer to rather small geographic areas and are not representative of other similar areas. As a matter of fact, a number of case studies highlight the significant differences in the building stock between urban and rural areas, between towns in the same country and even between districts of the same town. It is demonstrated that these differences affect the losses estimated in risk studies. Therefore, the distribution of buildings among the typologies in one area may not be simply used in a similar area without appropriate verification and consideration of the uncertainties introduced in the damage estimates.

Census data are collected for individual buildings and may then be aggregated at the desired level of spatial resolution. A further advantage is that data are georeferenced. The necessary information for risk assessment is recorded in most earthquake-prone areas of Europe and therefore it is worth to invest resources in collecting and, where necessary, harmonising the available census data for use in a sufficiently wide and reliable pilot risk assessment study. The effort to collect the additional data, i.e. building height or number of storeys and main construction material, is minimal and ways to include this in future censuses in all European countries should be investigated. Recall that the collection, analysis and dissemination of data relevant to the reduction of losses is strongly promoted in the Sendai Framework and by the European policies for resilience against natural disasters.

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