DELIVERABLE

D26.2 Methods for Developing European Residential Exposure Models

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Table of Contents

Summary

This deliverable presents the methodology that is being used to develop an exposure model of the residential building stock in Europe. This model describes the geographical distribution, structural characteristics (following the GEM Building taxonomy, as described in Deliverable D26.1, which includes information about construction materials, lateral load resisting system, design level and range of number of storeys), average built-up area, replacement cost, expected number of occupants, and number of dwellings and buildings within 47 European countries. The methodology is based on both national population and housing statistics together with expert judgement from dozens of local researchers and practitioners. This model is being developed as input to the pan-European seismic risk model.

1 Introduction

1.1.1 Existing Exposure Modelling Efforts covering Europe

Various building inventory databases have been developed at a global scale, following different approaches and with distinct levels of accuracy and reliability. Jaiswal et al. (2010) developed a global building inventory database for the PAGER system, which provides a distribution of building classes for urban and rural areas, at a national scale. These Authors harmonized various sources of information and applied mapping schemes to infer structural building types globally. This database is open and publicly available.

The Global Exposure Database (GED) from the Global Earthquake Model (GEM) provides a spatial inventory of residential buildings and population for the purposes of seismic risk modelling and earthquake loss estimation (Gamba, 2014). Data is available at three different geographical scales and the sources of information depend on the selected scale. The datasets used to populate GED include the Database of Global Administrative Areas (GADM), the Global Rural-Urban Mapping Project (GRUMP), the Gridded Population of the World (GPW), the Multiple Indicator Cluster Surveys (MICS), UN Habitat's Global Urban Observatory (GUO) data, United Nations statistics, PAGER building inventory database, among others. The GED database is publicly available through the OpenQuake platform[1].

Another global initiative regarding building inventories is The World Housing Encyclopedia (WHE, 2014). Detailed housing reports from all over the world are publically available and include information about the building type, construction practice, average floor areas, average construction cost, and a qualitative estimation of building's vulnerability under seismic events. However, the WHE reports do not cover the number of buildings in each country or the associated geographical distribution.

At a regional level, the first efforts to develop a European residential exposure model began in the European FP6 NERIES project, based on land use cover and population distributions. The countrywide approximated building database for 27 countries in Europe was obtained from Corine Land Cover and population databases from 2000. The methodology used in obtaining the country basis geographic distribution of the number of buildings from Corine Land Cover and Population databases is described in Appendix A of BU-KOERI (2010). Once the gridded distribution (at 150 arc seconds) of the total number of buildings was obtained, the approximate number of buildings in each building class was computed using the countrywide overall building class ratios provided in the PAGER database (Jaiswal and Wald 2008).

[1] http://platform.openquake.org

Within the European FP7 NERA project, further progress on the development of a European model of the residential building stock was made by collecting building stock information at a national level from building or population/dwelling censuses and national records on construction practices performed by statistical or financial services of the country (Crowley et al. 2012). Some countries (e.g. Italy, Portugal, Turkey) were found to have sufficient data to directly distribute the buildings in terms of structural building classes, whereas in other countries, the data available from the dwelling/building census (such as function, age, number of storeys and outer façade material) was mapped to building classes through expert judgment-based mapping schemes. The final distributions of building classes at different geographical levels within each European country was included within GEM's Global Exposure Database and is available from the OpenQuake platform.

1.1.2 Methodology

As part of the European risk framework work package of SERA (JRA4), further efforts to collect the latest building and population/dwelling census data across Europe at the smallest possible administrative level, to involve structural engineers from a number of countries across Europe in the development of the mapping schemes for residential buildings, and to further improve different aspects of the NERA methodology are being undertaken, as described in this deliverable.

The development of the European residential exposure model follows four main steps: i) definition of building classes, ii) mapping census data to building classes, iii) mapping dwellings to building, and iv) estimation of replacement cost and number of occupants. Each of these steps is described in more detail in the following sections.

The SERA JRA4 work package includes researchers from a number of European research institutions and universities in Italy, France, Portugal, Turkey, Greece and Switzerland, and they are identifying sources of data on residential buildings, and providing input on the main residential building classes and how these can be mapped to the census data, for these countries. For the other countries in Europe, various mechanisms have been identified in order to include contributions of local experts in the European exposure model. A European exposure workshop involving participants of 12 different countries took place in March 2018 in Pavia: Manya Deyanova (Bulgaria), Josip Atalic (Croatia), Danai Kazantzidou (Cyrpus and Greece), Philippe Gueguen and Adrien Pothon (France), Antonios Pomonis (Cyprus and Greece), Bjarni Bessason (Iceland), Georgios Tsionis and Luisa Sousa (Italy/Portugal/Europe), Veronika Sendova (Republic of Macedonia), Dominik Lang (Norway), Ricardo Monteiro (Portugal), Anže Babič and Jure Žižmond (Slovenia) and Armando Aguilar Melendez (Spain). A website was set up for this workshop so that all of the contributions of the participants and the outcomes of the workshop could be shared[2]. A template for collecting feedback from structural engineers on residential exposure information in urban and rural areas was tested at this workshop and the final version, that was improved following the feedback received during the workshop (see Appendix A), will be shared over the coming months with a large number of engineers from all across Europe.

2 Building Classes

A common classification scheme (i.e. taxonomy) will be used for buildings and other elements at risk within the European risk framework (see Deliverable D26.1: Crowley et al. 2017). By using a single classification scheme, it is possible to ensure that fragility/vulnerability models for specific elements at risk are compatible with the exposure models (that provide the location and value of those elements at risk) that may be developed by different parts of the engineering community. The

[2] https://sites.google.com/eucentre.it/sera-exposure-workshop

building taxonomy is based on an international standard (the GEM Building Taxonomy: Brzev et al. 2013) and allows buildings to be classified according to a number of structural attributes. The main attributes that have been selected for the consistent definition of structural systems across Europe are as follows:

- main construction material,
- lateral load resisting system,
- number of storeys,
- seismic design/ductility level

The values of each attribute that have been used in the building classes identified so far (or have been provided in feedback from local experts and will be used in updated exposure models) are provided in Table 1. Level 1 is the first level of detail required to describe an attribute, whereas Level 2 provides additional detail on the Level 1 attributes. The main residential building classes found across Europe are summarised in Table 2, whereas the full list of building classes identified within Europe (based on the information available at the time of producing this deliverable) is presented in Table 3.

Table 1. Values of attributes of GEM Building Taxonomy currently used to describe European residential buildings

ATTRIBUTE	ELEMENT CODE	LEVEL 1 VALUE	ELEMENT CODE	LEVEL 2 VALUE
MATERIAL OF LATERAL LOAD-RESISTING SYSTEM	CR	Concrete, reinforced	PC	Precast concrete
	MUR	Masonry, unreinforced	CL99	Fired clay unit, unknown type
	MR	Masonry, reinforced	ST99	Stone, unknown technology
	MCF	Masonry, confined	ADO	Adobe blocks
	MATO	Material, other	CB99	Concrete blocks, unknown type
	ER	Earth, reinforced		
	W	Wood		
	S	Steel		
LATERAL LOAD-RESISTING SYSTEM	LWAL	Wall	DUCL	Ductile, low
	LDUAL	Dual frame-wall	DUCM	Ductile, medium
	LFM	Moment frame	DUCH	Ductile, high
	LFINF	Infilled frame	DNO	Non-ductile
	LFLS	Flat slab/plate or waffle slab		
	LFLSINF	Infilled flat slab/plate or infilled waffle slab		
HEIGHT	H	Number of storeys above ground	HBET	Range of number of storeys above ground
			HEX	Exact number of storeys above ground

Table 2. Description of some common building classes in Europe

EXAMPLE BUILDING CLASSES	DESCRIPTION
 MUR/LWAL/HBET:1,4	Unreinforced masonry structures were commonly used for residential buildings across Europe. In urban areas, these buildings are usually multiple housing units with 2 to 4 storeys, while in rural areas it is more common to find single housing units with 1 or 2 storeys. The lateral load resisting system (LLRS) is characterised by unreinforced masonry walls in both directions. Walls are frequently made of fired clay hollow bricks with lime or cement mortar.
 MCF/LWAL/ HBET:1,8	Confined masonry structures are found in both urban and rural areas in Europe. The LLRS is characterised by unreinforced masonry walls confined with cast-in-place reinforced concrete (RC) tie columns and beams, which are built at regular intervals. The walls are commonly made of clay units or concrete blocks, and the RC elements are usually cast after the masonry walls have been constructed.
 CR/LDUAL/HBET:6,15 and CR/LWAL/HBET:6,15	Reinforced concrete (RC) dual frame-wall or RC wall residential buildings are generally multiple housing units found in the major urban areas of Europe. These buildings typically have from 6 to 15 storeys. The LLRS comprises columns, beams and walls (or only walls) connected by cast-in-place RC floor slabs. These buildings are usually designed following code standards, though the year of construction and design codes used will have an influence on the level of material, member and system ductility, and thus on the seismic performance.
 RC/LFM/HBET:3,7 and RC/LFINF HBET:3,7 and RC/LFLS/HBET:3,7 and RC/LFLSINF/HBET:3,7	Reinforced concrete frame or RC infilled frame buildings (which may in some cases be with flat slabs and no beams) are generally used for multiple housing units in urban areas of Europe. The LLRS is characterised by RC frames made of columns and beams (usually) with (or without) masonry-infill walls and cast-in-place RC floor slabs. Infilled walls are generally made of fired clay hollow bricks. These buildings typically have from 3 to 7 storeys. In some cases the ground floor of these buildings is not constructed with infill panels (for parking space, or commercial activities), and are thus prone to developing a soft storey. These buildings are usually designed following code standards, though the year of construction and design codes used will have an influence on the level of material, member and system ductility, and thus on the seismic performance.

Table 3. Building classes currently defined for European residential buildings

GEM TAXONOMY STRING	BUILDING CLASS DESCRIPTION
CR/LDUAL+DUCM/HBET:3,5	Reinforced concrete dual frame-wall system, medium ductility, between 3 - 5 storeys
CR/LDUAL+DUCM/HBET:3,5/SOS	Reinforced concrete dual frame-wall system, medium ductility, between 3 - 5 storeys, soft storey
CR/LDUAL+DUCM/HBET:6+	Reinforced concrete dual frame-wall system, medium ductility, more than 6 storeys
CR/LDUAL+DUCH/HBET:3,5	Reinforced concrete dual frame-wall system, high ductility, between 3 - 5 storeys
CR/LDUAL+DUCH/HBET:6+	Reinforced concrete dual frame-wall system, high ductility, more than 6 storeys
CR/LFINF+DUCL/HEX:1	Reinforced concrete infilled frame, low ductility, 1 storey
CR/LFINF+DUCL/HEX:2	Reinforced concrete infilled frame, low ductility, 2 storeys
CR/LFINF+DUCL/HBET:3,5	Reinforced concrete infilled frame, low ductility, between 3 - 5 storeys
CR/LFINF+DUCL/HBET:3,5/SOS	Reinforced concrete infilled frame, low ductility, between 3 - 5 storeys, soft storey
CR/LFINF+DUCL/HBET:6+	Reinforced concrete infilled frame, low ductility, more than 6 storeys
CR/LFINF+DUCM/HEX:1	Reinforced concrete infilled frame, medium ductility, 1 storey
CR/LFINF+DUCM/HEX:2	Reinforced concrete infilled frame, medium ductility, 2 storeys
CR/LFINF+DUCM/HBET:3,5	Reinforced concrete infilled frame, medium ductility, between 3 - 5 storeys
CR/LFINF+DUCM/HBET:3,5/SOS	Reinforced concrete infilled frame, medium ductility, between 3 - 5 storeys, soft storey
CR/LFINF+DUCM/HBET:6+	Reinforced concrete infilled frame, medium ductility, more than 6 storeys
CR/LFINF+DUCH/HEX:1	Reinforced concrete infilled frame, high ductility, 1 storey
CR/LFINF+DUCH/HEX:2	Reinforced concrete infilled frame, high ductility, 2 storeys
CR/LFINF+DUCH/HBET:3,5	Reinforced concrete infilled frame, high ductility, between 3 - 5 storeys
CR/LFINF+DUCH/HBET:6+	Reinforced concrete infilled frame, high ductility, more than 6 storeys
CR/LFM+DUCL/HEX:1	Reinforced concrete moment frame, low ductility, 1 storey
CR/LFM+DUCL/HEX:2	Reinforced concrete moment frame, low ductility, 2 storeys
CR/LFM+DUCL/HBET:3,5	Reinforced concrete moment frame, low ductility, between 3 - 5 storeys
CR/LFM+DUCL/HBET:3,5/SOS	Reinforced concrete moment frame, low ductility, between 3 - 5 storeys, soft storey
CR/LFM+DUCL/HBET:6+	Reinforced concrete moment frame, low ductility, more than 6 storeys
CR/LFM+DUCM/HEX:1	Reinforced concrete moment frame, medium ductility, 1 storey
CR/LFM+DUCM/HEX:2	Reinforced concrete moment frame, medium ductility, 2 storeys
CR/LFM+DUCM/HBET:3,5	Reinforced concrete moment frame, medium ductility, between 3 - 5 storeys

CR/LFM+DUCM/HBET:3,5/SOS	Reinforced concrete moment frame, medium ductility, between 3 - 5 storeys, soft storey
CR/LFM+DUCM/HBET:6+	Reinforced concrete moment frame, medium ductility, more than 6 storeys
CR/LFM+DUCH/HEX:1	Reinforced concrete moment frame, high ductility, 1 storey
CR/LFM+DUCH/HEX:2	Reinforced concrete moment frame, high ductility, 2 storeys
CR/LFM+DUCH/HBET:3,5	Reinforced concrete moment frame, high ductility, between 3 - 5 storeys
CR/LFM+DUCH/HBET:6+	Reinforced concrete moment frame, high ductility, more than 6 storeys
CR/LWAL+DUCL/HEX:1	Reinforced concrete wall system, low ductility, 1 storey
CR/LWAL+DUCL/HEX:2	Reinforced concrete wall system, low ductility, 2 storeys
CR/LWAL+DUCL/HBET:3,5	Reinforced concrete wall system, low ductility, between 3 -5 storeys
CR/LWAL+DUCL/HBET:6+	Reinforced concrete wall system, low ductility, more than 6 storeys
CR/LWAL+DUCM/HEX:1	Reinforced concrete wall system, medium ductility, 1 storey
CR/LWAL+DUCM/HEX:2	Reinforced concrete wall system, medium ductility, 2 storeys
CR/LWAL+DUCM/HBET:3,5	Reinforced concrete wall system, medium ductility, between 3 -5 storeys
CR/LWAL+DUCM/HBET:6+	Reinforced concrete wall system, medium ductility, more than 6 storeys
CR/LWAL+DUCH/HEX:1	Reinforced concrete wall system, high ductility, 1 storey
CR/LWAL+DUCH/HEX:2	Reinforced concrete wall system, high ductility, 2 storeys
CR/LWAL+DUCH/HBET:3,5	Reinforced concrete wall system, high ductility, between 3 -5 storeys
CR/LWAL+DUCH/HBET:6+	Reinforced concrete wall system, high ductility, more than 6 storeys
CR+PC/LWAL+DUCL/HEX:1	Precast concrete wall system, low ductility, 1 storey
CR+PC/LWAL+DUCL/HEX:2	Precast concrete wall system, low ductility, 2 storeys
CR+PC/LWAL+DUCL/HBET:3,5	Precast concrete wall system, low ductility, between 3 - 5 storeys
CR+PC/LWAL+DUCL/HBET:6+	Precast concrete wall system, low ductility, more than 6 storeys
CR+PC/LWAL+DUCM/HEX:1	Precast concrete wall system, medium ductility, 1 storey
CR+PC/LWAL+DUCM/HEX:2	Precast concrete wall system, medium ductility, 2 storeys
CR+PC/LWAL+DUCM/HBET:3,5	Precast concrete wall system, medium ductility, between 3 - 5 storeys
CR+PC/LWAL+DUCM/HBET:6+	Precast concrete wall system, medium ductility, more than 6 storeys
CR+PC/LWAL+DUCH/HEX:1	Precast concrete wall system, high ductility, 1 storey
CR+PC/LWAL+DUCH/HEX:2	Precast concrete wall system, high ductility, 2 storeys
CR+PC/LWAL+DUCH/HBET:3,5	Precast concrete wall system, high ductility, between 3 - 5 storeys
CR+PC/LWAL+DUCH/HBET:6+	Precast concrete wall system, high ductility, more than 6 storeys
MCF+CB99/LWAL+DUCL/HEX:1	Confined masonry with concrete blocks, low ductility, 1 storey
MCF+CB99/LWAL+DUCL/HEX:2	Confined masonry with concrete blocks, low ductility, 2 storeys

MCF+CB99/LWAL+DUCM/HEX:1	Confined masonry with concrete blocks, medium ductility, 1 storey
MCF+CB99/LWAL+DUCM/HEX:2	Confined masonry with concrete blocks, medium ductility, 2 storeys
MCF+CB99/LWAL+DUCM/HBET:6+	Confined masonry with concrete blocks, medium ductility, more than 6 storeys
MCF+CB99/LWAL+DUCH/HEX:1	Confined masonry with concrete blocks, high ductility, 1 storey
MCF+CB99/LWAL+DUCH/HEX:2	Confined masonry with concrete blocks, high ductility, 2 storeys
MCF+CB99/LWAL+DUCH/HBET:6+	Confined masonry with concrete blocks, high ductility, more than 6 storeys
MCF+CL99/LWAL+DUCL/HEX:1	Confined masonry with fired clay bricks, low ductility, 1 storey
MCF+CL99/LWAL+DUCL/HEX:2	Confined masonry with fired clay bricks, low ductility, 2 storeys
MCF+CL99/LWAL+DUCL/HBET:3,5	Confined masonry with fired clay bricks, low ductility, between 3 - 5 storeys
MCF+CL99/LWAL+DUCL/HBET:6+	Confined masonry with fired clay bricks, low ductility, more than 6 storeys
MCF+CL99/LWAL+DUCM/HEX:1	Confined masonry with fired clay bricks, medium ductility, 1 storey
MCF+CL99/LWAL+DUCM/HEX:2	Confined masonry with fired clay bricks, medium ductility, 2 storeys
MCF+CL99/LWAL+DUCM/HBET:3,5	Confined masonry with fired clay bricks, medium ductility, between 3 - 5 storeys
MCF+CL99/LWAL+DUCM/HBET:6+	Confined masonry with fired clay bricks, medium ductility, more than 6 storeys
MCF+CL99/LWAL+DUCH/HEX:1	Confined masonry with fired clay bricks, high ductility, 1 storey
MCF+CL99/LWAL+DUCH/HEX:2	Confined masonry with fired clay bricks, high ductility, 2 storeys
MCF+CL99/LWAL+DUCH/HBET:3,5	Confined masonry with fired clay bricks, high ductility, between 3 - 5 storeys
MUR+ST99/LWAL+DNO/HEX:1	Unreinforced stone masonry, non ductile, 1 storey
MUR+ST99/LWAL+DNO/HEX:2	Unreinforced stone masonry, non ductile, 2 storeys
MUR+ST99/LWAL+DNO/HBET:3,5	Unreinforced stone masonry, non ductile, between 3 - 5 storeys
MCF+ST99/LWAL+DUCL/HEX:1	Unreinforced stone masonry, low ductility, 1 storey
MCF+ST99/LWAL+DUCL/HEX:2	Unreinforced stone masonry, low ductility, 2 storeys
MCF+ST99/LWAL+DUCL/HBET:3,5	Unreinforced stone masonry, low ductility, between 3 - 5 storeys
MCF+ST99/LWAL+DUCM/HEX:1	Unreinforced stone masonry, medium ductility, 1 storey
MCF+ST99/LWAL+DUCM/HEX:2	Unreinforced stone masonry, medium ductility, 2 storeys
MCF+ST99/LWAL+DUCM/HBET:3,5	Unreinforced stone masonry, medium ductility, between 3 - 5 storeys
MCF+ST99/LWAL+DUCH/HEX:1	Unreinforced stone masonry, high ductility, 1 storey
MCF+ST99/LWAL+DUCH/HEX:2	Unreinforced stone masonry, high ductility, 2 storeys
MCF+ST99/LWAL+DUCH/HBET:3,5	Unreinforced stone masonry, high ductility, between 3 - 5 storeys
MUR+CB99/LWAL+DNO/HEX:1	Unreinforced concrete block masonry, non ductile, 1 storey
MUR+CB99/LWAL+DNO/HEX:2	Unreinforced concrete block masonry, non ductile, 2 storeys

MUR+CL99/LWAL+DNO/HEX:1	Unreinforced clay brick masonry, non ductile, 1 storey
MUR+CL99/LWAL+DNO/HEX:2	Unreinforced clay brick masonry, non ductile, 2 storeys
MUR+CL99/LWAL+DNO/HBET:3,5	Unreinforced clay brick masonry, non ductile, between 3 - 5 storeys
MUR+ADO/DNO/HBET:1,2	Unreinforced adobe block masonry, non ductile, between 1 - 2 storeys
MR+ST99/LWAL+DUCM/HEX:1	Reinforced stone masonry, medium ductility, 1 storey
MR+ST99/LWAL+DUCM/HEX:2	Reinforced stone masonry, medium ductility, 2 storeys
MR+CB99/LWAL+DUCM/HEX:1	Reinforced concrete block masonry, medium ductility, 1 storey
MR+CB99/LWAL+DUCM/HEX:2	Reinforced concrete block masonry, medium ductility, 2 storeys
MR+CB99/LWAL+DUCH/HEX:1	Reinforced concrete block masonry, high ductility, 1 storey
MR+CB99/LWAL+DUCH/HEX:2	Reinforced concrete block masonry, high ductility, 2 storeys
MR+CL99/LWAL+DUCL/HEX:1	Reinforced clay brick masonry, low ductility, 1 storey
MR+CL99/LWAL+DUCL/HEX:2	Reinforced clay brick masonry, low ductility, 2 storeys
MR+CL99/LWAL+DUCL/HBET:3,5	Reinforced clay brick masonry, low ductility, between 3 - 5 storeys
MR+CL99/LWAL+DUCL/HBET:6+	Reinforced clay brick masonry, low ductility, more than 6 storeys
MR+CL99/LWAL+DUCM/HEX:1	Reinforced clay brick masonry, medium ductility, 1 storey
MR+CL99/LWAL+DUCM/HEX:2	Reinforced clay brick masonry, medium ductility, 2 storeys
MR+CL99/LWAL+DUCM/HBET:3,5	Reinforced clay brick masonry, medium ductility, between 3 - 5 storeys
MR+CL99/LWAL+DUCH/HEX:1	Reinforced clay brick masonry, high ductility, 1 storey
MR+CL99/LWAL+DUCH/HEX:2	Reinforced clay brick masonry, high ductility, 2 storeys
MR+CL99/LWAL+DUCH/HBET:3,5	Reinforced clay brick masonry, high ductility, between 3 - 5 storeys
W/LWAL+DUCL/HBET:1,2	Wooden wall system, low ductility, between 1 - 2 storeys
W/LWAL+DUCM/HBET:1,2	Wooden wall system, medium ductility, between 1 - 2 storeys
W/LWAL+DUCM/HBET:3,5	Wooden wall system, medium ductility, between 3 - 5 storeys
W/LWAL+DUCH/HBET:1,2	Wooden wall system, high ductility, between 1 - 2 storeys
ER+W/LWAL+DUCL/HEX:1	Reinforced rammed earth, low ductility, 1 storey
ER+W/LWAL+DUCL/HEX:2	Reinforced rammed earth, low ductility, 2 storeys
ER+W/LWAL+DUCL/HBET:3,5	Reinforced rammed earth, low ductility, between 3 - 5 storeys
MATO/DNO/HBET:1,2	Other material, non ductile, between 1 - 2 storeys
UNK	Unknown

3 Mapping Census Data to Building Classes

Population and housing statistics usually provide information regarding the number of dwellings/buildings and physical housing attributes that exist in a given area. However, the information that is used to describe each dwelling/building in the census varies across the different countries, and may not cover all of the features required to characterize a structure according to its seismic performance. So far the latest census information of 19 countries has been accessed for the European exposure model, and this has been combined with the existing data from NERA and GED4GEM (see Table 4).

Table 4 shows that the statistics are available on just dwellings/households in some countries, whereas in others the data on buildings is also available. The oldest census data is from 2001, and the latest is from 2017. Some countries have detailed information on the structural characteristics of the buildings (e.g. Portugal, Turkey, Greece), whereas in others only the predominant material of the exterior walls and year of construction is available. For these latter countries, the contribution of local experts and the information provided within the building survey template (Appendix A) becomes of fundamental importance. By carefully exploring the information provided by the census of each country, it becomes apparent that in many cases the information within the census can be associated to more than one of the building classes presented in Table 3. For example, dwellings whose predominant exterior wall material is defined as clay bricks could be assigned to reinforced concrete infilled moment-frame, to confined masonry or unreinforced masonry structures. The percentage of the number of buildings in each class should be ultimately informed by the distribution of these three types of structures (possibly also as a function of the number of storeys, and whether the area is urban or rural), as provided by the local experts. Based on the year of construction, these classes could be further divided based on level of ductility, which is associated with the design code in place at the time year of construction and the level of seismic hazard. Across Europe, and over time, seismic design codes, years of enforcement and level of details of the regulations have varied considerably. However, it is fair to assume that there have been three levels of seismic regulations:

- Pre/low code: Before the implementation of a seismic code or the application of a code with no seismic provisions.
- Moderate code: Usually the first code implemented in a country with seismic provisions
- High-code: which refers to the first modern code with capacity design principles or Eurocode8.

The levels of ductility are not just based on the seismic regulation, because if a particular region has no (or very low) seismic hazard then the structures will still have low levels of ductility. The following scheme, that considers the year of construction and level of hazard, shows the type of scheme that will most likely be used to assign buildings to non-ductile, low, medium and high ductility levels:

- Given pre/low code, then the level of ductility will be non-ductile for URM and adobe construction and low ductility for reinforced concrete, confined masonry, reinforced masonry, wood and steel.
- Given moderate code:
  - Assign low ductility if the PGA for the 475 year return period hazard is < 0.1g.
  - Assign moderate ductility if the PGA for the 475 year return period hazard is > 0.1g
- Given high code:
  - Assign low ductility if the PGA for the 475 year return period hazard is < 0.1g
  - Assign moderate ductility if the PGA for the 475 year return period hazard is > 0.1g but < 0.3g
  - Assign high ductility if the PGA for the 475 year return period hazard is > 0.3g

In order to apply a system such as the one described above, it will be necessary to obtain information on the seismic design codes and hazard maps across time in each country and post-process the building data (using location and age) to assign the buildings to the correct ductility category. The scheme described above is based on initially proposed values and assumptions that may change in the future depending on the outcomes of the fragility modelling (which will based on simulated design for reinforced concrete and steel buildings, and will be described in Deliverable D26.5).

Occupancy can also used to distinguish between building classes; for example, apartments are usually found in higher buildings constructed with reinforced concrete, whereas detached houses are usually low-rise and built with unreinforced masonry. These relationships between the attributes used in the census data, and the final list of building classes are referred to as mapping schemes. The development of the mapping schemes closely follows the methodology thoroughly described in Yepes-Estrada et al. (2017). The advantage of this approach is that it can be continuously refined based on additional input from local experts.

So far, mapping schemes have been developed for all European countries (either directly by SERA partners or from the previous efforts in NERA). The following sources of information have been used to produce these preliminary mapping schemes, which will be updated as the project progresses and as the input from local experts is received through the template in Appendix A:

- NERA project (http://www.nera-eu.org/);
- SYNER-G project (http://www.vce.at/SYNER-G/) (in particular Reference Reports 2 and 3)
- BPIE – Improving the Energy Performance of Buildings across Europe (http://www.bpie.eu);
- TABULA - Typology Approach for Building Stock Energy Assessment (http://episcope.eu/iee-project/tabula/);
- World Housing Encyclopedia (WHE) (http://www.world-housing.net/);
- Peer-reviewed publications;
- United Nations Statistics;
- Global Exposure Database from GEM;
- PAGER building inventory database (https://pubs.usgs.gov/of/2008/1160/)

Ideally, mapping schemes should be provided separately for urban and rural areas within each country, and in some cases for a third category of historical centres (e.g. France), such that the differences in the distribution of building classes between these areas can be captured. In many cases the census already separates the data on the number of dwellings/buildings between urban/rural areas (see the urban/rural division column in Table 4), but when this was not provided, it has nevertheless been possible to obtain the definition of urban/rural within each country from the census, such that each municipality can be assigned to the correct category.

Figure 1 depicts two preliminary mapping schemes (i.e. based on the judgment of SERA partners and not yet revised based on the opinion of local experts) that are applied to buildings constructed before structural design codes (i.e pre-code). The first is applied to Greek buildings, and applies to both urban and rural areas. In this case the available census information is on the construction material (not the external wall material) and the number of storeys. The second is applied to buildings in historical centres in France, where the available information is simply whether the building is a detached house or an apartment.

Greece	Concrete/3 floors	Brick/Concrete Blocks/ 1 floor
Pre-code	69% CR/LFINF+DNO/HEX:3 1% CR/LFINF+DNO/HEX:3/SOS 29% CR/LFM+DNO/HEX:3 1% CR/LFM+DNO/HEX:3/SOS	60% MUR+CL99/LWAL+DNO/HEX:1 40% MUR+CB99/LWAL+DNO/HEX:1

Historical Centers	Detached houses	Apartments
Pre-code	20% W/LWAL+DNO/HBET:3,5 30% W/LWAL+DNO/HEX:2 15% W/LWAL+DNO/HEX:1 20% MUR+CL/LWAL+DNO/HEX:2 10% MUR+ST/LWAL+DNO/HEX:2 5% MUR+CL/LWAL+DNO/HEX:1	40% RC/LWAL+DNO/HBET:3,5 10% RC/LWAL+DNO/HBET:6+ 40% RC+PC/LWAL+DNO/HBET:3,5 10% RC/LFINF+DNO/HEX:2

Figure 1: Example mapping schemes in Greece and France

Table 4. Census information for European countries (countries with asterisk have been obtained from GED4GEM/NERA)

COUNTRY	DWELLINGS OR BUILDINGS?	YEAR OF CENSUS	URBAN/ RURAL DIVISION?	ATTRIBUTES	WEB LINK OF CENSUS
ALBANIA	both	2011	Yes	date of construction; material of exterior walls; number of storeys; occupancy	http://www.instat.gov.al
ANDORRA*	buildings	2011	No	-	http://www.estadistica.ad
AUSTRIA*	dwellings	2001	No	material of exterior walls; date of construction; number of storeys; occupancy	http://www.statistik.at
BELARUS*	dwellings	2009	Yes	date of construction; occupancy; material of exterior walls	http://www.belstat.gov.by
BELGIUM*	both	2012	No	date of construction; number of storeys; occupancy	http://census2011.fgov.be
BOSNIA AND HERZEGOVINA	both	2013	No	date of construction; occupancy	http://www.popis2013.ba http://www.popis.gov.ba
BULGARIA	both	2011	Yes	material of exterior walls; date of construction; material of LLRS; number of storeys; occupancy; LLRS	http://www.nsi.bg
CROATIA	dwellings	2011	No	date of construction; occupancy	https://www.dzs.hr
CYPRUS	dwellings	2011	Yes	date of construction; occupancy	http://www.cystat.gov.cy
CZECH REPUBLIC*	dwellings	2011	No	material of exterior walls; date of construction; number of storeys; occupancy	https://www.czso.cz
DENMARK*	both	2011	No	date of construction; occupancy	https://www.dst.dk
ESTONIA*	both	2011	Yes	date of construction; occupancy	https://www.stat.ee
FINLAND*	both	2012	No	material of exterior walls; date of construction; number of storeys; occupancy	https://www.stat.fi
FRANCE	dwellings	2014	Yes	date of construction; occupancy	https://www.insee.fr
GERMANY*	dwellings	2011	No	date of construction; occupancy	https://ergebnisse.zensus2011.de
GIBRALTAR*	households	2012	No	occupancy	https://www.gibraltar.gov.gi

COUNTRY	DWELLINGS OR BUILDINGS?	YEAR OF CENSUS	URBAN/ RURAL DIVISION?	ATTRIBUTES	WEB LINK OF CENSUS
GREECE	both	2011	No	material of exterior walls; date of construction; material of LLRS; number of storeys; occupancy; LLRS	http://www.statistics.gr
HUNGARY*	dwellings	2001	No	material of exterior walls; date of construction; number of storeys; occupancy	https://www.ksh.hu
ICELAND	dwellings	2011	No	date of construction; occupancy	https://www.hagstofa.is https://www.statice.is
IRELAND*	dwellings	2011	Yes	date of construction; occupancy	http://www.cso.ie
ISLE OF MAN*	households	2011	No	-	https://www.gov.im
ITALY	both	2011	Yes	material of exterior walls; date of construction; material of LLRS; number of storeys; occupancy; LLRS	https://www.istat.it
KOSOVO	both	2011	Yes	material of exterior walls; date of construction; material of LLRS; number of storeys; occupancy; LLRS	http://ask.rks-gov.net
LATVIA*	dwellings	2009	No	material of exterior walls; date of construction; occupancy	http://www.csb.gov.lv
LIECHTENSTEIN*	both	2010	No	date of construction; occupancy	https://www.llv.li http://etab.llv.li
LITHUANIA*	both	2001	No	material of exterior walls; date of construction; occupancy	https://osp.stat.gov.lt http://statistics.bookdesign.lt
LUXEMBOURG*	both	2001	No	date of construction; occupancy	http://www.statistiques.public.lu
MALTA*	dwellings	2005	No	date of construction; occupancy	https://nso.gov.mt
MOLDOVA*	dwellings	2011	No	material of exterior walls; number of storeys; occupancy	http://www.statistica.md
MONACO*	dwellings	2008	No	date of construction; occupancy	http://www.monacostatistics.mc
MONTENEGRO	dwellings	2011	Yes	date of construction; occupancy	http://monstat.org/cg
NETHERLANDS*	dwellings	2011	No	date of construction; occupancy	https://www.cbs.nl https://opendata.cbs.nl

COUNTRY	DWELLINGS OR BUILDINGS?	YEAR OF CENSUS	URBAN/ RURAL DIVISION?	ATTRIBUTES	WEB LINK OF CENSUS
NORWAY	dwellings	2017	Yes	date of construction; number of storeys; occupancy	https://www.ssb.no
POLAND*	both	2011	No	date of construction; occupancy	http://stat.gov.pl
PORTUGAL	both	2011	No	material of exterior walls; date of construction; material of LLRS; number of storeys; occupancy; LLRS	https://ine.pt
REPUBLIC OF MACEDONIA	dwellings	2002	No	material of exterior walls; date of construction; material of LLRS; number of storeys; occupancy; LLRS	http://www.stat.gov.mk
ROMANIA	both	2011	Yes	material of exterior walls; date of construction; material of LLRS; number of storeys; occupancy; LLRS	http://www.recensamantromania.ro
SAN MARINO*	Unknown (GED4GEM)	-	No	-	http://www.statistica.sm
SERBIA	dwellings	2011	No	date of construction; number of storeys; occupancy	http://webrzs.stat.gov.rs
SLOVAKIA*	dwellings	2001	No	material of exterior walls; date of construction; number of storeys; occupancy	https://bit.ly/2GhTgeL
SLOVENIA	both	2002	No	material of exterior walls; date of construction; material of LLRS; number of storeys; occupancy; LLRS	http://www.stat.si/
SPAIN	both	2011	Yes	date of construction; number of storeys; occupancy	http://www.ine.es
SWEDEN*	dwellings	2011	-	-	http://www.statistikdatabasen.scb.se
SWITZERLAND	both	2016	Yes	date of construction; number of storeys; occupancy	https://bit.ly/2DQEea2 https://bit.ly/2pzXzIi https://bit.ly/2pA0dOe
TURKEY	both	2016	No	material of exterior walls; date of construction; material of LLRS; number of storeys; occupancy; LLRS	https://biruni.tuik.gov.tr
UKRAINE*	dwellings	2010	-	-	http://www.ukrstat.gov.ua
UNITED KINGDOM*	dwellings	2001	No	occupancy	https://www.ons.gov.uk

4 Mapping Dwellings to Buildings

As shown in Table 4, the available census data from many countries includes the number of dwellings and not the number of buildings. Whilst the former is useful to estimate the total built-up area or replacement cost of a given type of construction (as discussed in the next section), it does not allow the number of buildings in a given damage state (e.g. slight damage, moderate damage, collapse) to be estimated for a specific seismic event, which is a useful risk metric, in particular for emergency planning. Thus, the information of the present model was used to calculate the number of buildings ($N_{buildings}$), by dividing the number of dwellings ($N_{dwellings}$) by the average number of dwellings per storey $N_{dwellings/storey}$ (based on expert feedback in the building survey template) and by the average number of storeys per building $N_{storeys/building}$ (from the census, where available, or from the mapping scheme), as represented in the following expression:

$$N_{buildings} = \frac{N_{dwellings}}{N_{\frac{dwellings}{storey}} \times N_{\frac{storeys}{building}}}$$

5 Estimation of Replacement Cost and Population

The final step to complete the exposure model is the estimation of the replacement cost and population per building class.

The replacement cost refers to the value of replacing a building in accordance with the latest building standards applicable for the country, and it includes the cost of the structural and non-structural components (the cost of the land is not included). Since construction cost is commonly found per square metre, the average constructed area per building class is required.

The constructed area of a given building class ($A_{building\ class}$) can be obtained by multiplying the number of dwellings for each building class ($N_{dwellings|building\ class}$) by the average floor area per dwelling within that building class ($A_{dwelling|building\ class}$):

$$A_{building\ class} = N_{dwellings|building\ class} \times A_{dwelling|building\ class}$$

The average area per dwelling for each building class together with the replacement cost per square metre needs to be defined separately for urban and rural areas and large cities, and is included in the building survey template (Appendix A). Given that some countries have their own currency, Euros have been selected as the reference currency in order to homogenise and compare values among countries. Table 5 presents an example of how the cost of construction varies between urban, rural and large cities (e.g. with more than 1 million inhabitants) in Germany.

Table 5. Average replacement costs of residential buildings across Germany (Kleist et al., 2006)

Region/city	Inhabitants according to (INFAS)	Average replacement costs per inhabitant [EUR]	Average replacement costs per living area [EUR/m^2]	Average living area per inhabitant [m^2]	Average number of inhabitants per residential building
Germany	82 440 307	46 601	1180	39.5	4.2
Berlin	3 388 434	66 665	1745	38.2	9.8
Munich	1 227 958	60 433	1550	39.0	8.9
Hamburg	1 726 363	57 574	1622	35.5	6.8
Stuttgart	587 152	49 000	1339	36.6	7.4
Cologne	967 940	49 176	1318	37.3	6.8
Dresden	478 631	54 039	1415	38.2	9.0
		Rural communities			
Aldenhoven	13 911	33 683	1053	32.0	3.9
Templin	13 843	35 309	1169	30.2	5.2
Timmendorfer Strand	8956	56 646	1037	54.6	2.8
Lichtenstein	9460	46 390	1180	39.3	3.6
Offenau	2734	48 755	1172	41.6	3.7

For the population, a similar method is applied which requires the average number of people per dwelling (which is commonly available in census data). The population of a given building class ($P_{building\ class}$) can be obtained by multiplying the number of dwellings for each building class ($N_{dwellings|building\ class}$) by the average number of people per dwelling ($P_{dwelling}$):

$$P_{building\ class} = N_{dwelling|building\ class} \times P_{dwellings}$$

For the above method, a check on the total population available within each administrative boundary also needs to be carried out, to ensure consistency with the census data.

6 SERA European Residential Exposure Model v0

The methodology presented herein is still being applied for the development of the SERA European residential exposure model. The main activities that are ongoing include the collection of the latest census data, the evaluation and processing of a first set of building survey templates by local experts that attended the exposure workshop, and the distribution of building survey templates to a wider pool of experts across Europe.

However, based on the information and expertise that has been collected to date, and the use of NERA/GED4GEM data in countries that have not yet been covered within SERA, a v0 beta European exposure model has been developed, as a proof of concept of the methodology presented herein. This model will continue to be improved over the next year of the project to account for the local expert input as described above. The final model used in the European risk assessment will be based on the methodology described herein, but the final numbers of buildings and the distribution amongst building classes may differ from those obtained within v0. Hence, it is not proposed to release v0 (which is a beta model), but to release v1, which will be fully described in the Deliverable D26.7 “Framework for European integrated risk assessment” which will be submitted at month 24.

The main data contained that will be contained within the v1 residential exposure model will be follows:

- The number of dwellings within urban and rural areas within each administrative boundary (at the highest resolution available) for each country in Europe.

- The number of buildings within urban and rural areas within each administrative boundary (at the highest resolution available) for each country in Europe (either directly from census data, or from mapping dwellings to buildings, as described in Section 4).
- The distribution of these buildings across each residential building class for each administrative boundary (at the highest resolution available), based on the application of mapping schemes to the census data (see Section 3).
- The replacement cost within urban, rural areas and big cities for each building class within each administrative boundary (at the highest resolution available) for each country in Europe based on the method described in Section 5.
- The population within urban and rural areas for each building class within each administrative boundary (at the highest resolution available) for each country in Europe based on the method described in Section 5.

A summary of the statistics for each country in the current v0 beta model is presented in Table 6. The total number of buildings in each country is mapped in Figure 2 together with pie charts showing the distribution of structural materials of the building classes in each country. Additional maps of this type will be developed for the v1 model, and all data will be made available through the EFEHR (www.efehr.org) and OpenQuake (https://platform.openquake.org) platforms.

Table 6. Summary of residential building exposure model statistics for European countries (v0 beta model)

Country	Highest resolution	Number of Buildings	Replacement cost [Euro million]	Population
Albania	district	598,267	11,882	2,905,000
Andorra	country	9,652	6,254	67,341
Austria	provinces	1,764,500	1,291,331	8,042,000
Belarus	district	1,630,267	125,240	9,507,000
Belgium	commune	3,681,800	1,521,910	10,290,000
Bosnia and Herzegovina	municipality	1,072,231	53,977	3,605,000
Bulgaria	municipality	2,072,389	170,705	7,388,000
Croatia	municipality	1,274,193	55,760	4,281,000
Cyprus	district	171,530	51,524	1,125,000
Czech Republic	municipality	2,115,886	764,692	10,500,000
Denmark	municipality	1,534,526	1,026,633	5,571,000
Estonia	municipality	214,831	58,377	1,327,000
Finland	municipality	1,258,095	645,074	5,414,000
France	municipality	15,110,800	5,085,994	65,660,000
Germany	districts	18,204,400	12,288,406	80,270,000
Gibraltar	country	2,995	2,537	32,194
Greece	municipality	3,245,604	368,717	11,100,000
Hungary	county	2,702,200	723,843	10,190,000
Iceland	municipality	59,577	10,229	319,014
Ireland	town	1,881,929	666,741	4,577,000
Isle of Man	country	13,909	3,765	83,737
Italy	municipality	12,187,698	1,751,440	56,970,000

Country	Highest resolution	Number of Buildings	Replacement cost [Euro million]	Population
Kosovo	municipality	251,366	25,968	1,791,000
Latvia	region	352,087	62,111	2,142,000
Liechtenstein	municipality	10,383	15,809	36,003
Lithuania	municipality	511,321	78,197	3,471,000
Luxembourg	district	119,600	148,880	441,525
Malta	locality	94,400	28,129	403,834
Moldova	district	648,888	54,903	2,804,801
Monaco	country	7,022	15,123	35,853
Montenegro	municipality	136,883	8,619	620,079
Netherlands	municipality	3,160,040	2,572,400	16,690,000
Norway	municipality	1,561,138	806,328	4,953,000
Poland	county	6,006,608	1,376,528	38,060,000
Portugal	parish	3,369,372	358,000	10,560,000
Republic of Macedonia	municipality	427,014	35,924	2,049,000
Romania	county	5,326,972	176,897	20,150,000
San Marino	-	4,772	2,183	31,110
Serbia	municipality	2,139,607	90,070	7,234,000
Slovakia	municipality	1,192,897	344,887	5,379,000
Slovenia	municipality	463,029	28,448	1,995,000
Spain	municipality	9,730,999	2,557,383	49,190,000
Sweden	municipality	2,054,000	1,359,407	9,449,000
Switzerland	municipality	1,730,415	680,878	8,372,000
Turkey	province	6,792,278	1,338,164	64,190,000
Ukraine	-	8,065,039	485,394	45,870,000
United Kingdom	country	14,890,058	6,671,184	59,120,000

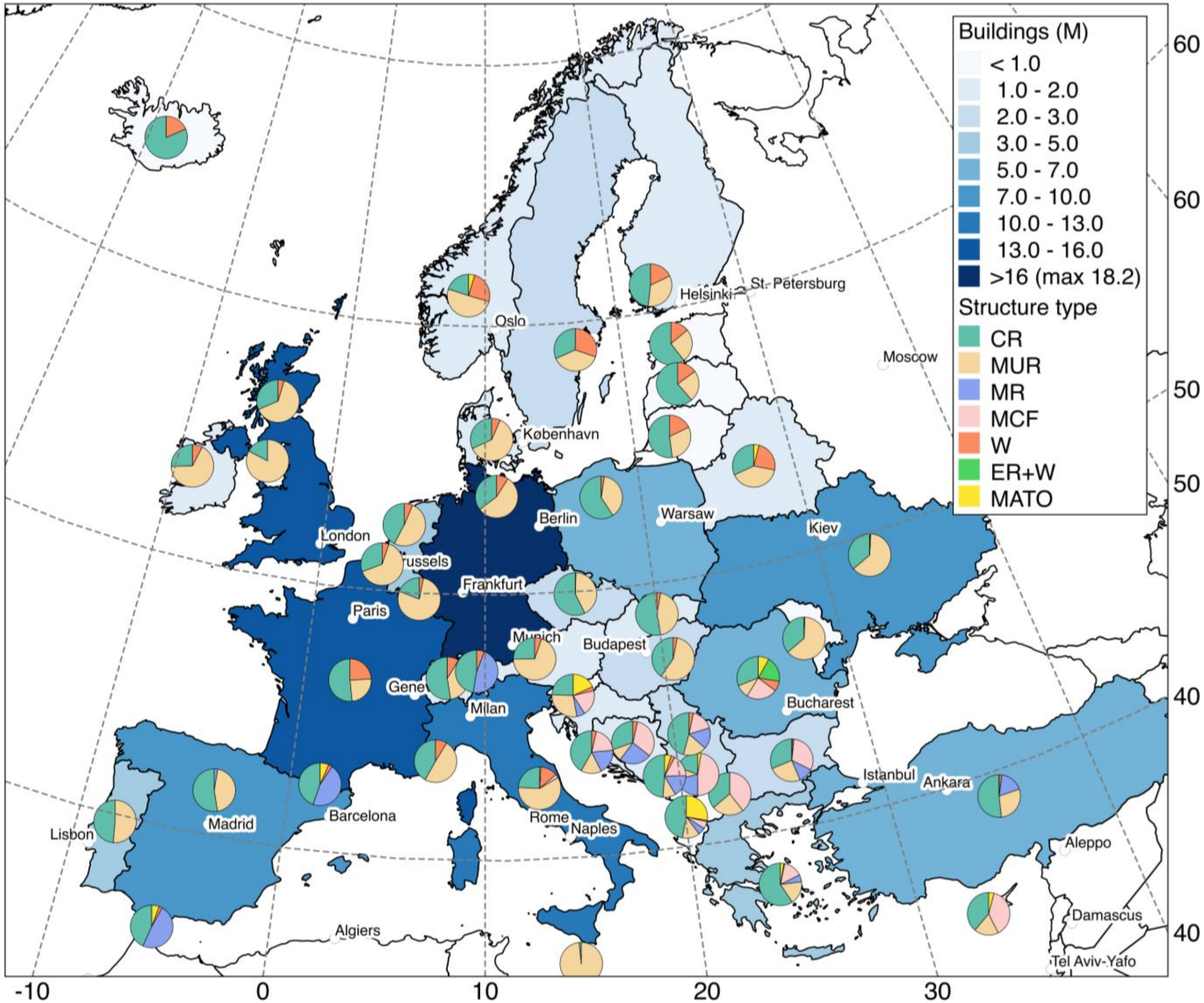

Figure 2: Number (in millions) and dominant types of buildings in European countries according to the v0 beta European residential exposure model. The structure type is only described in terms of material (for simplicity of presentation) using the material types shown in Table 1.

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8 Appendix A: Building Survey Template

Each tab of the Excel template used for collecting information from local experts on residential buildings is summarised in the following sections.

8.1 Read Me

This is a survey in order to identify the most common building classes within a country for the residential, commercial and industrial building stock, and some important statistics related to distribution, area and replacement cost.

In this survey **replacement cost refers** to the cost of rebuilding a structure, including structural and non structural components but NOT contents (e.g., maschinery or furniture).

Light industry, includes for example the manufacturing of foods, beverages, clothes or shoes, while industries such as power plants, or petrochemical industry refers to heavy industry (which is not considered herein).

Please fill the survey separately for urban and rural areas for the residential buildings. If, however, you believe that the distribution of the building classes does not considerably change between urban and rural areas, you can only fill the spreadsheet called "Residential_Buildings_URBAN".

The definition of the building classes is performed based on the **GEM Building Taxonomy** that is a uniform and comprehensive classification system that characterizes the buildings according to a number of attributes, such as the height or the main material of the external walls of the buildings. Full definition of the strings used in this survey are included as comments in each cell or you can alternatively explore the following website: https://taxonomy.openquake.org/. A short list of the most used attributes is also included herein for convenience.

Please send your completed files to helen.crowley@eucentre.it and **THANK YOU** in advance for your time and contribution in building reliable and representative exposure models.

8.2 Residential Buildings (Urban/Rural)

The template includes two tabs on residential buildings, one for urban areas and another for rural areas, and follows the scheme shown in the following figure.

Average replacement cost per sq.m (Euros)

For your country, the fraction of building types in terms of percentage of total number of buildings is:

CR	
MCF	
MUR	
S	
W	
MR	
CR+PC	
Unknown	
Other	
Total	PLEASE REVISE, NEEDS TO SUM TO 100%

Based upon your experience, how would CR be distributed among the types of lateral load resisting systems (LLRS) mentioned below? Please provide percentages and follow the same procedure for the remaining building types you have previously identifidied

	LATERAL LOAD RESISTING SYSTEM TYPES (LLRS)							
	LFINF	LDUAL	LFM	LWAL	LFLSINF	LFLS	Unknown	Total
CR								NEEDS TO SUM TO 100%

Based upon your experience, how would CR of each LLRS be distributed among different building heights? Please provide percentages and follow the same procedure for the remaining building types you have previously identified

CR	LFINF	LDUAL	LFM	LWAL	LFLSINF	LFLS	Unknown	Building Typology	Average number of dwellings	Average area per dwelling (sq.m)
HEX:1								CR/HEX:1		
HEX:2								CR/HEX:2		
HEX:2/SOS								CR/HEX:2/SOS		
HBET:3,5								CR/HBET:3,5		
HBET:3,5/SOS								CR/HBET:3,5/SOS		
HBET:6+								CR/HBET:6+		
HBET:6+/SOS								CR/HBET:6+/SOS		
Total	NEEDS TO SUM TO 100%	NEEDS TO SUM TO 100%	NEEDS TO SUM TO 100%	NEEDS TO SUM TO 100%	NEEDS TO SUM TO 100%	NEEDS TO SUM TO 100%	NEEDS TO SUM TO 100%			

	LFINF	LDUAL	LFM	LWAL	LFLSINF	LFLS	Unknown	Total
MCF								NEEDS TO SUM TO 100%

MCF	LFINF	LDUAL	LFM	LWAL	LFLSINF	LFLS	Unknown	Building Typology	Average number of dwellings	Average area per dwelling (sq.m)
HEX:1								MCF/HEX:1		
HEX:2								MCF/HEX:2		
HEX:2/SOS								MCF/HEX:2/SOS		
HBET:3,5								MCF/HBET:3,5		
HBET:3,5/SOS								MCF/HBET:3,5/SOS		
HBET:6+								MCF/HBET:6+		
HBET:6+/SOS								MCF/HBET:6+/SOS		
Total	NEEDS TO SUM TO 100%	NEEDS TO SUM TO 100%	NEEDS TO SUM TO 100%	NEEDS TO SUM TO 100%	NEEDS TO SUM TO 100%	NEEDS TO SUM TO 100%	NEEDS TO SUM TO 100%			

	LFINF	LDUAL	LFM	LWAL	LFLSINF	LFLS	Unknown	Total
MUR								NEEDS TO SUM TO 100%

MUR	LFINF	LDUAL	LFM	LWAL	LFLSINF	LFLS	Unknown	Building Typology	Average number of dwellings	Average area per dwelling (sq.m)
HEX:1								MUR/HEX:1		
HEX:2								MUR/HEX:2		
HEX:2/SOS								MUR/HEX:2/SOS		
HBET:3,5								MUR/HBET:3,5		
HBET:3,5/SOS								MUR/HBET:3,5/SOS		
HBET:6+								MUR/HBET:6+		
HBET:6+/SOS								MUR/HBET:6+/SOS		
Total	NEEDS TO SUM TO 100%	NEEDS TO SUM TO 100%	NEEDS TO SUM TO 100%	NEEDS TO SUM TO 100%	NEEDS TO SUM TO 100%	NEEDS TO SUM TO 100%	NEEDS TO SUM TO 100%			

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