SERA
Seismology and Earthquake Engineering Research Infrastructure Alliance for Europe

DELIVERABLE

D26.1 Taxonomy of European residential, commercial, industrial buildings and industrial plants

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Summary

This deliverable describes the common classification scheme (i.e. taxonomy) that will be used within the European risk framework being developed in SERA JRA4 for buildings and other elements at risk (with a focus on the main components of industrial facilities, i.e. pipelines and storage tanks). By using a single classification scheme, it is possible to ensure that fragility/vulnerability models[1] 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 building taxonomy presented herein is based on an international standard (the GEM Building Taxonomy) and it is being used in the development of building exposure models in SERA Task 26.1 and fragility and vulnerability functions in SERA Task 26.3. A new taxonomy for pipelines and storage tanks is presented herein, based on the experience gained in the European projects SYNER-G, STREST and INDUSE-2-SAFETY, and this classification will be used for the data model of the European vulnerability database that is being developed within SERA Task 26.3.

[1] Fragility/vulnerability models describe the probability of reaching or exceeding levels of damage/loss, conditional on specific levels of ground motion

1 Classifying Elements at Risk

A probabilistic seismic risk assessment (PSRA) involves the estimation of the probability of damage and losses resulting from potential future earthquakes. This damage and loss might occur to buildings, infrastructure, people or even the environment. Within the European risk framework that is being developed within SERA, the focus is being placed on estimating damage and loss for residential, commercial and industrial buildings (and their occupants) and the main components of critical infrastructure (primarily pipelines and storage tanks in industrial plants).

In simple terms, a PSRA involves the calculation and convolution of seismic hazards (which might be strong ground shaking, or ground failure due to liquefaction and landslides), fragility/vulnerability functions for each element at risk, and exposure models, describing primarily the location and value of all elements at risk (Equation 1). In order to ensure there is full compatibility between the exposure model and the fragility/vulnerability functions, it is necessary to classify these elements using a common language or classification scheme, i.e. taxonomy.

$$\text{SEISMIC RISK} = \text{SEISMIC HAZARD} * \text{FRAGILITY/VULNERABILITY} * \text{EXPOSURE} \quad (1)$$

The main classifications of European residential buildings that have been used in past risk assessments (e.g. RISK-UE, LESSLOSS) were reviewed in the EU-funded NERA project (Crowley et al., 2015). These classes of buildings were typically described with a simple classification scheme (e.g. RC1L refers to low-rise reinforced concrete moment frames) that was not easily expanded to include missing types of construction, such as those used for commercial and industrial buildings. They did not make use of a comprehensive building taxonomy. To address this lack of flexibility, the NERA project used the GEM Building Taxonomy (Brzev et al., 2013) to classify European residential buildings, and this classification scheme will continue to be used in the European risk framework being developed in SERA for residential, commercial and industrial buildings. Chapter 2 describes the main features of the GEM Building Taxonomy and how engineers across Europe are using it to describe the building stock.

The main components at risk within European industrial plants include gas, oil and water/wastewater pipelines and storage tanks. Classifications of these elements at risk have been addressed in the EU-funded projects SYNER-G, STREST and INDUSE-2-SAFETY. The main findings of these three projects have been used herein to produce a new classification scheme for pipelines and tanks to be used within the European risk framework and the European vulnerability database, as described in Chapter 3.

2 Classification of Buildings

This section describes how residential, commercial and industrial buildings will be classified within the European risk framework, and how data is being collected across Europe to produce a common set of structural systems to be used in the Europe-wide risk assessment (Task 26.5). A preliminary list of the structural systems used in European residential buildings is also provided, and this will soon be expanded for commercial and industrial buildings.

2.1 GEM Building Taxonomy

The GEM Building Taxonomy (Brzev et al., 2013) is a uniform classification system supported by the Global Earthquake Model (www.globalquakemodel.org) that can be applied to buildings across the globe. A genetic code (genome) that is a unique description for a building or a building typology can be generated using this taxonomy. This code is defined by 13 main attributes and each attribute corresponds to a specific building characteristic that affects its seismic performance such as material, lateral load-resisting system, building height, etc. (Figure 1). The taxonomy is organized as a series of expandable tables and each attribute can be described by one or more level of detail (Figure 2).

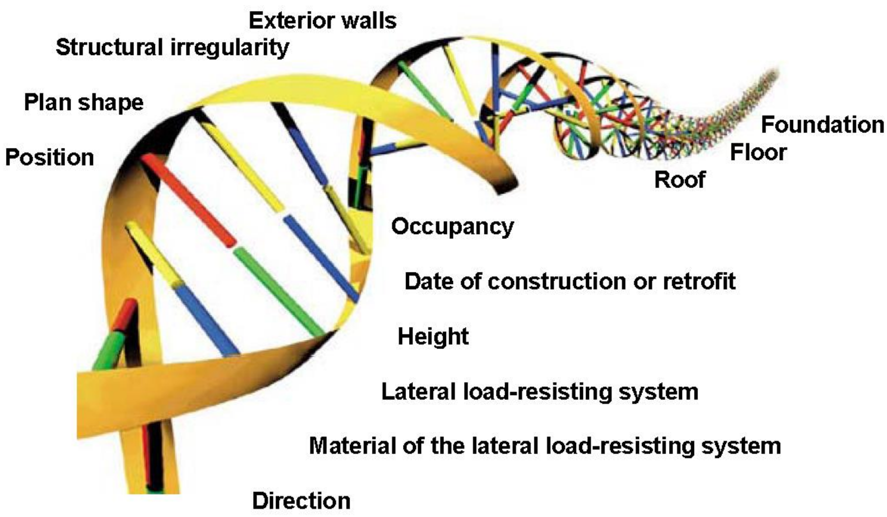


Figure 1: 13 main characteristics of the GEM Building Taxonomy that can be used to define a genetic code (genome) of a building

The main benefit of the GEM Building Taxonomy is that it is expandable and collapsible, and so it can be used to describe both the detailed attributes of a single building as well as the general characteristics of a structural system used for a class of buildings. It is thus ideal for the European risk framework, which should lay out the principles of damage and loss assessment for different scales of resolution, from site-specific, to local, to national/continental (often also referred to as regional). Many of the attributes in the taxonomy are also relevant for other natural hazards, and expansion of the taxonomy for use in flood, storms and volcano risk is being carried out in collaboration with the World Bank's Global Facility for Disaster Risk Reduction (GFDRR), the CIMA Foundation (International Centre on Environmental Modelling), and the British Geological Survey.

A few attributes of the GEM building taxonomy that may need to be modified or expanded for the purpose of the European risk framework have been identified by the team working on this deliverable: ductility of lateral load resisting system; foundation; and composite steel-concrete solutions. The ductility of the lateral load resisting system partly covers the design code used at the time of construction, but it is proposed that this should instead be more explicitly included with an attribute for design code with the following values: no code, low code, medium code and high code. For the foundation, this would ideally be expanded to also account for the foundation soil type in order to allow the soil-structure interaction affects of foundation flexibility and radiation damping to be accounted for in fragility functions (see e.g. Karapatrou et al., 2015). Finally, modifications will need to be made to allow typical solutions that are often adopted for composite buildings (e.g. steel columns with composite floor beams, composite columns with steel floor beams, composite columns with composite floor beams, RC columns with steel floor beams, RC columns with composite floor beams) to be more easily described.

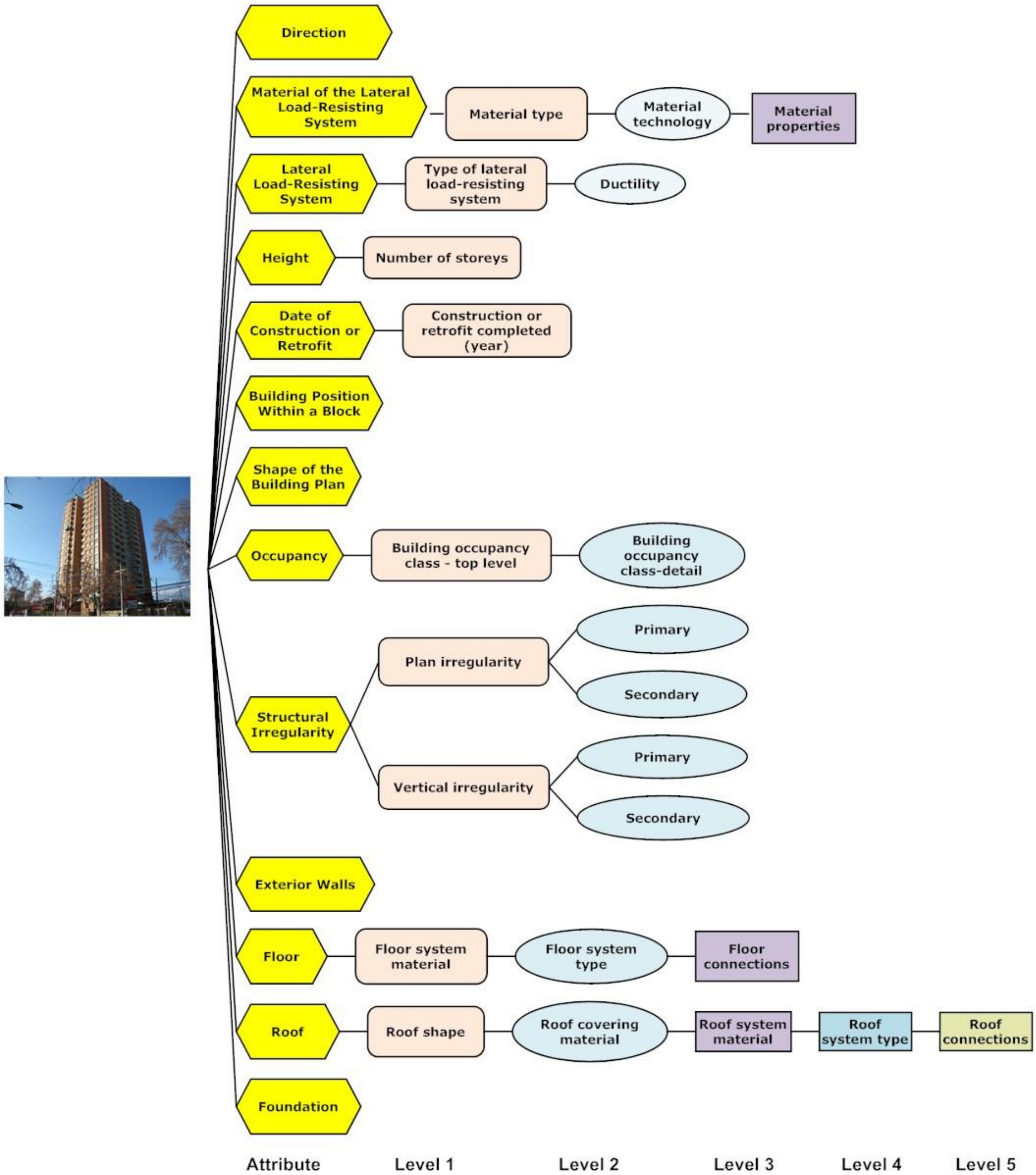


Figure 2: GEM Building Taxonomy: attributes and associated levels of detail

There are a number of tools that have been developed using the GEM Building Taxonomy. Readers are referred to these tools in order to familiarise themselves with the classification scheme:

- TaxT web tool (https://platform.openquake.org/taxtweb/): this tool can be used to describe a building using the GEM Building Taxonomy and produce the associated GEM taxonomy string.
- Glossary for GEM Building Taxonomy (https://taxonomy.openquake.org/): this glossary describes in detail each attribute of the GEM Building Taxonomy, with a number of photos and illustrations.
- Building Data Capture application (https://play.google.com/store/apps/details?id=org.globalquakemodel.org.idctdo): an app that can be downloaded to Android phones or tablets for collecting exposure information according to the GEM Building Taxonomy.
- GEM Building Classification Survey (https://platform.openquake.org/building-class/): an online survey being used to create a detailed inventory of the most frequent building typologies in the world.

The last tool (Building Classification Survey) is being used within SERA JRA4 to collect information for the European residential, commercial and industrial exposure models (to be described in deliverables D26.2 and D26.3), and is thus described in more detail in the next section.

2.2 Building Classification Survey

The Global Earthquake Model (GEM) has developed an online Building Classification Survey, which is being sent to hundreds of researchers, engineers, architects, urban planners and disaster risk modellers in Europe in order to obtain building data for the European risk modelling framework being developed within SERA. The survey was also recently featured in the newsletter of the European Commission's Disaster Risk Management Knowledge Centre's newsletter (Figure 3).

Anyone contributing to the survey is asked to register to the OpenQuake platform (https://platform.openquake.org), and their contributions will be acknowledged in any future publications (should they opt for their details to be shared).

Figure 4 shows the different categories of buildings for which the survey can be compiled for each country: residential, commercial, industrial, educational, healthcare and governmental. Once a category of buildings has been selected, the survey compiler begins to describe the buildings within the country of choice (or region within the country, which can be specified within the notes section).

First, the material of the lateral load resisting system is selected (Figure 5) and then a set of selections related to the material type is presented (e.g. unreinforced, reinforced, confined, unknown). The compiler can decide to end the classification of the building at any level. If at any stage the compiler does not have the information to define the attribute, they can select unknown and continue with the details of the next attribute (Figure 6). As the survey is being filled, a table is compiled at the bottom of the survey with the details that have been input. Once all buildings have been added, the compiler is expected to provide a quantitative or qualitative description of the distribution of the buildings across the rural and urban areas of the country (or region) (Figure 7).

A video tutorial explaining how to compile the survey is also available (in a number of languages including English, Portuguese, Turkish, and Spanish) from the following link: https://platform.openquake.org/building-class/tutorial.

Reducing the risk posed by natural and anthropogenic earthquakes across Europe: the SERA project

The recently launched Horizon 2020 project SERA (Seismology and Earthquake Engineering Research Infrastructure Alliance for Europe) aims to reduce the risk posed by natural and anthropogenic earthquakes across Europe. As part of this effort, a comprehensive earthquake risk modelling framework for Europe is being developed by a core group of engineering / risk partners in collaboration with the Global Earthquake Model or GEM (www.globalquakemodel.org/), and with contributions from the wider engineering / risk community via online tools and workshops. This model will identify the regions in Europe with high seismic risk, and will generate a number of risk metrics fundamental for the development and implementation of disaster risk reduction measures.

One of the first activities of this endeavour involves the compilation of GEM's Building Classification Survey by hundreds of architects, engineers, urban planners and risk modellers across Europe. The aim is to create a detailed inventory of the most frequent building typologies used for residential, commercial and industrial construction in Europe. The tool follows GEM's Building Taxonomy, which is a scheme for classifying buildings worldwide using thirteen different attributes that influence the seismic performance of buildings. Many of these attributes are also relevant for other natural hazards, and expansion of the taxonomy for use in flood risk is being carried out in collaboration with the World Bank's Global Facility for Disaster Risk Reduction (GFDRR), the CIMA Foundation (International Centre on Environmental Modelling), and the British Geological Survey.

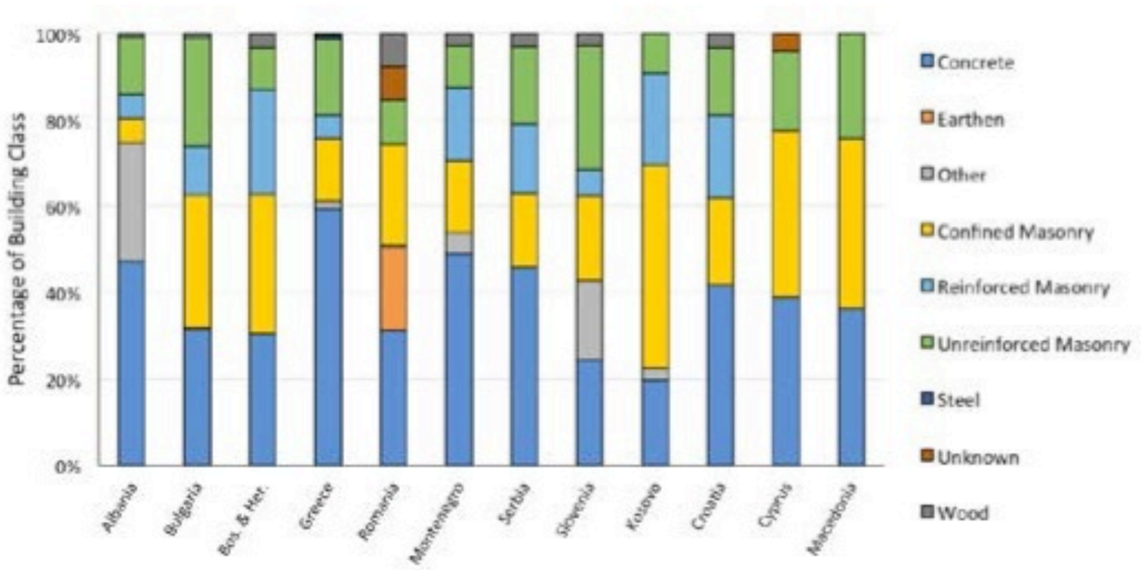
You can help us to build knowledge on the European building stock! If you have data or knowledge on the building stock in any country in Europe, then we encourage you to fill in the "Building Classification Survey" at the following web-link below:

https://platform.openquake.org/building-class/

Your contribution will be much appreciated, and will be acknowledged in any future publications. A Workshop to discuss the input received from this survey, and its use within a European building exposure model, will take place in March 2018, in Pavia, Italy. Finally, all data, models, software and results developed during the SERA project and useful for assessing seismic risk across Europe will be openly released to the community during and after the project.

Helen Crowley
Seismic risk consultant and researcher at the European Centre for Training and Research in Earthquake Engineering (EUCENTRE), who is leading the SERA project work package on European Risk Modelling

For more information:
http://www.sera-eu.org/



Example of analysis of preliminary percentages of building class materials, for countries in the Balkans region.

Figure 3: Dissemination of the Building Classification Survey in the European Commission's Disaster Risk Management Knowledge Centre's newsletter (http://drmkc.jrc.ec.europa.eu/)

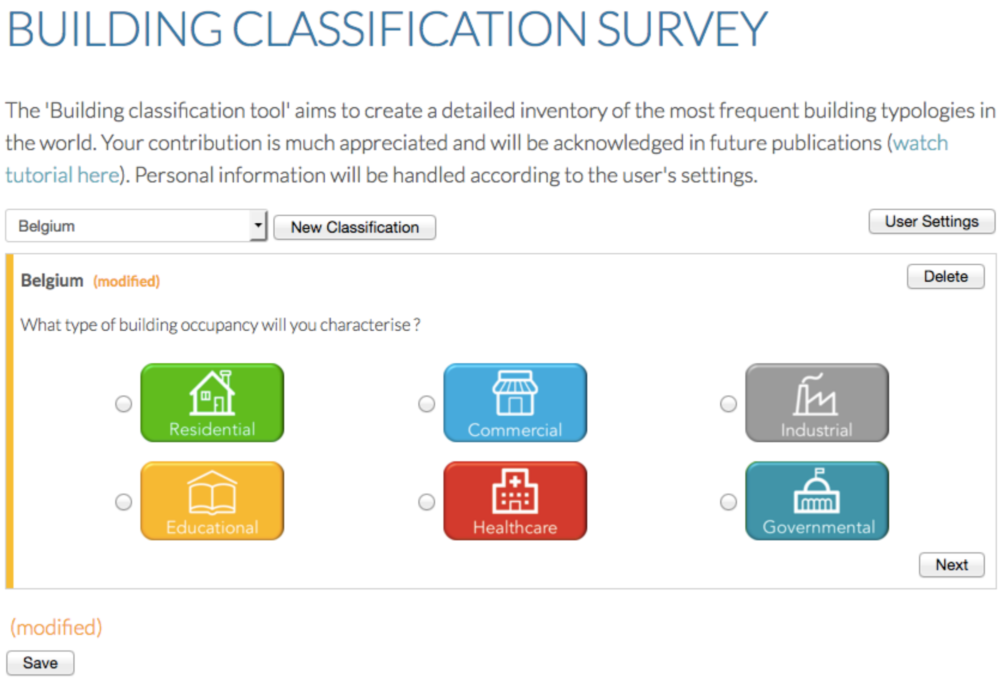


Figure 4: Building Classification Survey: screenshot of building categories

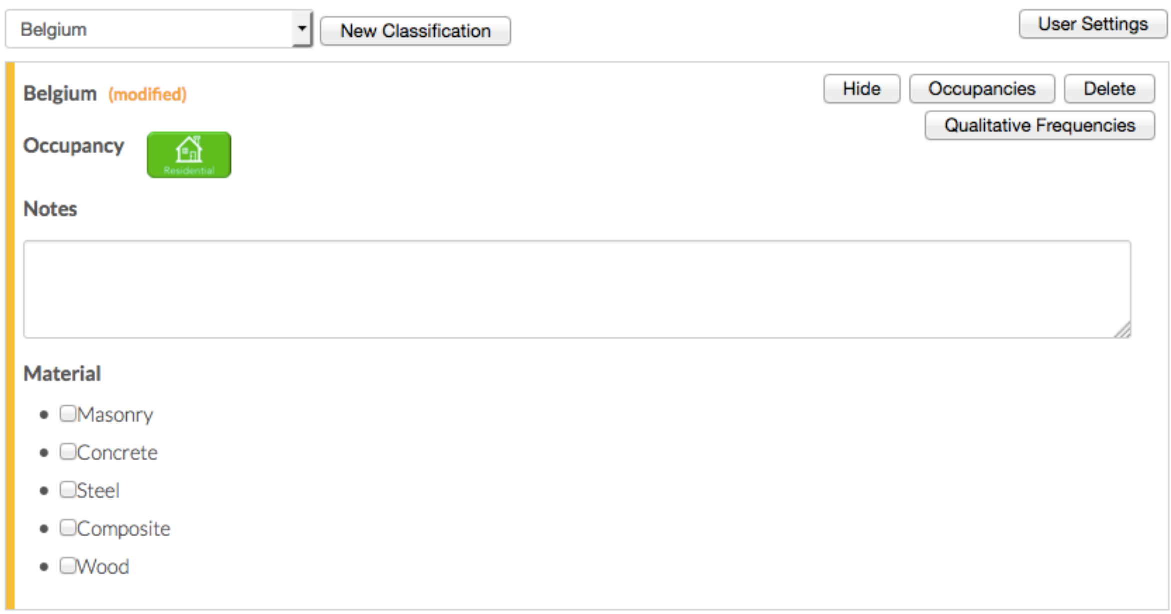


Figure 5: Building Classification Survey: screenshot of lateral load resisting materials

Figure 6: Building Classification Survey: screenshot of detailed attributes of building

Building Type	Urban	Rural
Concrete | Reinforced | Moment frame | Low rise (<3 floors) | Irregular-soft storey | Non ductile (PGA<0.1g) | Cast in place	Frequent	Rare
Concrete | Reinforced | Moment frame | Low rise (<3 floors) | Regular | Non ductile (PGA<0.1g) | Cast in place	Frequent	Rare
Masonry | Unreinforced | Mid rise (4-6 floors) | Regular | Non ductile (PGA<0.1g) | Stone	Moderately Freq	Rare
Masonry | Unreinforced | Low rise (<3 floors) | Non ductile (PGA<0.1g) | Stone	Rare	Frequent

Building Type	Urban	Rural
Concrete | Reinforced | Moment frame | Low rise (<3 floors) | Irregular-soft storey | Non ductile (PGA<0.1g) | Cast in place	0.05	0.1
Concrete | Reinforced | Moment frame | Low rise (<3 floors) | Regular | Non ductile (PGA<0.1g) | Cast in place	0.05	0.5
Masonry | Unreinforced | Mid rise (4-6 floors) | Regular | Non ductile (PGA<0.1g) | Stone	0.1	0.2
Masonry | Unreinforced | Low rise (<3 floors) | Non ductile (PGA<0.1g) | Stone	0.8	0.2

Figure 7: Building Classification Survey: screenshot of summary of buildings and qualitative and quantitative description of their frequency within the urban and rural areas of the country.

So far (month 6 into the project), surveys have been compiled for Portugal, Italy, Cyprus and Austria and many more are expected to arrive in the coming weeks and months. These will be discussed in further detail at a European Building Exposure workshop that will take place on 2nd March 2018 in Pavia, Italy, and the outcomes will be incorporated in the residential, industrial and commercial European exposure models (to be documented in Deliverables D26.2 and D26.3).

The main task that will need to be undertaken once the surveys are completed will be to identify a common set of structural systems (with the same level of detail in terms of structural attributes) that can be used to classify buildings for the European-wide risk assessment (Task 26.5). A first attempt to produce this list of structural systems (for which fragility and vulnerability models will need to be selected/developed in Task 26.3, and documented in Deliverable D26.5) is described for residential buildings in the next section, based on knowledge from previous projects and risk assessments in Europe.

2.3 Preliminary Classification of European Residential Buildings

Based on the current knowledge of residential buildings in Europe from European projects (including RISK-UE, LESSLOSS, NERIES, SYNER-G, STREST and NERA) and national/continental risk assessments (e.g. Silva et al., 2013 for Portugal; Crowley et al., 2008 for Italy; Corbane et al., 2017 for Europe) a preliminary classification of structural systems used for European residential buildings has been developed. This classification makes use of the following four attributes of the GEM Building Taxonomy:

- Material of lateral load-resisting system
- Lateral load-resisting system
- Ductility of the lateral load resisting system (used to account for seismic provisions)
- Height

The values of each attribute are provided in Table 1, whereas a list of 142 structural systems identified within Europe is provided in Table 2.

Table 1. Values of attributes of GEM Building Taxonomy 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	CB99	Concrete blocks, unknown type
	MR	Masonry, reinforced	CL99	Fired clay unit, unknown type
	MCF	Masonry, confined	ST99	Stone, unknown technology
	MATO	Material, other	ADO	Adobe blocks
	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
HEIGHT	H	Number of storeys above ground	HBET	Range of number of storeys above ground
			HEX	Exact number of storeys above ground

Table 2. Preliminary list of 142 distinct structural systems used in European residential buildings, described using the GEM Building Taxonomy

'CR+PC/LWAL+DNO/HBET:3,5'	'CR/LFM+DUCH/HEX:2'	'MCF+CL99/LWAL+DUCL/HEX:2'
'CR+PC/LWAL+DNO/HBET:6+'	'CR/LFM+DUCL/HBET:3,5'	'MCF+CL99/LWAL+DUCM/HBET:3,5'
'CR+PC/LWAL+DNO/HEX:1'	'CR/LFM+DUCL/HBET:3,5/SOS'	'MCF+CL99/LWAL+DUCM/HBET:6+'
'CR+PC/LWAL+DNO/HEX:2'	'CR/LFM+DUCL/HBET:6+'	'MCF+CL99/LWAL+DUCM/HEX:1'
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'CR/LFM+DUCH/HBET:6+'	'MCF+CL99/LWAL+DUCL/HBET:6+'	
'CR/LFM+DUCH/HEX:1'	'MCF+CL99/LWAL+DUCL/HEX:1'	

3 Classification of Components of Industrial Plants

This section describes how pipelines and tanks within industrial buildings will be classified within the European risk framework. Although an exposure model of components of industrial plants across Europe is not going to be developed within SERA, the European vulnerability database that is being developed within Task 26.3 will include fragility and consequence models for pipelines and tanks, and this will need to follow a common taxonomy. The taxonomy presented herein has been developed using the classification experience developed in SYNER-G (Hancila and Taucer, 2013; Gehl et al., 2014), STREST (Crowley et al., 2016) and INDUSE-2-SAFETY (Bursi et al., 2016; Bursi, et al., 2017; Paolacci, et al., 2017).

For gas, water and oil pipelines, a single set of attributes has been defined as presented in Table 3. The most important attributes for the seismic performance of pipelines (as identified by a number of studies including those documented in ALA, 2001 and FEMA, 2004) are: pipe barrel material (with more ductile materials showing lower damage), pipeline joints (with continuous joints such as welded or mechanically restrained showing better performance than rigid segmented joints, such as cement), extent of corrosion (that can be identified from material type, age, wall thickness, corrosion protection and surrounding soil type), diameter (with larger pipes demonstrating lower damage rates than smaller pipes), and burial depth (as wall thickness increases and soils improve with depth), pipe wall thickness (which can have a major impact on the magnitude of pipe deformation before leakage) and operational internal pressure (which can heavily influence the magnitude of the eventual loss of containment). With regard to pipelines present in industrial plants -not buried - critical parts are elbows and bolted flange joints close to vessels and nozzles of storage tanks. Also the interaction with support structures can become critical if support structures – made of steel or concrete for fire safety measures – are not properly designed for seismic loading (Bursi et al., 2017).

Although all of these attributes could be used to describe the seismic performance of pipelines, many of them are correlated and the majority of available fragility functions only use, at a maximum, the attributes that have been selected herein (Table 3). However, it is clear that additional attributes could easily be added to the pipeline taxonomy in the future, should it be necessary to further differentiate between fragility functions for pipelines being uploaded to the European vulnerability database. It is noted that the taxonomy for pipelines is also applicable for pipelines in lifeline networks at a city/regional scale.

The taxonomy string should be defined using the appropriate element codes for each attribute, presented in the following manner:

CONTENT/LOCATION/GEOMORPHOLOGY/MATERIAL/DIAMETER/WALL-THICKNESS/YEAR_CONSTRUCTION/JOINT_TYPE/DESIGN_CODE/CORROSIVENESS_SOILS/FOUNDATION_SOIL

For example, a 30 cm diameter, buried, welded steel pipeline with arc-welded connections carrying water in corrosive soil with bulky walls, and designed with Eurocode would be described as follows: WW/BU/GE99/WS/SM/BW/Y99/AW/EC/SC/S99. The minimum attributes that should be provided to the European vulnerability database when uploading data related to pipelines are location, material and joint type.

Table 3. Attributes of proposed taxonomy to described pipelines in industrial plants

ATTRIBUTE	ELEMENT CODE	VALUE
CONTENT	GS	Gas
	OL	Oil
	WW	Water, wastewater
	CNO	Other content
	CN99	Unknown content
LOCATION	BU	Buried
	EL	Elevated
GEOMORPHOLOGY	MOU	Mountains
	RIV	Rivers
	STS	Regions with steep slopes
	SHS	Regions with shallow slopes
	GEO	Other geomorphology
	GE99	Unknown geomorphology
MATERIAL	PVC	Polyvinyl chloride
	PE	Polyethylene
	CI	Cast iron
	DI	Ductile iron
	WS	Welded steel
	SS	Stainless steel
	RPM	Reinforced plastic mortar
	RTM	Resin transfer moulding
	AC	Asbestos-cement
	C	Concrete
	CL	Clay
	OM	Other material
	B99	Unknown, brittle
	D99	Unknown, ductile
	M99	Unknown material
DIAMETER	SM	Small (< 40 cm)
	LG	Large (≥ 40 cm)
	DI99	Unknown diameter
WALL-THICKNESS	TW	Thin walls ≤ SCH40/STD
	BW	Bulky walls >SCH40/STD

ATTRIBUTE	ELEMENT CODE	VALUE
	T99	Unknown thickness
YEAR OF CONSTRUCTION	YBET:	Bounds for the years of construction
	Y99	Date unknown
JOINT TYPE	AW	Arc welded
	GW	Gas welded
	CE	Cemented
	FW	Fillet weld
	ELB	Elbow
	BS	Bell and spigot (caulked)
	RI	Riveted
	MR	Mechanical restrained
	BF	Bolted flange joint
	SCR	Screwed
	RU	Rubber gasket
	SG99	Unknown, segmented
	C99	Unknown, continuous
	JO	Other joint
	J99	Unknown joint
DESIGN CODE	EC	Eurocode
	API	API
	ASME	ASME
	DCO	Other code
	DC99	Unknown
CORROSIVENESS OF SOILS	SC	Corrosive
	SNC	Non corrosive
	SC99	Unknown corrosiveness
FOUNDATION SOIL	FSR	Rock
	FSF	Firm soil
	FSS	Soft soil
	FS99	Unknown soil

For storage tanks, the main attributes that influence the seismic performance (and which have been used to distinguish fragility functions in past studies) are presented in Table 4. As discussed in Gehl et al. (2014), damage reports from past earthquakes have identified that the most important attributes for the seismic performance of storage tanks include material (with steel and reinforced concrete being the main materials used), anchorage (with unanchored tanks being highly vulnerable), height-to-diameter ratio (with tanks with larger ratios, i.e. slender tanks, showing more damage), and the amount of liquid stored (as full tanks are subject to larger lateral forces and overturning moments due to liquid sloshing). Moreover, one needs to include the tank wall thickness (which can influence common failure modes including elephant foot buckling and diamond shape buckling), the presence of floating roofs for broad tanks and the type of nozzle reinforcement that could influence their seismic performance. Also the presence of support columns is important (Paolacci et al., 2017).

The taxonomy string should be defined using the appropriate element codes for each attribute, presented in the following manner:

LOCATION/MATERIAL/YEAR_CONSTRUCTION/ANCHORAGE/SHAPE_FACTOR/CONTENT/WALL-THICKNESS/FLOATING_ROOF/FOUNDATION_TYPE/FOUNDATION_SOIL/DESIGN_CODE

For example, a 90% full steel anchored tank located at grade with height over diameter ratio of 0.3 and thin walls would be described as follows: AG/S/Y99/ANC/SQ/FU/TW/R99/FO99/S99/DC99. The minimum attributes that should be provided to the European vulnerability database when uploading data related to storage tanks are location, material and anchorage.

Table 4. Attributes of proposed taxonomy to described storage tanks in industrial plants

ATTRIBUTE	ELEMENT CODE	LEVEL 1 VALUE
LOCATION	AG	At grade
	EL	Elevated
MATERIAL	S	Steel
	CR	Reinforced Concrete
	W	Wood
	MUR	Unreinforced masonry
	MO	Material, other
	M99	Material, unknown
YEAR OF CONSTRUCTION	YBET:	Bounds for the years of construction
	Y99	Date unknown
ANCHORAGE	ANC	Anchored
	UANC	Unanchored
	ANC99	Unknown anchorage
SHAPE FACTOR	SQ	Squat (Height/Diameter < 0.7)
	SL	Slender (Height/Diameter ≥ 0.7)
	SF99	Unknown shape factor

ATTRIBUTE	ELEMENT CODE	LEVEL 1 VALUE
CONTENT	FU	Near full (50-100%)
	HF	Up to half-full (<50%)
	EMP	Empty (0%)
	CN99	Unknown content
WALL-THICKNESS	TW	Thin walls – thickness to diameter ratios t/d<1/2000
	BW	Bulky walls – thickness to diameter ratio /d≥1/2000
	T99	Unknown thickness
FLOATING ROOF	RP	Present
	RNP	Not present
	R99	Unknown presence
FOUNDATION TYPE	SH	Shallow foundation
	DE	Deep foundation
	FO99	Unknown foundation type
FOUNDATION SOIL	FSR	Rock
	FSF	Firm soil
	FSS	Soft soil
	FS99	Unknown soil type
DESIGN CODE	EC	Eurocode
	API	API
	ASME	ASME
	DCO	Other code
	DC99	Unknown design code

4 Next Steps

The next few months will involve the evaluation of the Building Classification Surveys currently being compiled by engineers, researchers, urban planners, architects and risk modellers from around Europe. The data will be evaluated to identify a common set of structural systems (most likely based on the attributes of the material of the lateral load-resisting system, the type of lateral load-resisting system (including its associated ductility) and system height) for commercial, industrial and residential buildings across Europe. A revised version of this deliverable will be prepared during the project to include the final sets of structural systems for the aforementioned building types.

The European vulnerability database is currently being developed, starting from the data model of the GEM Global Vulnerability Database (https://platform.openquake.org/vulnerability/list). This database currently only includes buildings, and so it will need to be expanded (considering the taxonomies presented herein) for the main components of industrial plants, i.e. pipelines and storage tanks. As fragility and vulnerability models are collected for input into this database, the need to expand the taxonomies proposed herein may be identified, and any changes will be documented in a revised version of this deliverable.

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