

Support Action for Strengthening PAlestine capabilities for seismic Risk Mitigation

SASPARM 2.0

**2014 PROJECT FOR CIVIL PROTECTION FINANCIAL INSTRUMENT
PREPAREDNESS AND PREVENTION SCHEME**

TAXONOMY PRESENTATION

Name
e-mail



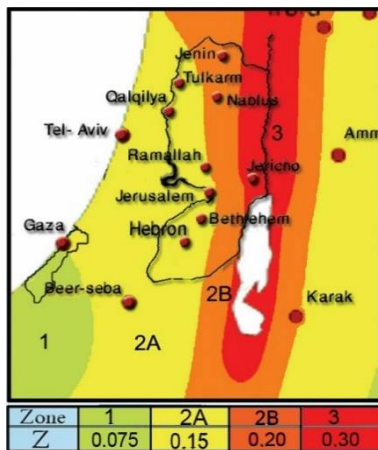
Project goal

SEISMIC RISK

$$R = H \cdot V \cdot E$$



Hazard



Vulnerability



Exposure



Data collection necessary to:

- ✓ Identify significant typologies;
- ✓ Elaborate vulnerability functions;
- ✓ Assign vulnerability function to each building typology.



Creation of a reasonable **TAXONOMY** able to classify all the different kinds of structures.



Taxonomy

Buildings vary around the world, but they have a common set of characteristics.



Taxonomy

Some existing typologies aim to group different building types spread in different countries of the world:

- ✓ PAGER-STR (Jaiswal and Wald 2008, global)
- ✓ RISK-UE (2001-2004, for Europe)
- ✓ SYNER-G (2011, for Europe)



PAGER – STR Taxonomy

- ✓ Building stock model using housing census, statistical data and data from literature → early post-earthquake estimates of losses for rapid emergency decisions:

3 phases:

- ✓ Database identification, preparation and confidence ratio to estimate quality of data;
- ✓ Data aggregation and quality ranking;
- ✓ Data assignment for missing entries.



PAGER – STR Taxonomy

- ✓ 15 classes are defined with relative and more detailed subclasses

LABEL	DESCRIPTION
W	Wood
W1	Wood frame, wood stud, wood, stucco, or brick veneer
W2	Wood frame, heavy members, diagonals or bamboo lattice, mud infill
W3	Wood frame, prefabricated steel stud panels, wood or stucco exterior walls
W4	Log building
S	Steel
S1	Steel moment frame ^a
S2	Steel braced frame ^a
S3	Steel light frame
S4	Steel frame with cast-in-place concrete shear walls ^a
S5	Steel frame with unreinforced masonry infill walls ^a
C	Reinforced Concrete
C1	Ductile reinforced concrete moment frame ^a
C2	Reinforced concrete shear walls ^a
C3	Nonductile reinforced concrete frame with masonry infill walls ^a
C4	Nonductile reinforced concrete frame without masonry infill walls ^a
C5	Steel reinforced concrete (steel members encased in reinforced concrete) ^a
PC1	Precast concrete tilt-up walls (low rise)
PC2	Precast concrete frames with concrete shear walls ^a
TU	Precast wall panel construction (mid to high rise, former Soviet Union style)
RM	Reinforced Masonry
RM1	Reinforced masonry bearing walls with wood or metal deck diaphragms ^b
RM2	Reinforced masonry bearing walls with concrete diaphragms ^a
MH	Mobile Homes
M	Mud Walls
M1	Mud walls without horizontal wood elements
M2	Mud walls with horizontal wood elements

LABEL	DESCRIPTION
A	Adobe Block (Unbaked Dried Mud Block) Walls
A1	Adobe block, mud mortar, wood roof and floors
A2	Same as A1, bamboo, straw, and thatch roof
A3	Same as A1, cement-sand mortar
A4	Same as A1, reinforced concrete bond beam, cane and mud roof
A5	Same as A1, with bamboo or rope reinforcement
RE	Rammed Earth/Pneumatically Impacted Stabilized Earth
RS	Rubble Stone (Field Stone) Masonry
RS1	Local field stones dry stacked (no mortar). Timber floors. Timber, earth, or metal roof.
RS2	Same as RS1 with mud mortar.
RS3	Same as RS1 with lime mortar.
RS4	Same as RS1 with cement mortar, vaulted brick roof and floors
RS5	Same as RS1 with cement mortar and reinforced concrete bond beam.
DS	Rectangular Cut Stone Masonry Block
DS1	Rectangular cut stone masonry block with mud mortar, timber roof and floors
DS2	Same as DS1 with lime mortar
DS3	Same as DS1 with cement mortar
DS4	Same as DS2 with reinforced concrete floors and roof
UFB	Unreinforced Fired (baked) Brick Masonry
UFB1	Unreinforced brick masonry in mud mortar without timber posts
UFB2	Unreinforced brick masonry in mud mortar with timber posts
UFB3	Unreinforced fired brick masonry, cement mortar, timber or timber-and-steel gravity system
UFB4	Same as UFB3, but with reinforced concrete floor and roof slabs
UCB	Unreinforced Concrete Block Masonry, Lime/Cement Mortar
MS	Massive Stone Masonry in Lime/Cement Mortar
INF	Informal Construction (makeshift dwellings, made from plastic/GI sheets or other material)
UNK	Unknown (Not specified)



PAGER – STR Taxonomy

- ✓ Simple and collapsible;
- ✓ Capture most of the key structural aspects that affect seismic performance;
- ✓ International coverage: variety of structural types found outside the more developed countries;
- ✓ Difficulty in extending it (if necessary to be more specific, # possible structural types increases rapidly, making taxonomy unmanageable).



RISK – UE Taxonomy

- ✓ Assessment of earthquake scenarios at city-scale within European context (application in 7 European cities);
- ✓ Implementation of Risk Management Plans and Plans of Action;
- ✓ Modular methodology comprised of different work packages.



RISK – UE Taxonomy

- ✓ 23 classes defined grouped by structural types and material;
- ✓ 3 different height classes represent further sub-groups.

Label	Description	Rise	Average No. of stories
M11L M11M	Rubble Stone, fieldstone	Low-rise	1-2
		Mid-Rise	3-5
M12L M12M M12H	Simple Stone	Low-rise	1-2
		Mid-Rise	3-5
		High-rise	6+
M13L M13M M13H	Massive Stone	Low-rise	1-2
		Mid-Rise	3-5
		High-rise	6+
M2L	Adobe	Low-Rise	1-2
M31L M31M M31H	Wooden slabs URM	Low-rise	1-2
		Mid-Rise	3-5
		High-rise	6+
M32L M32M M32H	Masonry vaults URM	Low-rise	1-2
		Mid-Rise	3-5
		High-rise	6+
M33L M33M M33H	Composite slabs URM	Low-rise	1-2
		Mid-Rise	3-5
		High-rise	6+
M34L M34M M34H	RC slabs URM	Low-rise	1-2
		Mid-Rise	3-5
		High-rise	6+
M4L	Reinforced or confined masonry	Low-rise	1-2

Label	Description	Rise	Average No. of stories
M4M M4H		Mid-Rise	3-5
		High-rise	6+
M5L M5M M5H	Overall strengthened masonry	Low-rise	1-2
		Mid-Rise	3-5
		High-rise	6+
RC1L RC1M RC1H	RC moment frames	Low-rise	1-2
		Mid-Rise	3-5
		High-rise	6+
RC2L RC2M RC2H	RC shear walls	Low-rise	1-2
		Mid-Rise	3-5
		High-rise	6+
RC31L RC31M RC31H	Regularly infilled RC frames	Low-rise	1-2
		Mid-Rise	3-5
		High-rise	6+
RC32L RC32M RC32H	Irregular RC frames	Low-rise	1-2
		Mid-Rise	3-5
		High-rise	6+
RC4L RC4M RC4H	RC dual systems	Low-rise	1-2
		Mid-Rise	3-5
		High-rise	6+
RC5L RC5M RC5H	Precast concrete tilt-up walls	Low-rise	1-2
		Mid-Rise	3-5
		High-rise	6+



RISK – UE Taxonomy

- ✓ Methodology to collect and classify buildings and earthquake data for urban seismic risk assessment in Europe;
- ✓ Completion of European manual for implementing earthquake scenarios, taking into account distinctive European features;
- ✓ Takes into account main structural typologies, but not other non-engineered buildings.



SYNER-G Taxonomy

- ✓ Built to classify European buildings and to overcome problems of other existing taxonomies;
- ✓ Modular structure in order to add categories, sub-categories and further categories for describing non-structural elements.



SYNER-G Taxonomy

✓ 10 classes and respective sub-classes;

CATEGORY	SUB-CATEGORY
Force Resisting Mechanism (FRM1) <ul style="list-style-type: none"> • Moment Resisting Frame (MRF) • Structural Wall (W) • Flat Slab (FS) • Bearing Walls (BW) • Precast (P) • Confined Masonry (CM) 	Force Resisting Mechanism (FRM2) <ul style="list-style-type: none"> • Embedded beams (EB) • Emergent beams (EGB)
FRM Material (FRMM1) <ul style="list-style-type: none"> • Concrete (C) • Masonry (M) 	FRM Material (FRMM2) <ul style="list-style-type: none"> • Reinforced Concrete (RC) • Unreinforced Masonry (URM) • Reinforced Masonry (RM) • High strength concrete (>50MPa) (HSC) • Average strength concrete (20-50 MPa) (ASC) • Low strength concrete (<20 MPa) (LSC) • Adobe (A) • Fired brick (FB) • Hollow clay tile (HC) • Stone (S) • High yield strength reinforcing bars (>300MPa) (HY) • Low yield strength reinforcing bars (<300MPa) (LY) • Classification of reinforcing bars based on EC2 (A,B,C) • Lime mortar (LM) • Cement mortar (CM) • Mud mortar (MM) • Smooth rebars (SB) • Non-smooth rebars • Concrete Masonry Unit (CMU) • Autoclaved Aerated Concrete (AAC) • High % of voids (H%) • Low % of voids (L%) • Regular Cut (Rc) • Rubble (Ru)
Plan (P) <ul style="list-style-type: none"> • Regular (R) • Irregular (IR) 	

CATEGORY	SUB-CATEGORY
Elevation (E) <ul style="list-style-type: none"> • Regular geometry (R) • Irregular geometry (IR) 	
Cladding (C) <ul style="list-style-type: none"> • Regular infill vertically (RI) • Irregular infill vertically (IRI) • Bare (B) 	Cladding Characteristics (CM) <ul style="list-style-type: none"> • Fired brick masonry (FB) • High % voids (H%) • Low % voids (L%) • Autoclaved Aerated Concrete (AAC) • Precast concrete (PC) • Glazing (G) • Single layer of cladding (SL) • Double layer of cladding (DL) • Open first floor (Pilotis) (P) • Open upper floor (U)
Detailing (D) <ul style="list-style-type: none"> • Ductile (D) • Non-ductile (ND) • With tie rods/beams (WTB) • Without tie rods/beams (WoTB) 	
Floor System (FS) <ul style="list-style-type: none"> • Rigid (R) • Flexible (F) 	Floor System Material (FSM) <ul style="list-style-type: none"> • Reinforced concrete (RC) • Steel (S) • Timber (T)
Roof System (RS) <ul style="list-style-type: none"> • Peaked (P) • Flat (F) • Gable End Walls (G) 	Roof System Material (RSM) <ul style="list-style-type: none"> • Timber (Ti) • Thatch (Th) • Corrugated Metal Sheet (CMS)
Height Level (HL) <ul style="list-style-type: none"> • Low-rise (1-3) (L) • Mid-rise (4-7) (M) • High-rise (8-19) (H) • Tall (20+)(Ta) 	Number of stories (NS) [Here the number of stories is explicitly given, if known]
Code Level (CL) <ul style="list-style-type: none"> • None (NC) • Low (<0.1g) (LC) • Moderate (0.1-0.3g) (MC) • High (>0.3g) (HC) 	

SYNER-G Taxonomy

- ✓ Not-hierarchical taxonomy and possibility of increase to capture all the vulnerabilities;
- ✓ Potentiality to treat non-buildings because of the way it is structured;
- ✓ Potentiality for greatest degree of completeness and most flexibility.

Building Typologies

First step for large scale vulnerability assessment:

Identification of
building types



Assessment of seismic
vulnerability for each type

4 building types in Nablus:

- ✓ Reinforced concrete frame buildings;
- ✓ Shear wall buildings;
- ✓ Masonry buildings;
- ✓ Buildings with soft storey.

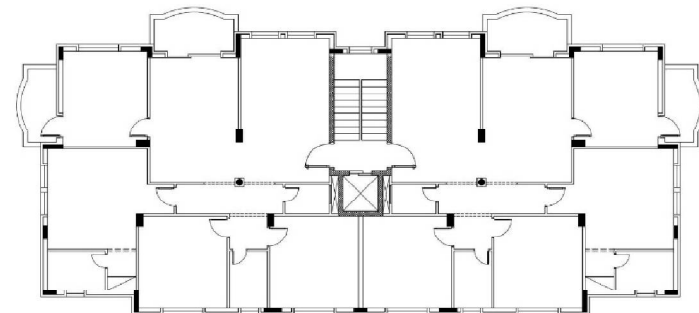
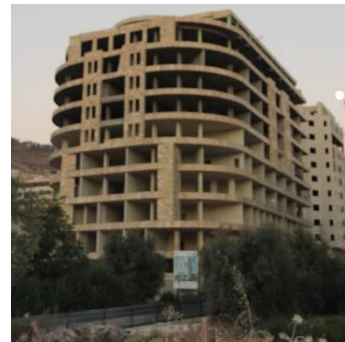


Reinforce Concrete Frame Buildings

Residential: 2 ÷ 3 bays in x,y directions;
up to 15 floors.

Structure: in-situ casted reinforce concrete slabs;
reinforced concrete beams and columns;

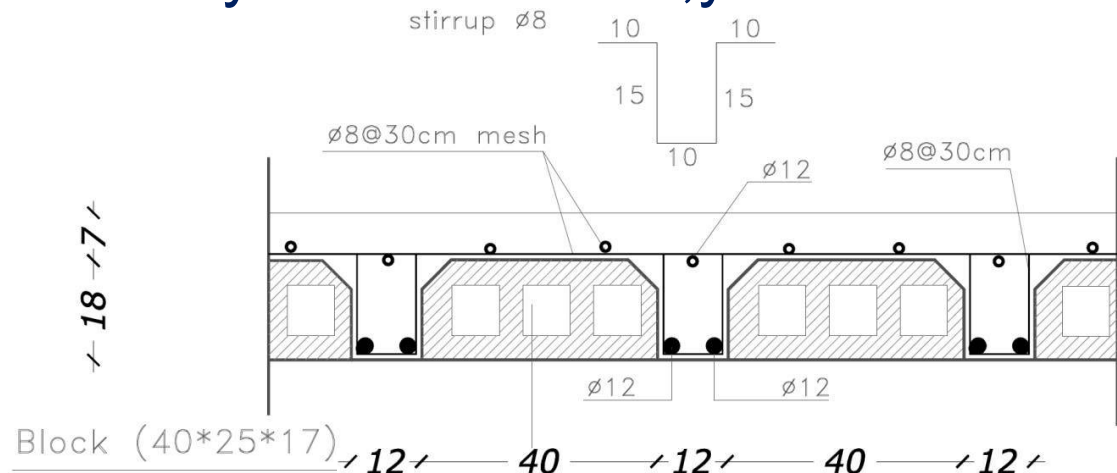
Exterior Walls: masonry made of 3 layers;
hollow concrete blocks.



Reinforce Concrete Frame Buildings

2 slab typologies :

- ✓ **Ribbed with hidden beams:** one-way or two way ribbed slabs with hollow concrete blocks ($140-320 \times 200 \times 400\text{mm}$)
 Dimensions: $100-200 \times 200-500\text{mm}$
 Beams usually hidden within thickness.
 Interstorey h : $3.0 \div 3.5\text{m}$
 Width of bays: $4 \div 6\text{ m}$ in x,y directions



Reinforce Concrete Frame Buildings

2 slab typologies :

- ✓ **Solid with drop beams:** one-way or two-way

Thickness: $150 \div 300\text{mm}$



Beams depth: $400 \div 800\text{mm}$ (allowing large spans for slab panels $6 \div 8\text{m}$ in x,y)



Interstorey h: $2.8 \div 5\text{m}$

Use: car parking garages and commercial bld

Reinforce Concrete Frame Buildings

2 walls typologies :

- ✓ **Masonry walls** made of 3 layers:



Hollow concrete blocks (100mm);

Weak concrete (130mm);

Stone layer (70mm)

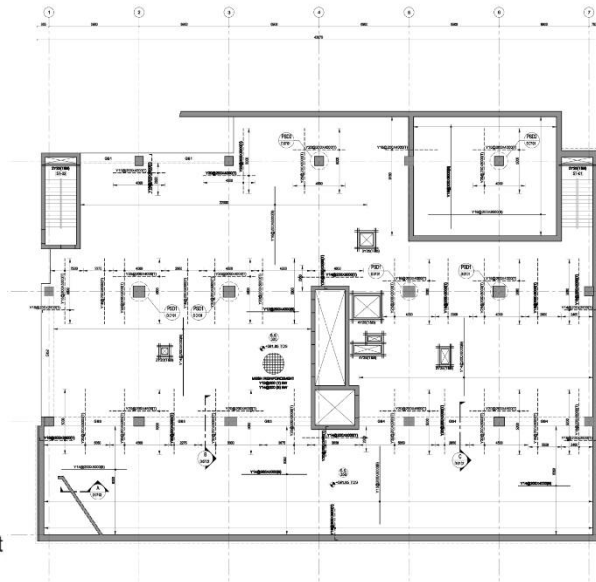
- ✓ **Hollow concrete blocks:** 150 ÷ 200mm

Shear Wall Buildings

Residential: 3 ÷ 5 bays in each direction;
5 ÷ 20 floors.

Structure: reinforced concrete walls for lateral and
vertical support;
possible interior reinforced concrete columns
(gravity loads);

Exterior Walls: masonry stones.



Shear Wall Buildings

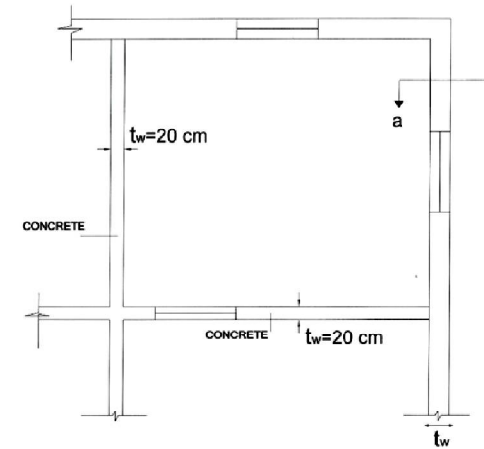
Exterior Walls: cladded with masonry stones giving the appearance of masonry building.



Masonry Buildings

Residential: 1- 2 bays in each direction;
2 - 3 floors.

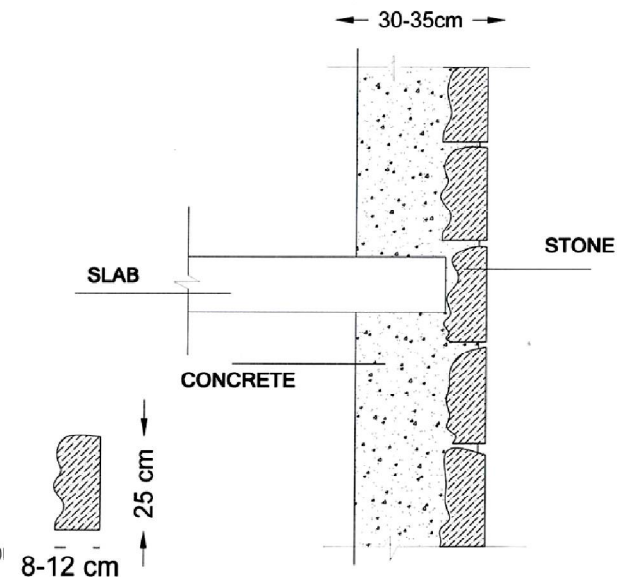
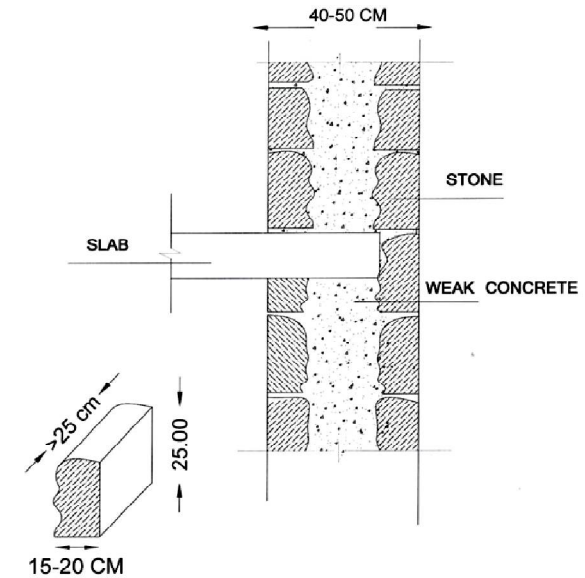
Structure: masonry walls;
reinforced concrete slabs.



Masonry Buildings

2 wall categories:

- ✓ Two layers of masonry stones with concrete in between;
thickness: 400 ÷ 500mm;
- ✓ Masonry cladded row-by-row and concrete is cast behind them via suitable formwork;
thickness: up to 350mm.



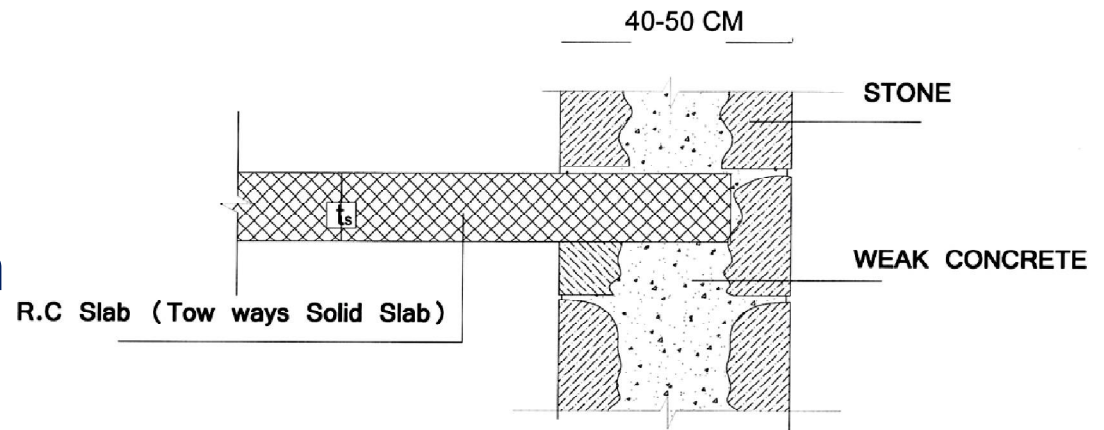
Masonry Buildings

2 kind of slabs:

✓ Two-way solid slab:

thickness: 200 ÷ 250mm

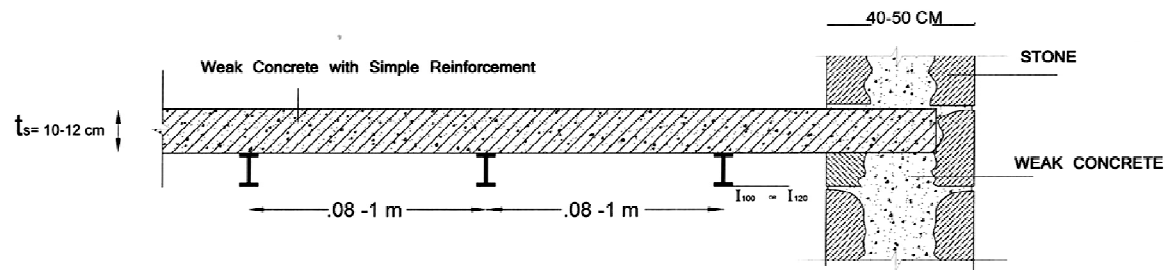
span: 4 - 5m;



✓ Steel concrete slab:

thickness: 100 ÷ 120mm;

span: 5-7m;



Buildings with soft story

Residential

Structure: shear wall system or
reinforced concrete frame system.

Missing infill walls everywhere or in part of floors



Reduced stiffness and eccentricity problems



Thank you for your attention!

