Towards a National Plan for Integrated Seismic and Energy Efficiency Rehabilitation of Schools: Raising the Bar to Enhance Community Resilience and Sustainability

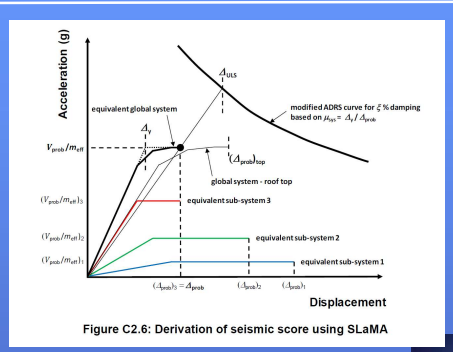
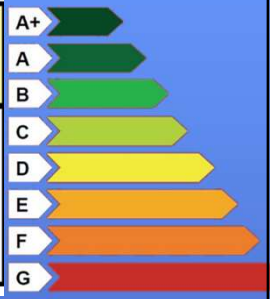
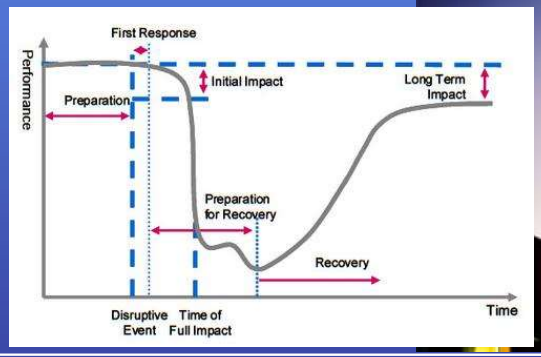


Figure C2.6: Derivation of seismic score using SLaMA

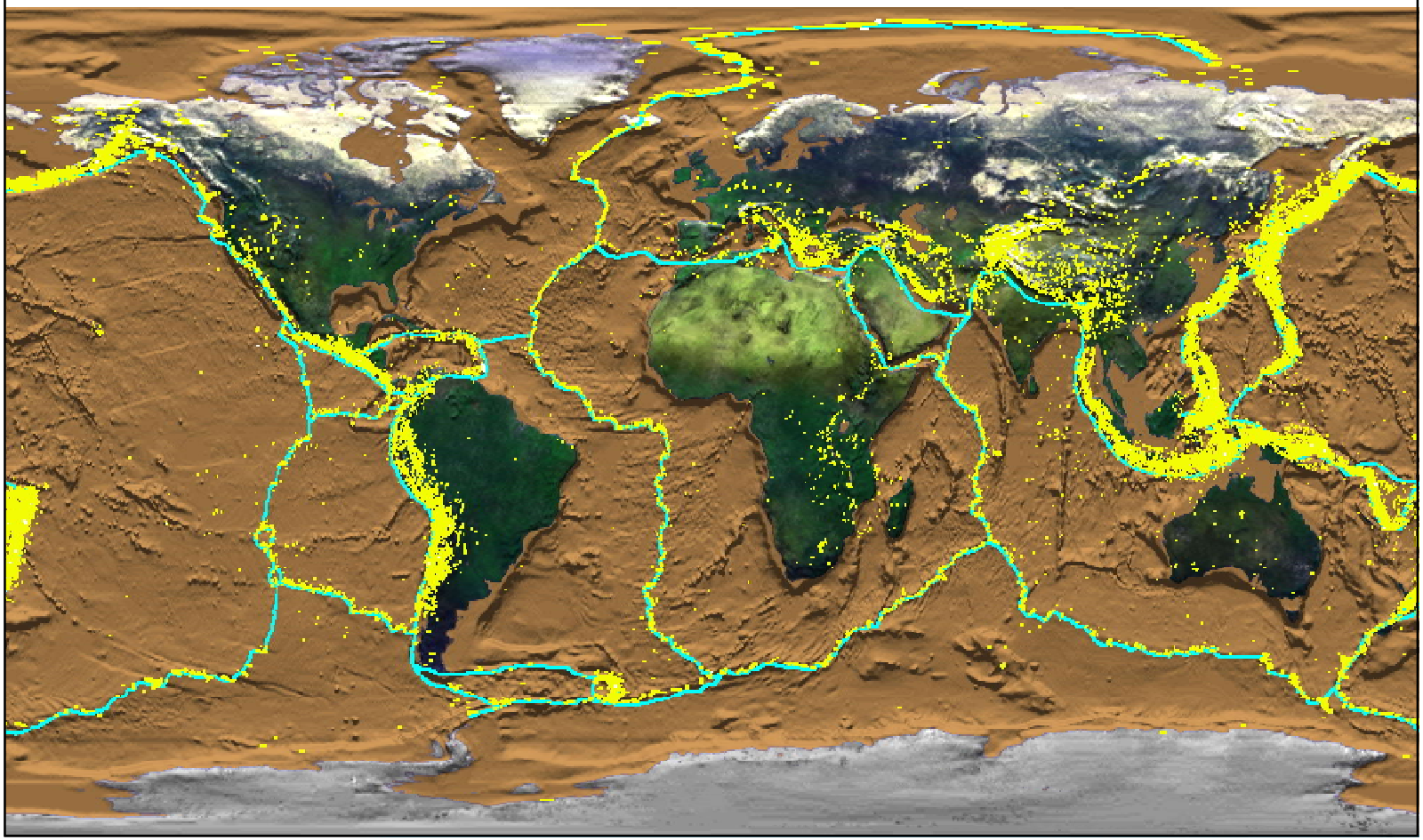
Percentage of New Building Standard (%NBS)	Letter grade	Relative risk (approx)
>100	A+	< 1 time
80–100	A	1–2 times
67–80	B	2–5 times
33–67	C	5–10 times
20–33	D	10–25 times
<20	E	> 25 times



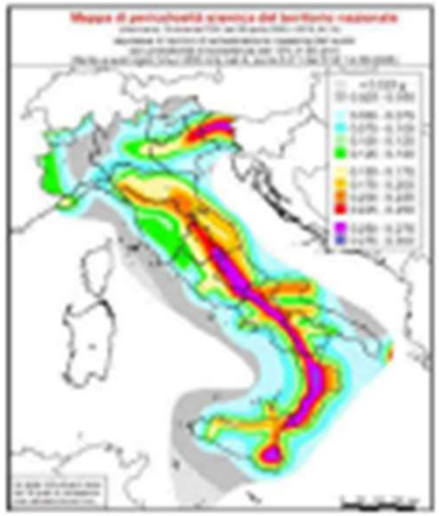


Stefano Pampanin
Professor, University of Rome "La Sapienza" , Italy
Adjunct Professor, University of Canterbury, Christchurch, New Zealand

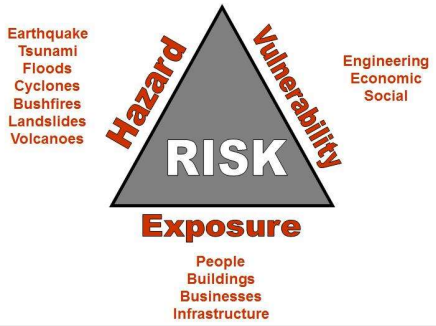
A Common Problem Worldwide



Seismic Risk

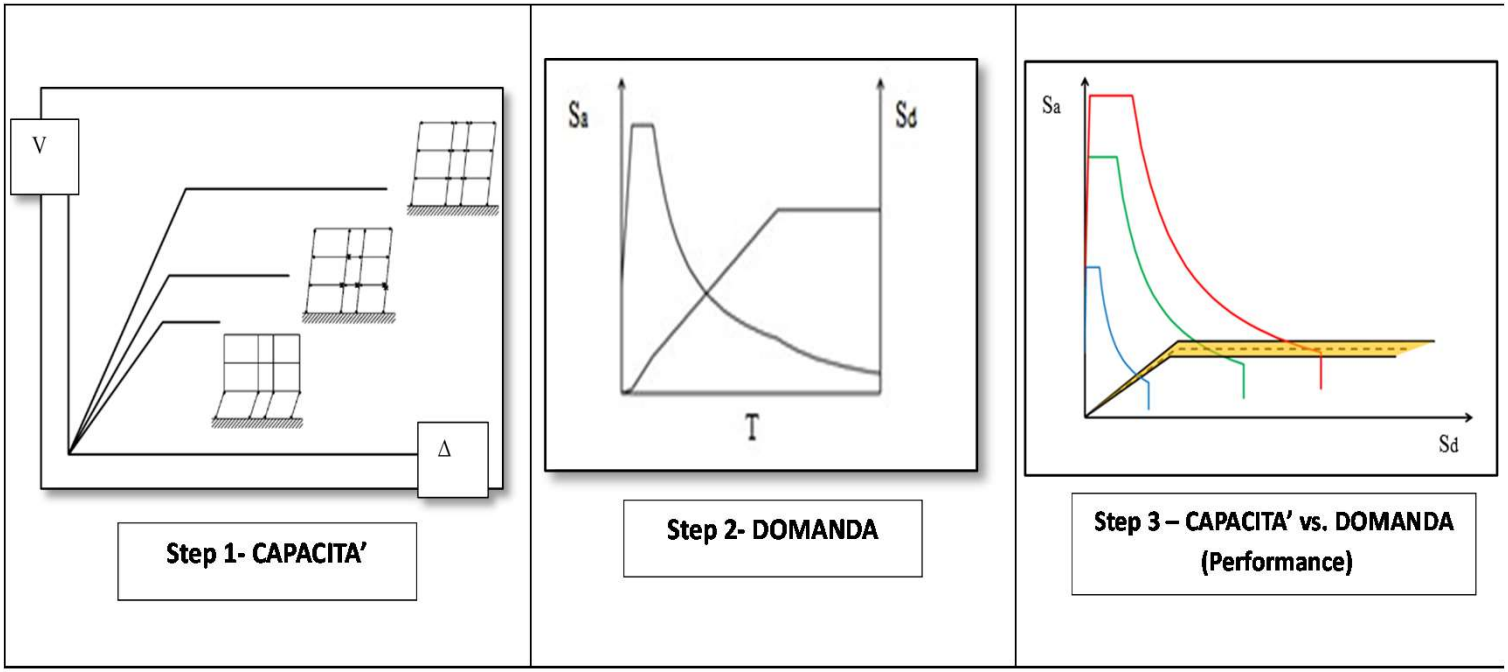


Hazard (Pericolosità) X Vulnerability X Exposure



Prof. Dr. Eng. Stefano Pampanin

Capacity vs.Demand (Performance)

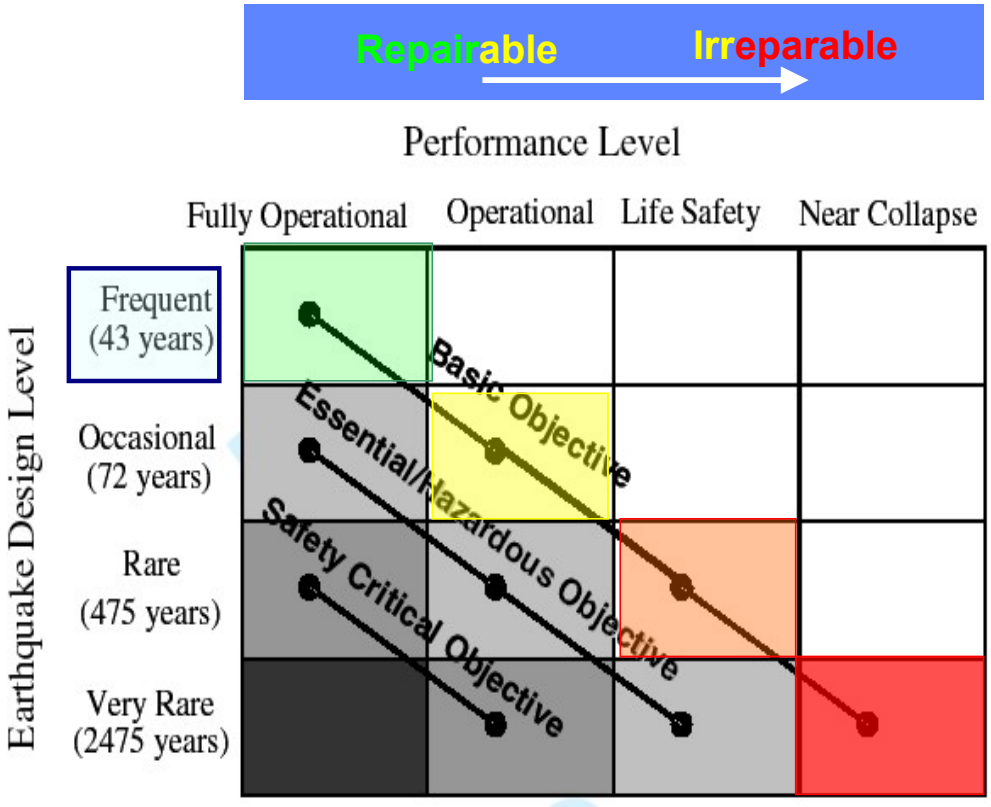


Step 1- CAPACITA'

Step 2- DOMANDA

Step 3 – CAPACITA' vs. DOMANDA (Performance)

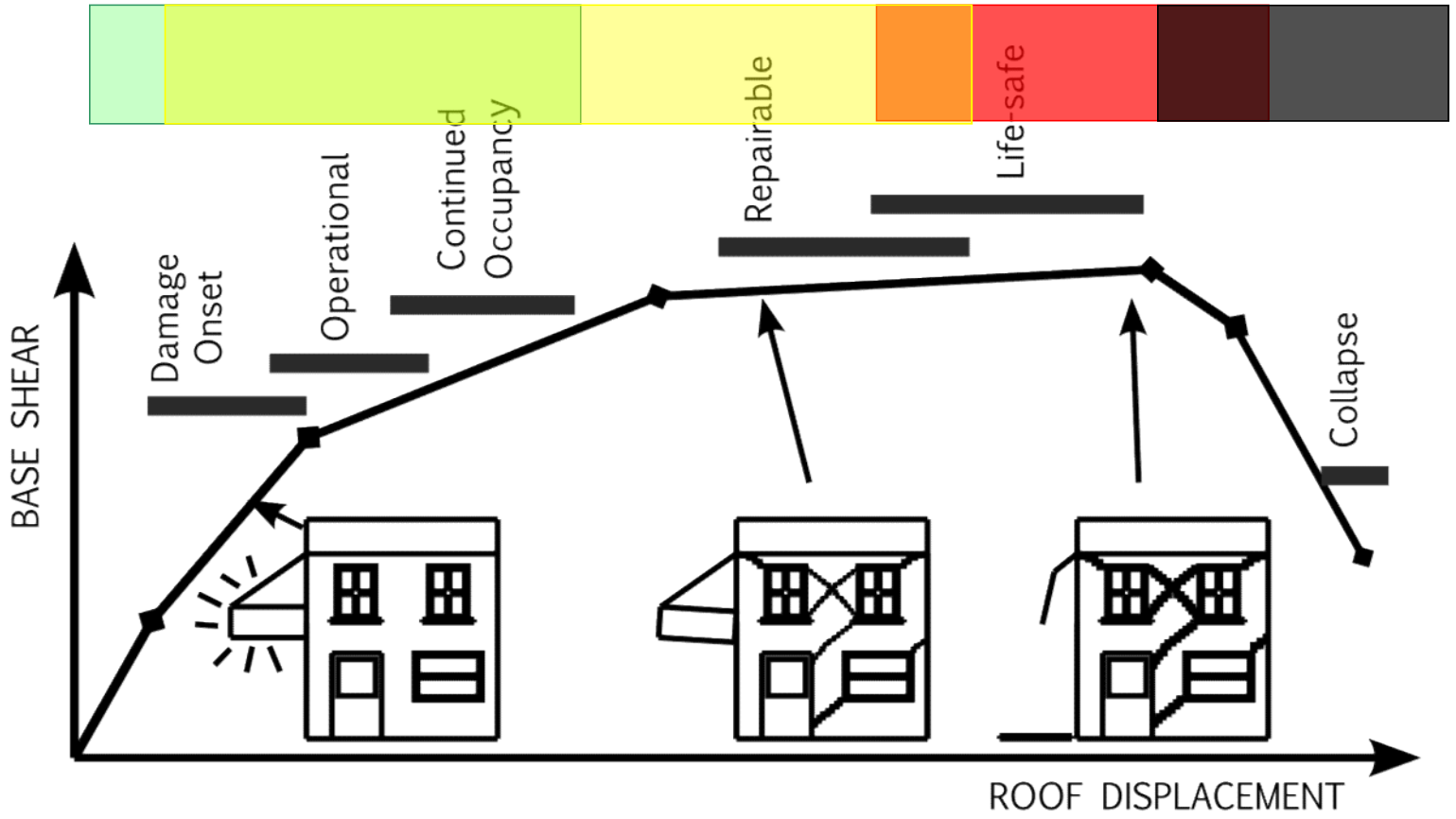
"Our" understading of Earthquake-Resistant



From SEAOC Vision 2000 (1995)

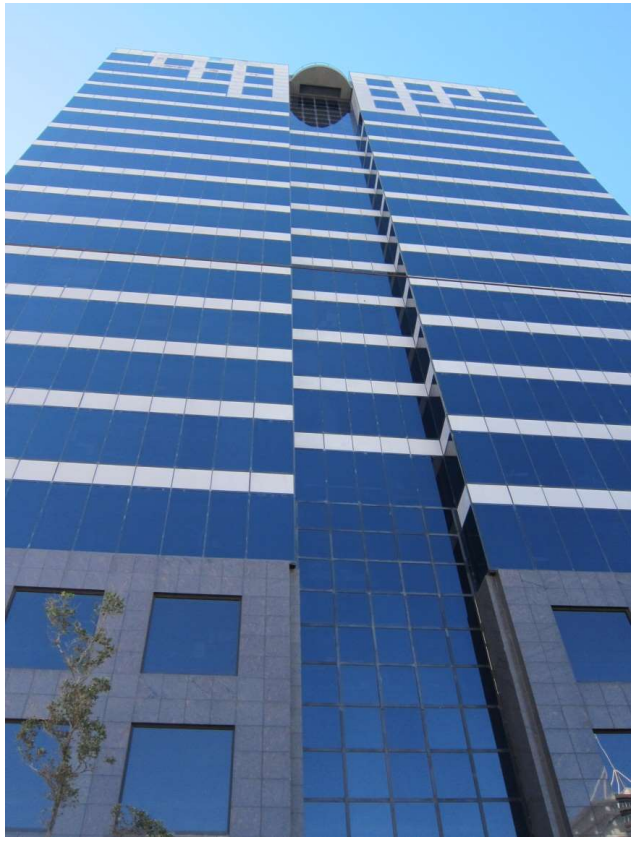
Which means…..

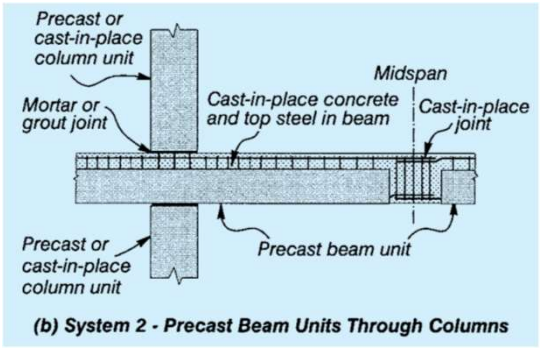
from the point of view of a Structural Engineer….



Modified after Hamburger and Mohele, 2000

PwC- 22-storeys
emulative precast concrete post-1980s





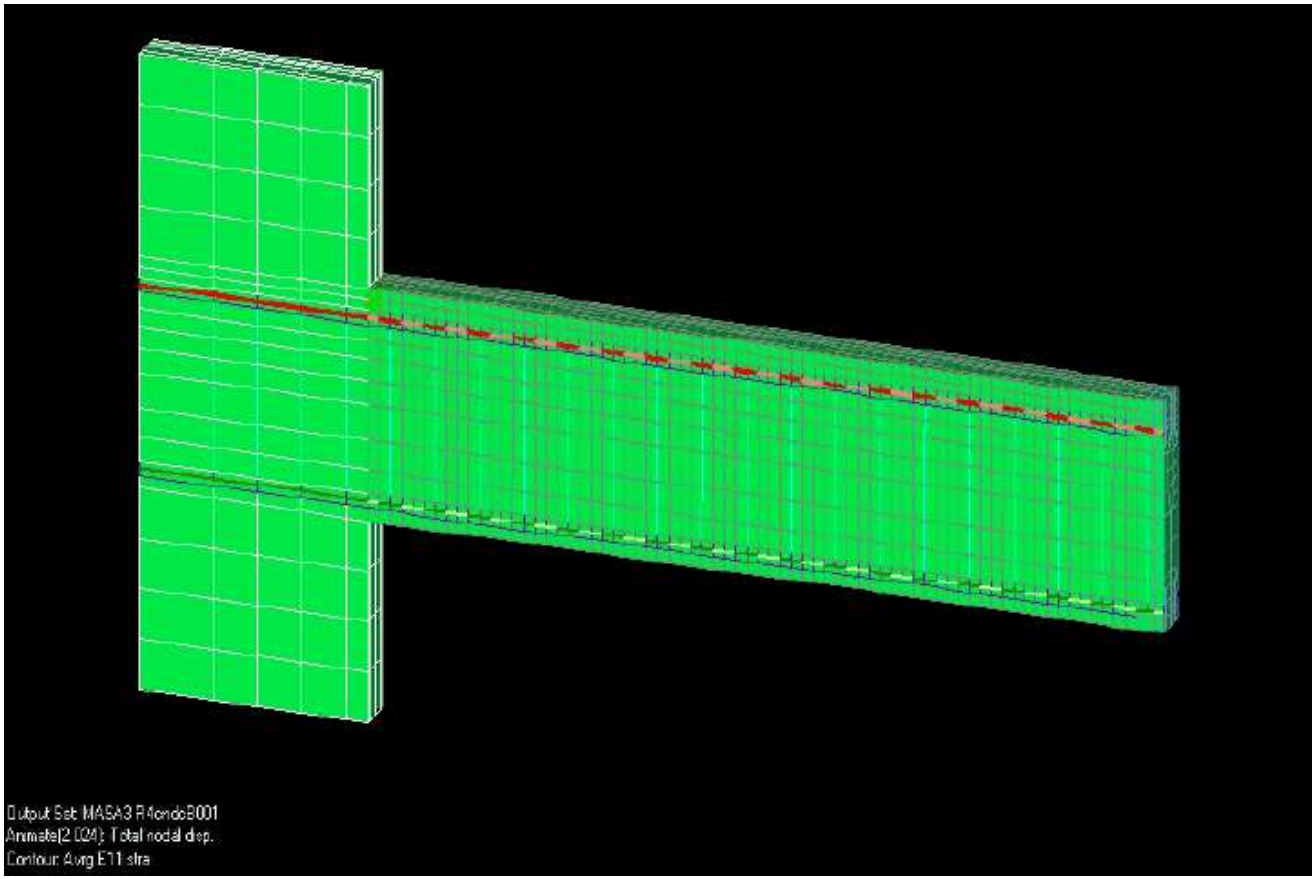
(b) System 2 - Precast Beam Units Through Columns

Extensive damage (beyond reparability?) to modern Buildings

Typical **plastic hinges** in beams
(intended to act as sacrificial fuses)

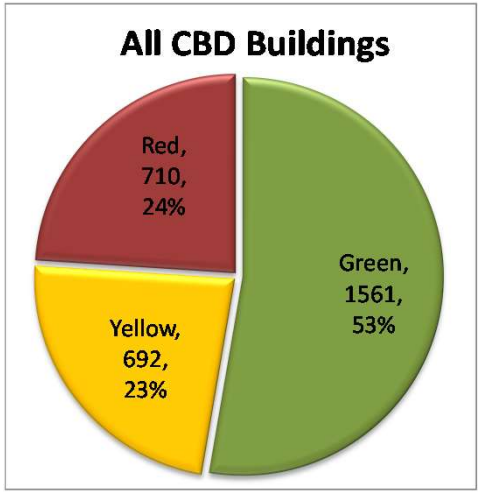
Computer Modeling of Plastic Hinge

(Research collaboration with University of Stuttgart, Germany)



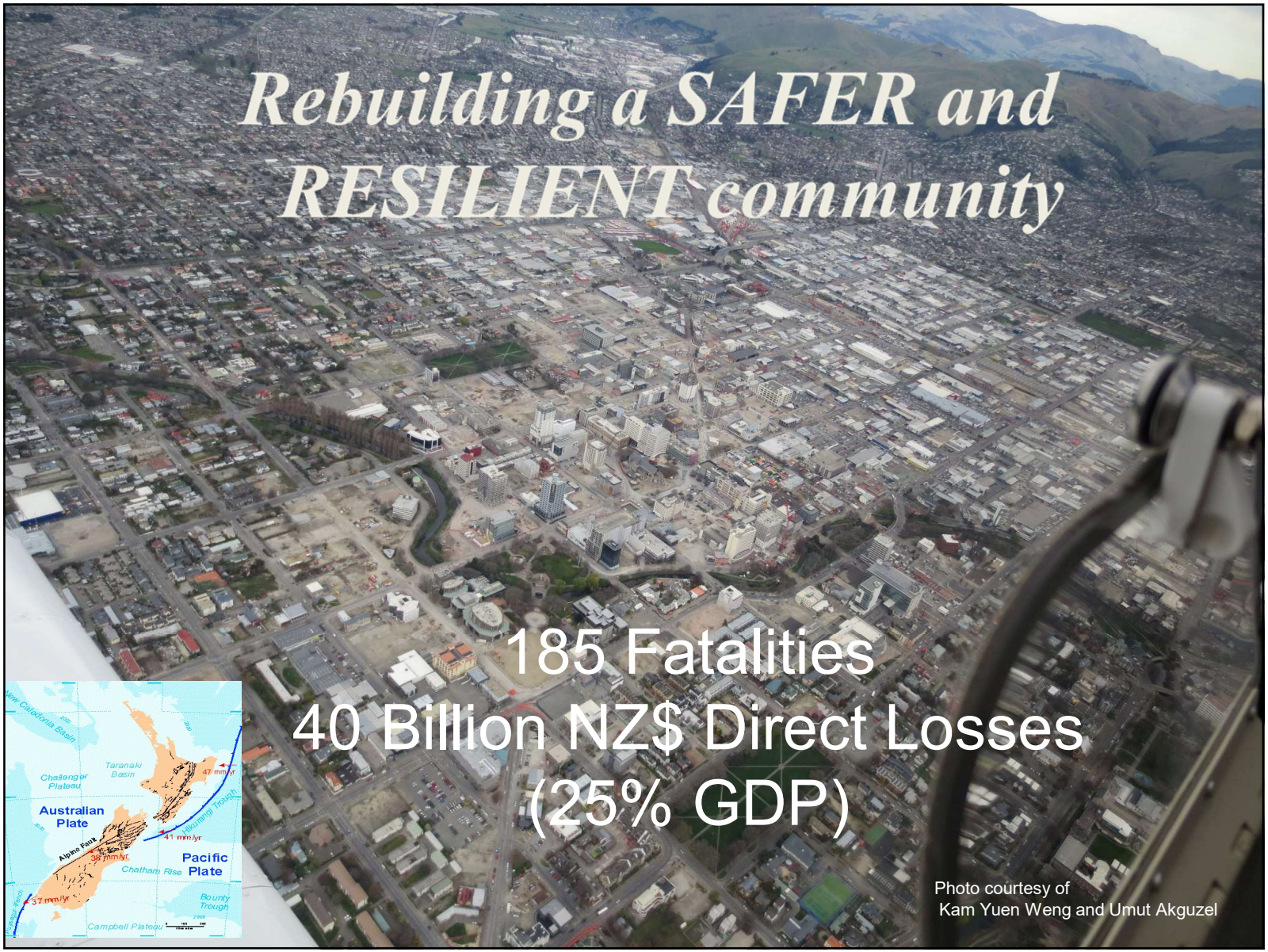
Prof. Dr. Eng. Stefano Pampanin

A very common end : Man-made Demolition



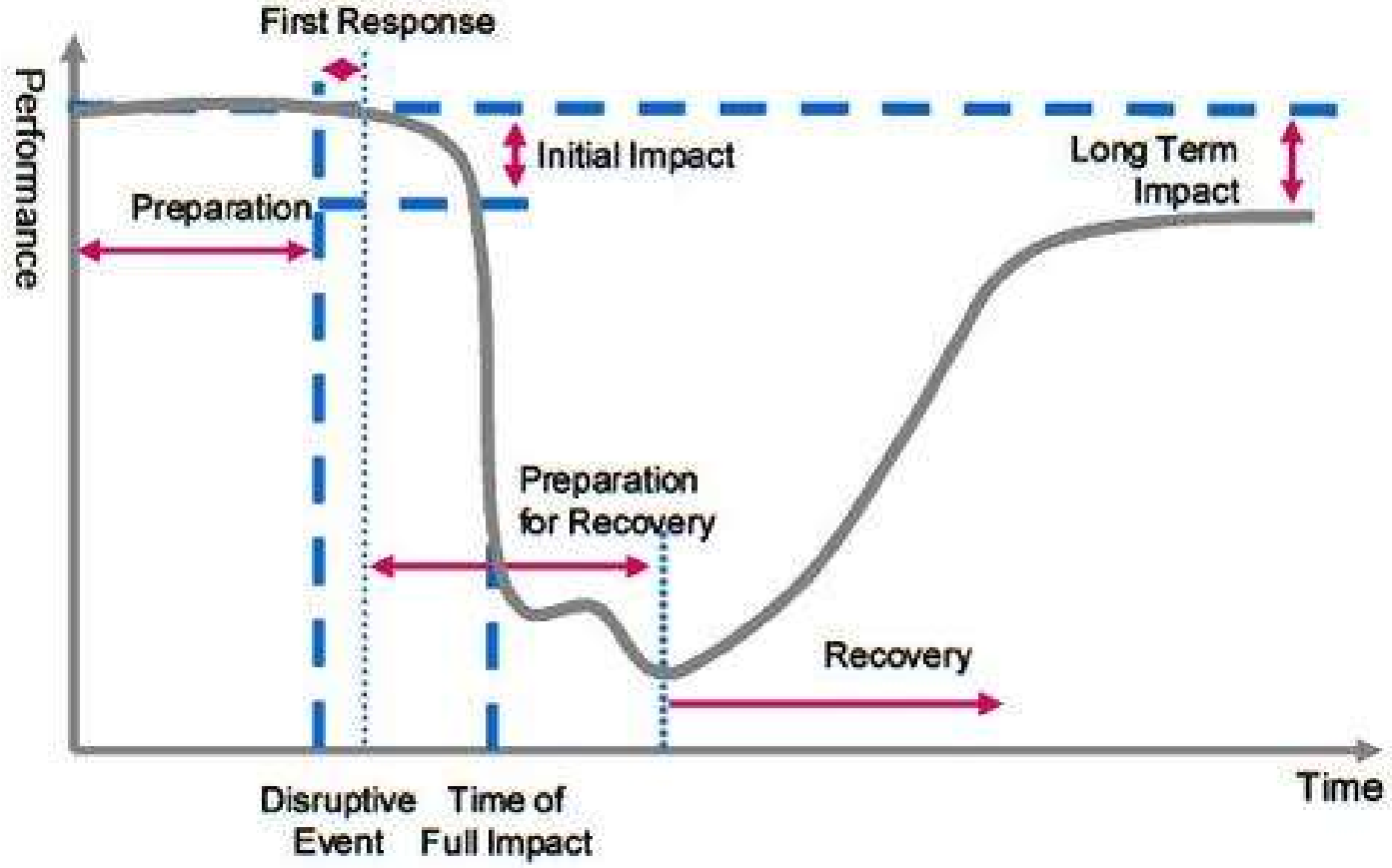
As per 12 June 2011
Source: CCC Data
(Kam, Pampanin, Elwood, 2012)

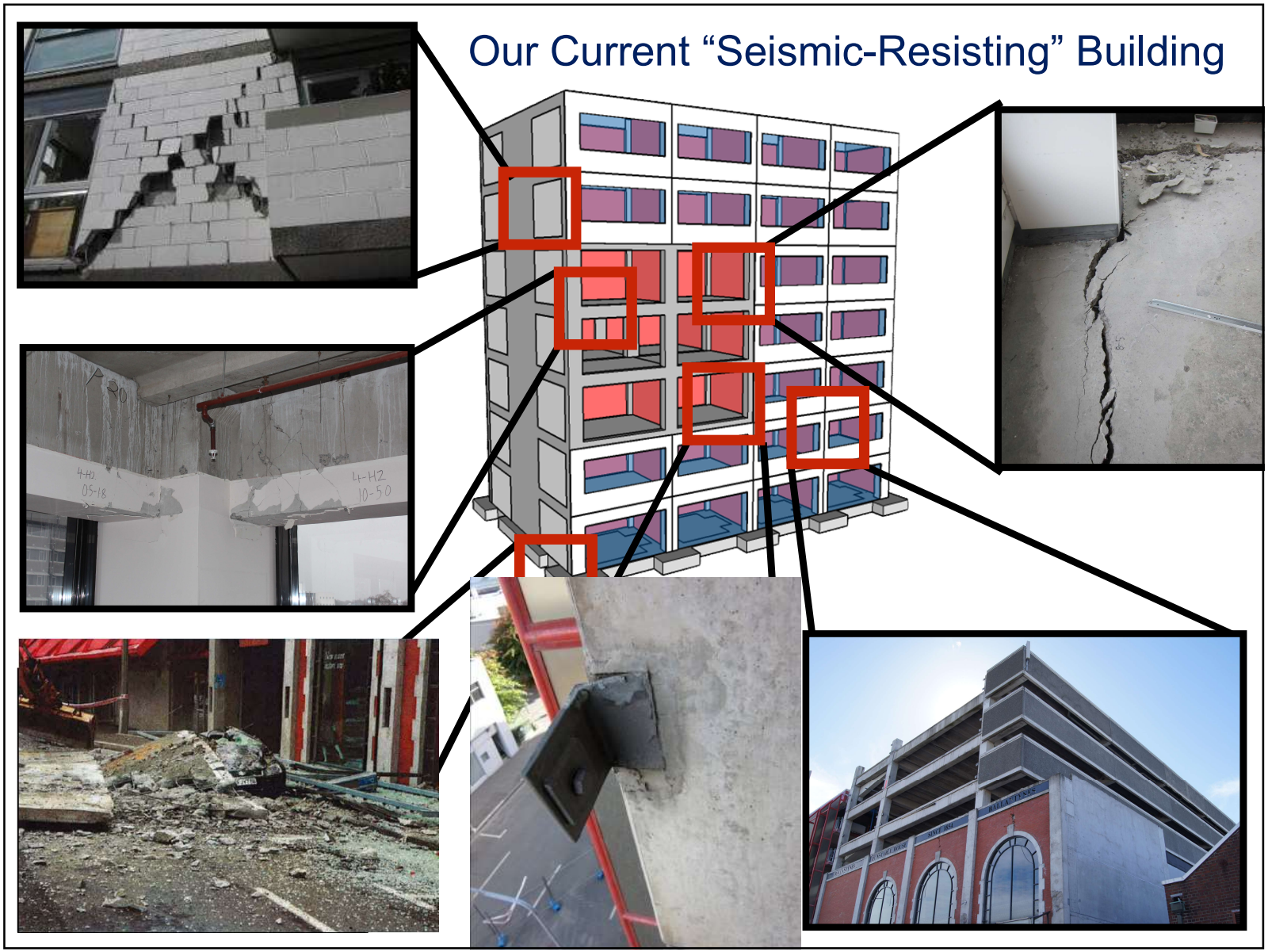
"But they [buildings] did what they were meant to do"



Prof. Dr. Eng. Stefano Pampanin

The Concept of Resilience




Our Current “Seismic-Resisting” Building

Fallacy

*The Code-Standard is **NOT** meant to be used as a Target or Ultimate Goal but as a minimum by law*

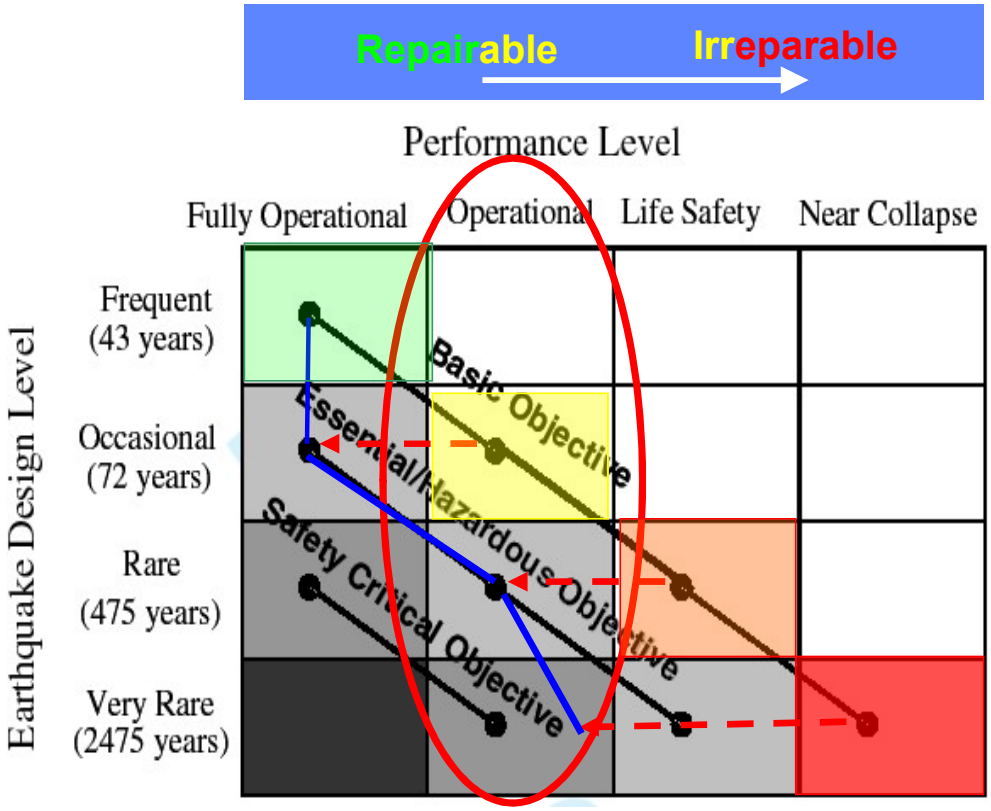
Corollary

Earthquake-Resistant ≠ *Earthquake-Proof*

(earthquake engineering community's view)

(everyone else's view)

The Renewed Challenge of Eartquake Engineering: Raising the bar to meet Society's Expectations



MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

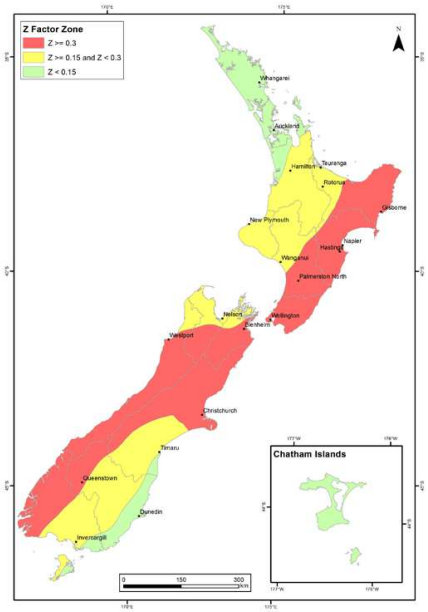
New Framework for managing earthquake-prone buildings in New Zealand

Ministry of Business, Innovation and Employment, 2016

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

New framework for managing earthquake-prone buildings

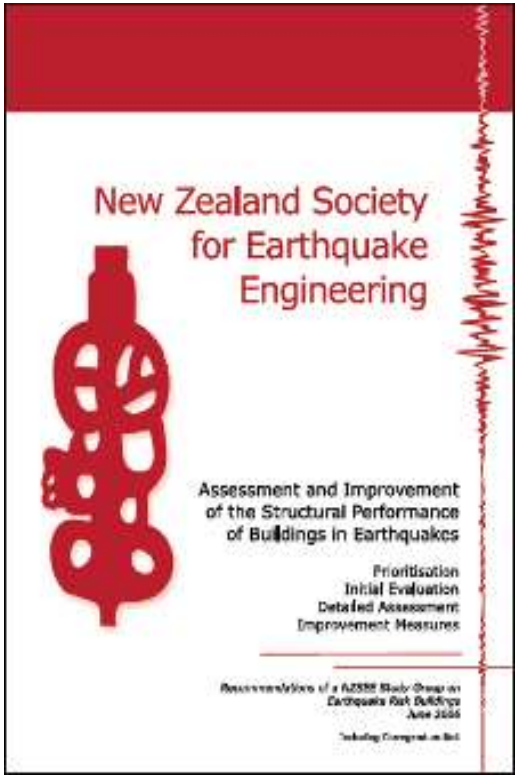
(Mandatory - effective from 1 July 2017)

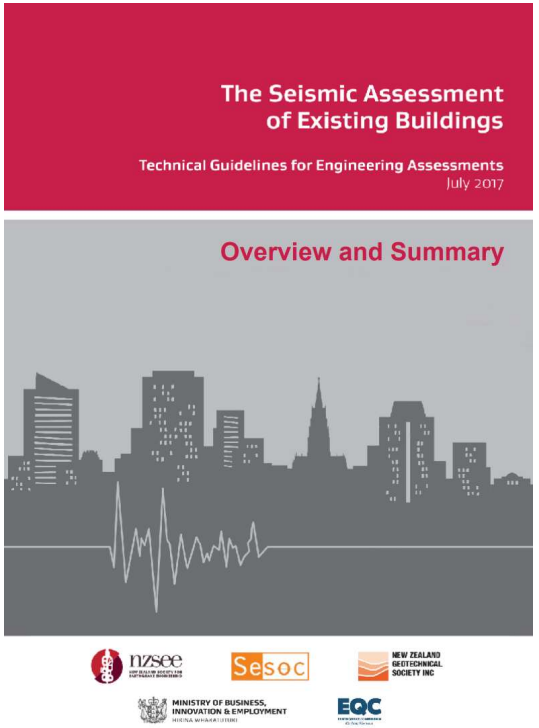


Risk-Based Approach

Seismic risk area	TAs must identify potentially earthquake-prone buildings within:		Owners must strengthen or demolish earthquake-prone buildings within:	
	Priority	Other	Priority	Other
High	2 ½ years	5 years	7 ½ years	15 years
Medium	5 years	10 years	12 ½ years	25 years
Low	n/a	15 years	n/a	35 years

NZSEE2017 – Seismic Assessment Guidelines
http://www.eq-assess.org.nz/





NZSEE 2006 → **NZSEE2017**

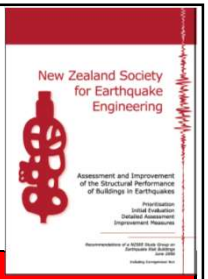


Table 2.2 NZSEE2006 Risk Classifications and Improvement Recommendations

Description	Grade	Risk	%NBS	Existing Building Structural Performance	Improvement of Structural Performance	
					Legal Requirement	NZSEE Recommendation
Low Risk Building	A or B	Low	Above 67	Acceptable (improvement may be desirable)	The Building Act sets no required level of structural improvement (unless change in use) This is for each TA to decide. Improvement is not limited to 34%NBS.	100%NBS desirable. Improvement should achieve at least 67%NBS
Moderate Risk Building	B or C	Moderate	34 to 66	Acceptable legally. Improvement recommended		Not recommended. Acceptable only in exceptional circumstances
High Risk Building	D or E	High	33 or lower	Unacceptable (Improvement required under Act)	Unacceptable	Unacceptable

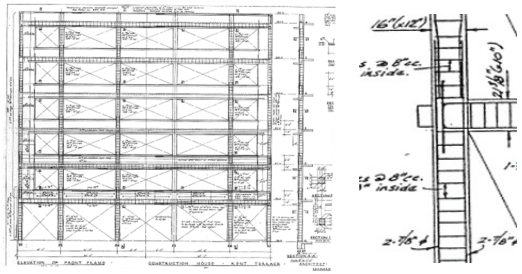
There are many buildings in New Zealand constructed prior to 1976.
The cost to the community of requiring full compliance with current standards would be considerable, and arguably disproportionate to the risk reduction achieved.

Chapter 5
Concrete Buildings

Leader: Stefano Pampanin

Step 1- CAPACITY

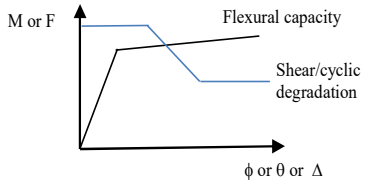
Building data:
- Geometry
- Material properties
- Structural details



1a- Component Level (beam, column, joint)

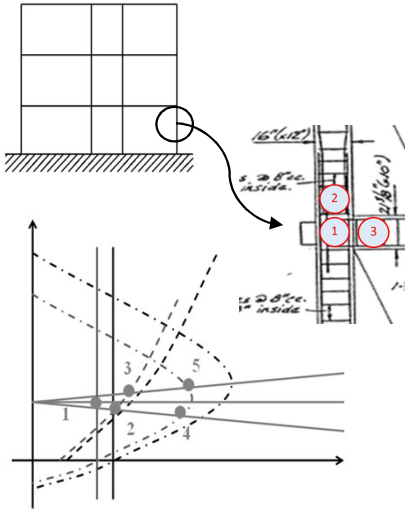
Evaluate strength and deformation capacity:
-Flexure, Shear, Flexure-shear interaction
- Cyclic degradation; Lap splices failure; Bi-directional effects

Outcomes (capacity curves):
Moment-curvature/rotation and/or Force-Displacement



1b- Subassembly Level

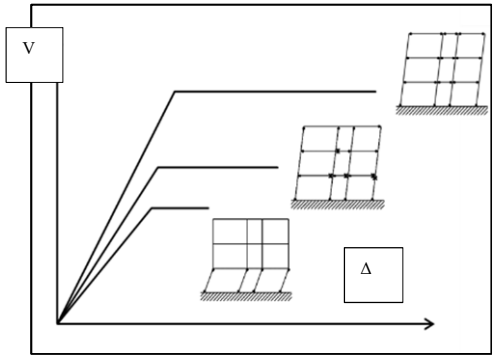
Evaluate the Hierarchy of Strength and sequence of events at a subassembly level



1c - Structural System Level

Identify the global mechanism

Evaluate the Global Capacity Curve (Force-Displacement)



Sesoc

NEW ZEALAND SOCIETY FOR EARTHQUAKE ENGINEERING

NEW ZEALAND GEOTECHNICAL SOCIETY INC
www.nzgs.org

Evaluation of Safety (Risk) Index
(% NBS, New Building Standard)

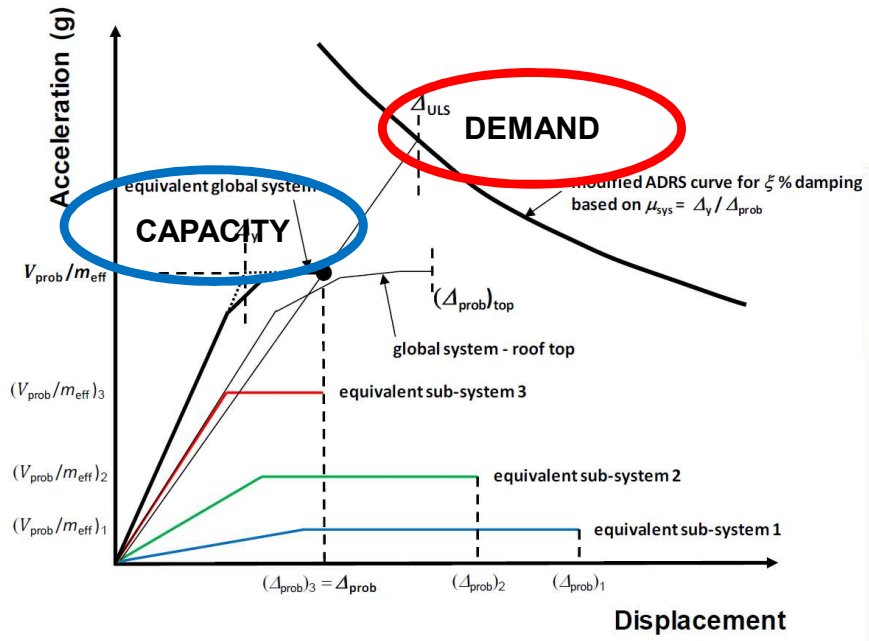
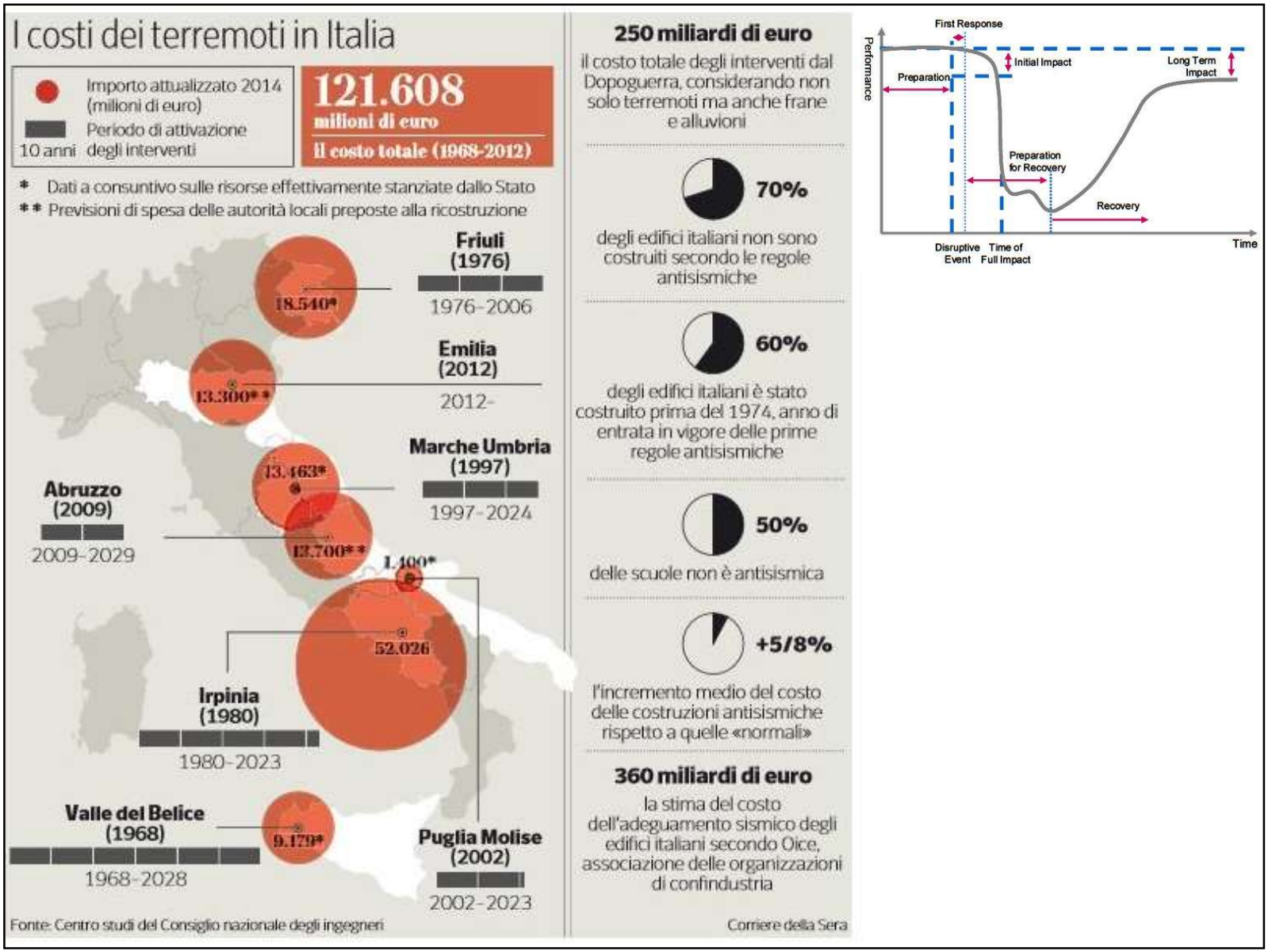


Figure C2.6: Derivation of seismic score using SLaMA

SEISMIC RATING NZSEE-2006-2017 based on %NBS

Percentage of New Building Standard (%NBS)	Letter grade	Relative risk (approx)
>100	A+	< 1 time
80–100	A	1–2 times
67–80	B	2–5 times
33–67	C	5–10 times
20–33	D	10–25 times
<20	E	> 25 times


I costi dei terremoti in Italia
Importo attualizzato 2014 (milioni di euro)
Periodo di attivazione degli interventi
10 anni
121.608
milioni di euro
il costo totale (1968-2012)
* Dati a consuntivo sulle risorse effettivamente stanziate dallo Stato
** Previsioni di spesa delle autorità locali preposte alla ricostruzione
Friuli (1976)
18.540*
1976-2006
Emilia (2012)
13.300**
2012-
Marche Umbria (1997)
13.463*
1997-2024
Abruzzo (2009)
12.700**
2009-2029
1.400*
52.026
Irpinia (1980)
1980-2023
Valle del Belice (1968)
9.179*
1968-2028
Puglia Molise (2002)
2002-2023
Fonte: Centro studi del Consiglio nazionale degli ingegneri
250 miliardi di euro
il costo totale degli interventi dal Dopoguerra, considerando non solo terremoti ma anche frane e alluvioni
70%
degli edifici italiani non sono costruiti secondo le regole antisismiche
60%
degli edifici italiani è stato costruito prima del 1974, anno di entrata in vigore delle prime regole antisismiche
50%
delle scuole non è antisismica
+5/8%
l'incremento medio del costo delle costruzioni antisismiche rispetto a quelle «normali»
360 miliardi di euro
la stima del costo dell'adeguamento sismico degli edifici italiani secondo Oice, associazione delle organizzazioni di confindustria
Corriere della Sera
First Response
Performance
Preparation
Initial Impact
Long Term Impact
Preparation for Recovery
Recovery
Disruptive Event
Time of Full Impact
Time

Italian Seismic Risk Classification (2017)

1) (Life) Safety Index (%NBS, IS-V)

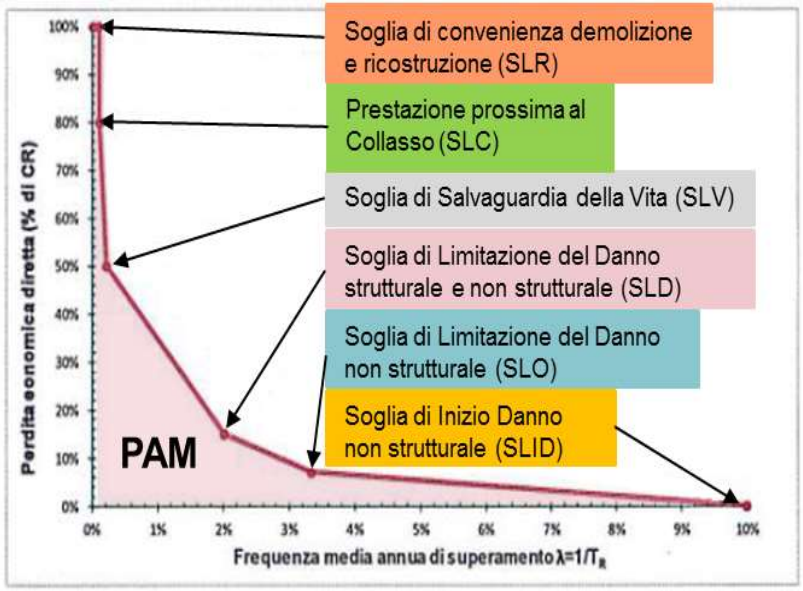
2) Economic Losses Index (EAL)

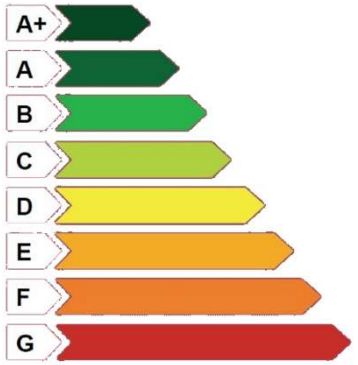
ITA2017 Matrix – IS-V(=%NBS), Risk Class, EAL/PAM

IS-V Class	IS-V ranges	EAL Class	EAL ranges
A^{+}_{IS-V}	IS-V >100	A^{+}_{PAM}	EAL ≤0.5%
A_{IS-V}	80%≤ IS-V< 100%	A_{PAM}	0.5%< EAL ≤1.0%
B_{IS-V}	60%≤I S-V< 80%	B_{PAM}	1.0%< EAL ≤1.5%
C_{IS-V}	45%≤ IS-V< 60%	C_{PAM}	1.5%< EAL ≤2.5%
D_{IS-V}	30%≤ IS-V< 45%	D_{PAM}	2.5%< EAL ≤3.5%
E_{IS-V}	15%≤ IS-V< 30%	E_{PAM}	3.5%< EAL ≤4.5%
F_{IS-V}	IS-V < 15%	F_{PAM}	4.5%< EAL ≤7.5%
-	-	G_{PAM}	7.5%≤ EAL

Financial Incentives **from the IT Government**
(Tax Rebate up to 85% or 110% of the Retrofit costs)

Evaluation of Losses - EAL/PAM and Risk Class



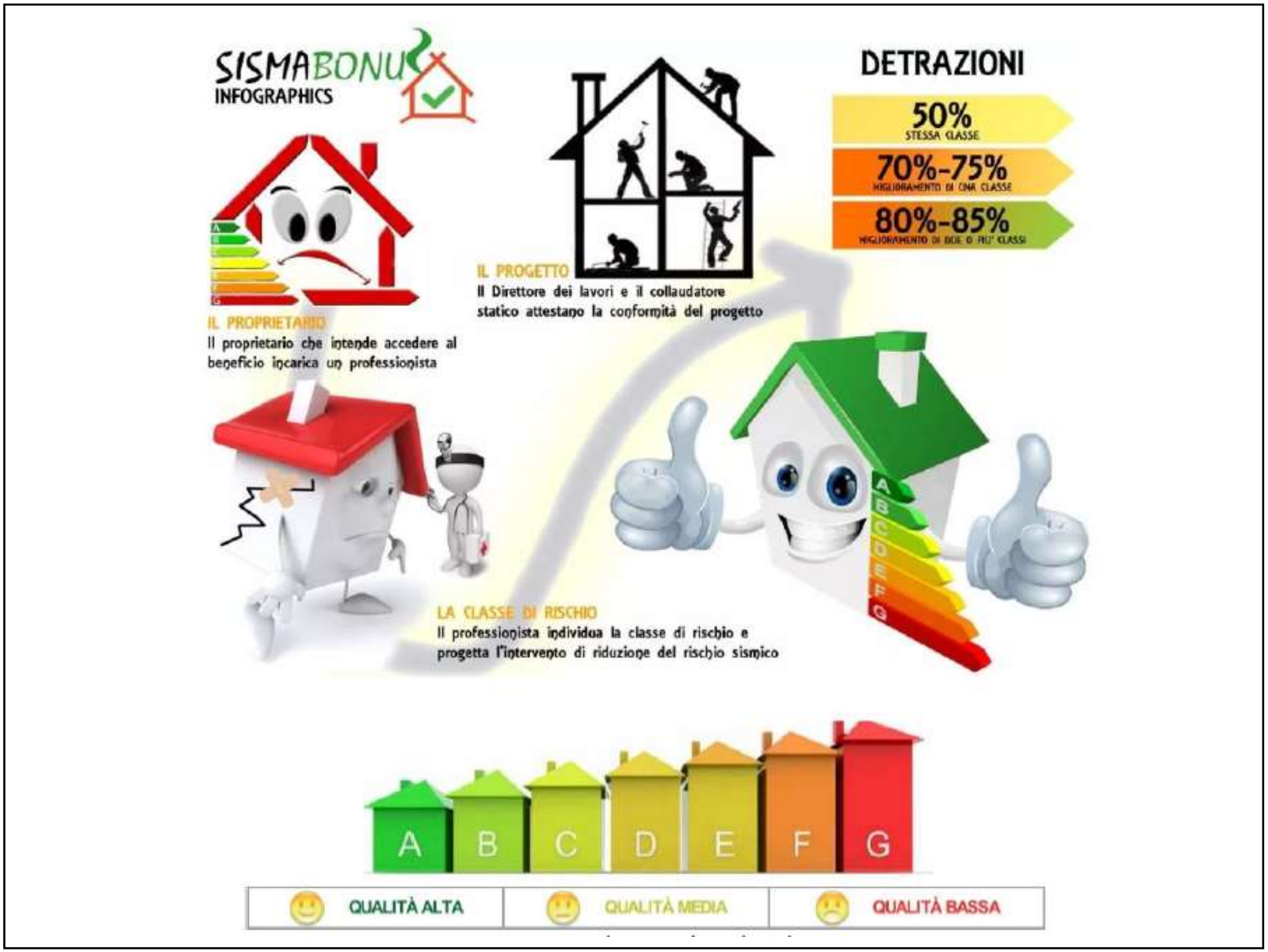


SLC= Collapse Prevention
SLV= Life safety
SLD= Damage Control
SLO= Operational

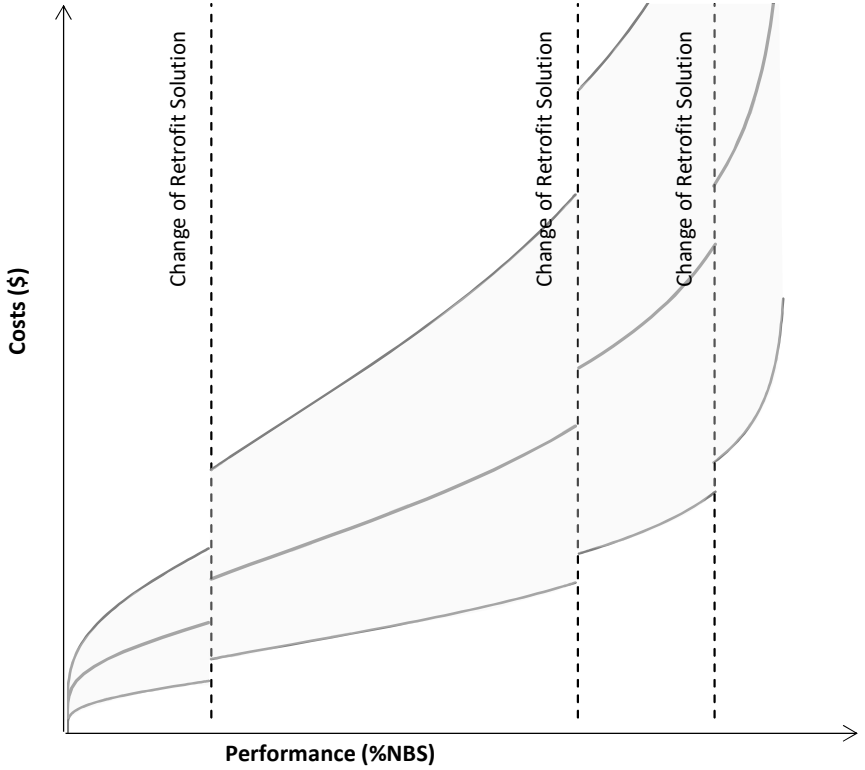
Stato Limite	CR(%)
SLR	100%
SLC	80%
SLV	50%
SLD	15%
SLO	7%
SLID	0%

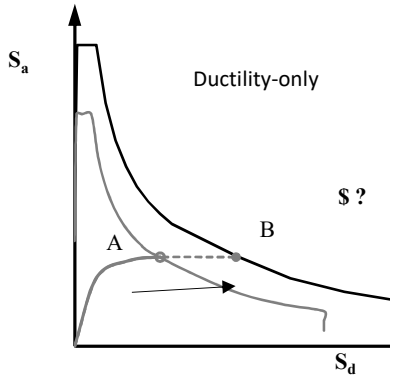
ITA2017 Matrix – IS-V(=%NBS), Risk Class, EAL/PAM

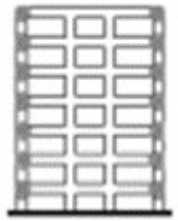
IS-V Class	IS-V ranges	EAL Class	EAL ranges
A^{+}_{IS-V}	IS-V >100	A^{+}_{PAM}	EAL ≤0.5%
A_{IS-V}	80%≤ IS-V< 100%	A_{PAM}	0.5%< EAL ≤1.0%
B_{IS-V}	60%≤I S-V< 80%	B_{PAM}	1.0%< EAL ≤1.5%
C_{IS-V}	45%≤ IS-V< 60%	C_{PAM}	1.5%< EAL ≤2.5%
D_{IS-V}	30%≤ IS-V< 45%	D_{PAM}	2.5%< EAL ≤3.5%
E_{IS-V}	15%≤ IS-V< 30%	E_{PAM}	3.5%< EAL ≤4.5%
F_{IS-V}	IS-V < 15%	F_{PAM}	4.5%< EAL ≤7.5%
-	-	G_{PAM}	7.5%≤ EAL


SISMABONUS
INFOGRAPHICS
DETRAZIONI
50%
STESSA CLASSE
70%-75%
MIGLIORAMENTO DI UNA CLASSE
80%-85%
MIGLIORAMENTO DI DUE O PIU' CLASSI
IL PROGETTO
Il Direttore dei lavori e il collaudatore statico attestano la conformità del progetto
IL PROPRIETARIO
Il proprietario che intende accedere al beneficio incarica un professionista
LA CLASSE DI RISCHIO
Il professionista individua la classe di rischio e progetta l'intervento di riduzione del rischio sismico
A
B
C
D
E
F
G
QUALITÀ ALTA
QUALITÀ MEDIA
QUALITÀ BASSA

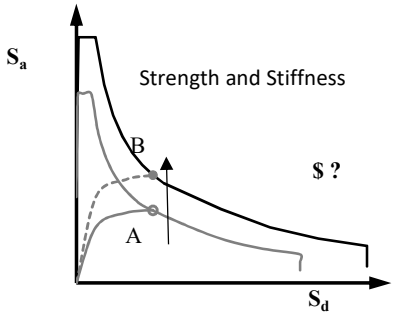
Comparing Alternative Retrofit Options (Multi-criteria Cost-benefit Approach)

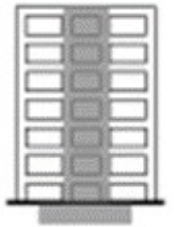






OPTION 2
(FRP)





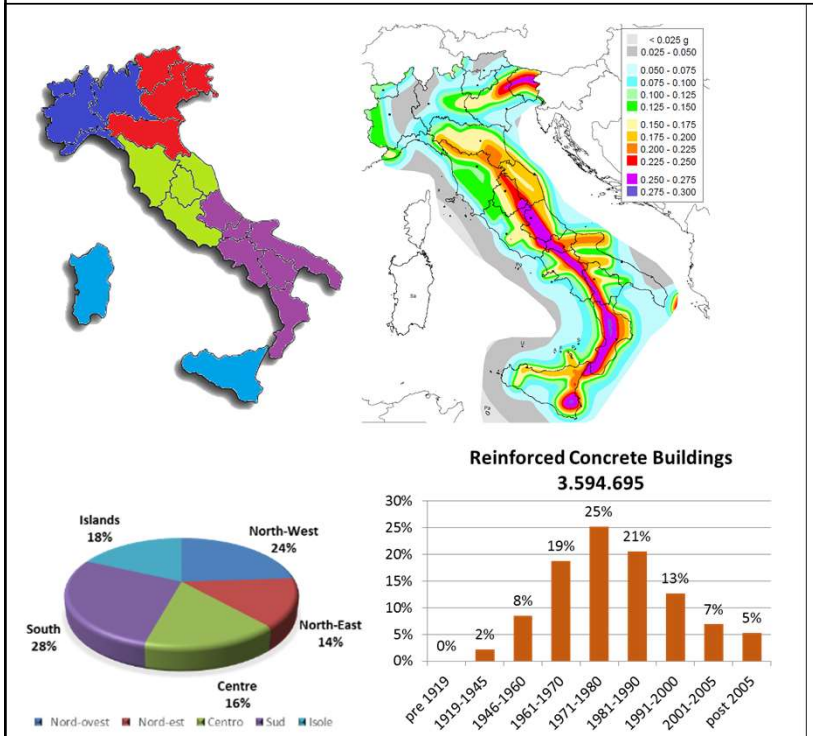
OPTION 3
(Shear Wall)

Pampanin, Beetham et al. 2012-

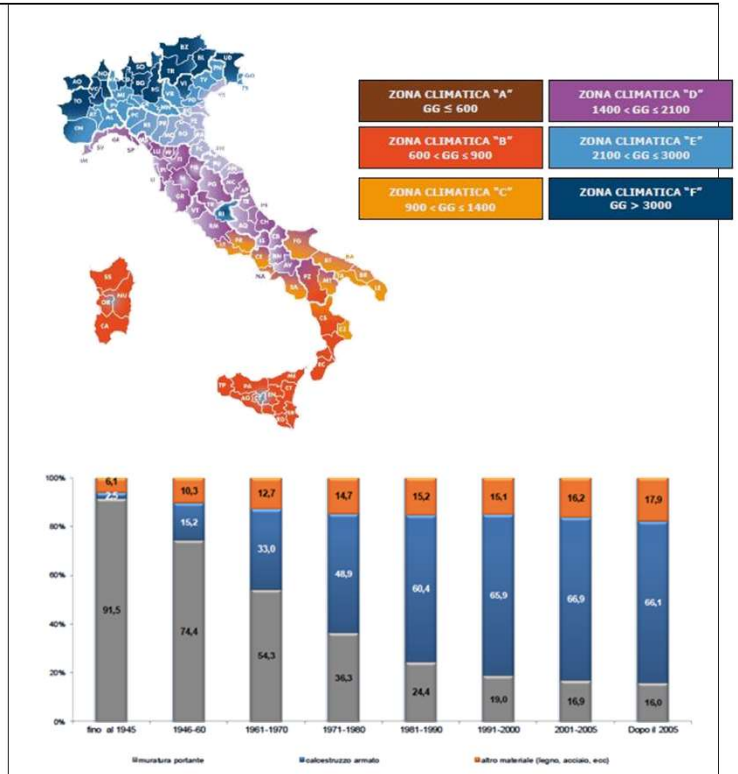
Towards a National Plan for an **Integrated Rehabilitation** of the building stock

(Seismic+Energy+Architectural)

(Pampanin et al., 2017)



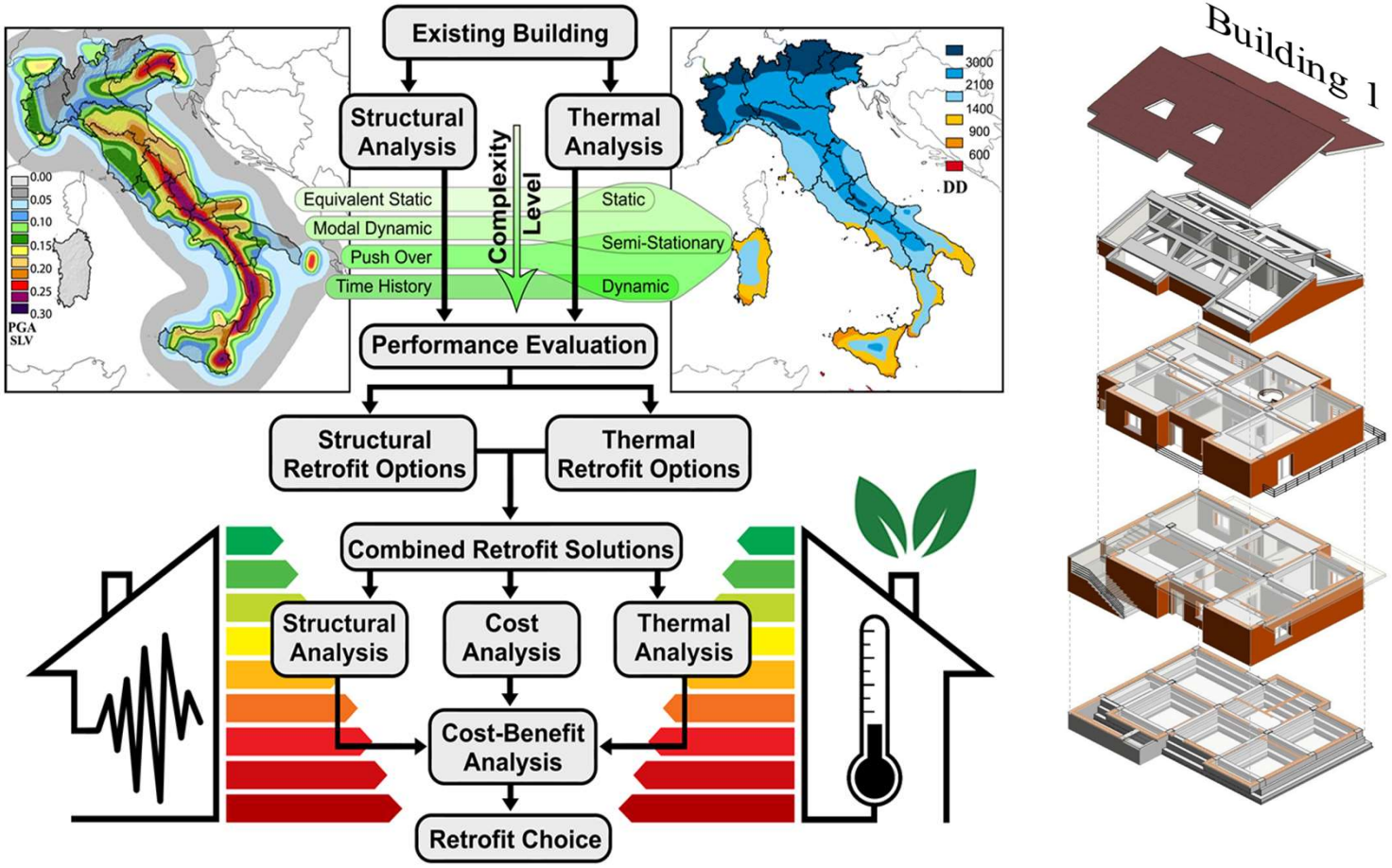
Seismic Zone and Climate Zones in Italy



Poentially Earthquake-Prone Bulldings

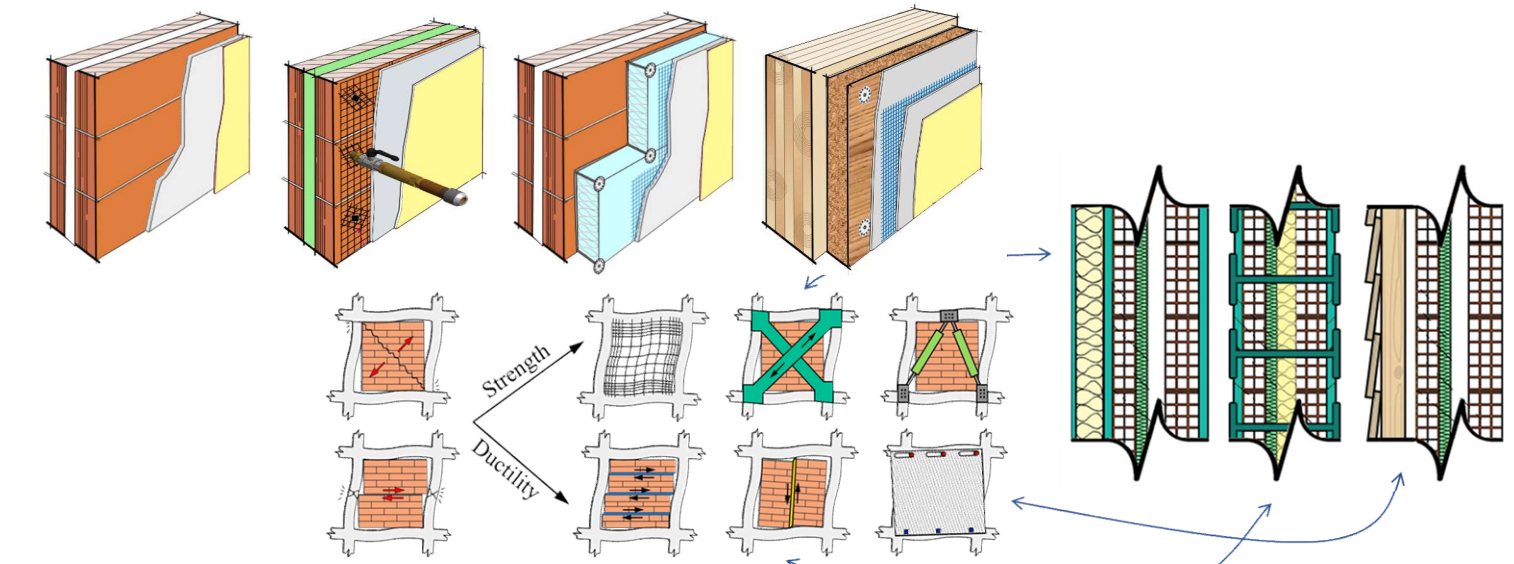
Prof. Dr. Eng. Stefano Pampanin

Phase I:
Combined Seismic-Enegy Assessment

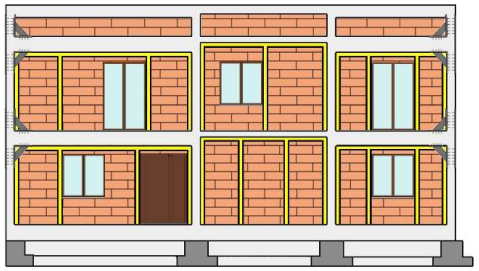


Di Vece and Pampanin,2019

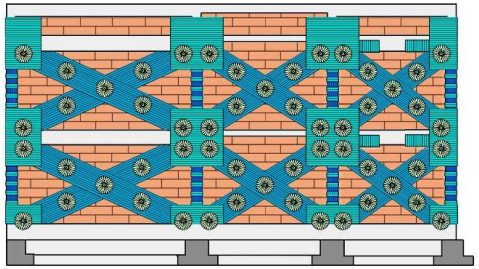
Phase II:
Integrated Seismic-Energy Interventions



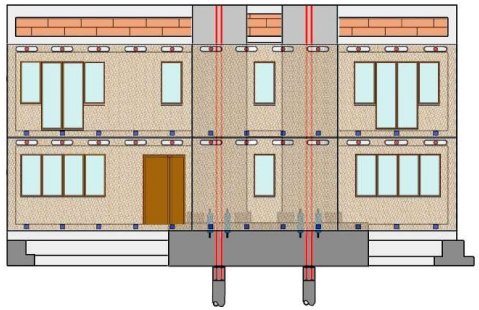
Haunch + Low-Damage Infills



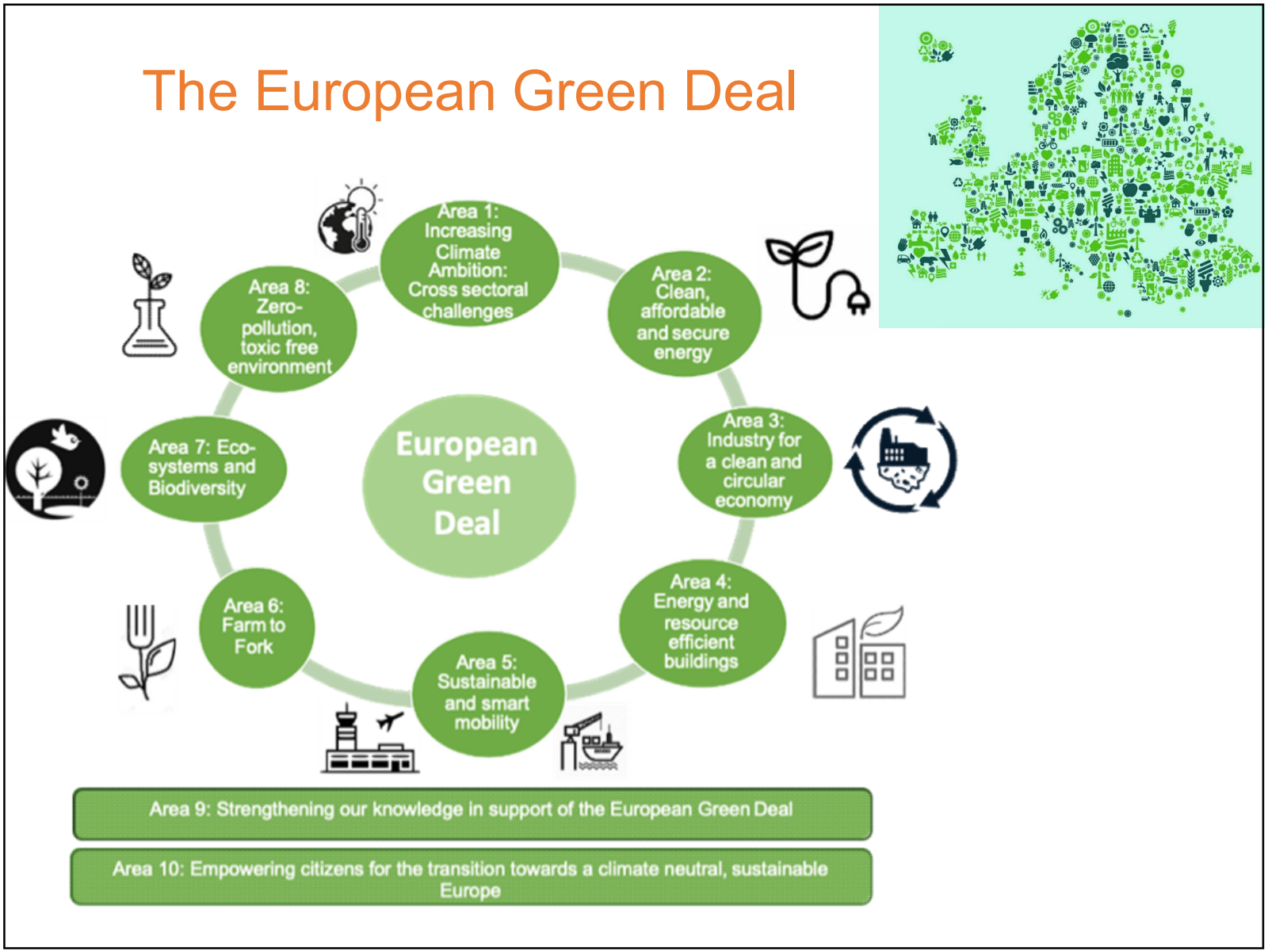
FRP+TRM & New Envelope



PRESSS & Cladding System



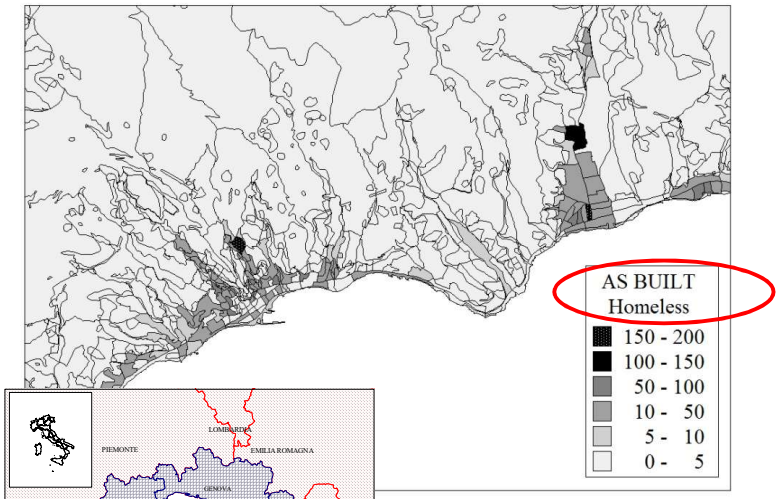
Di Vece and Pampanin,2019

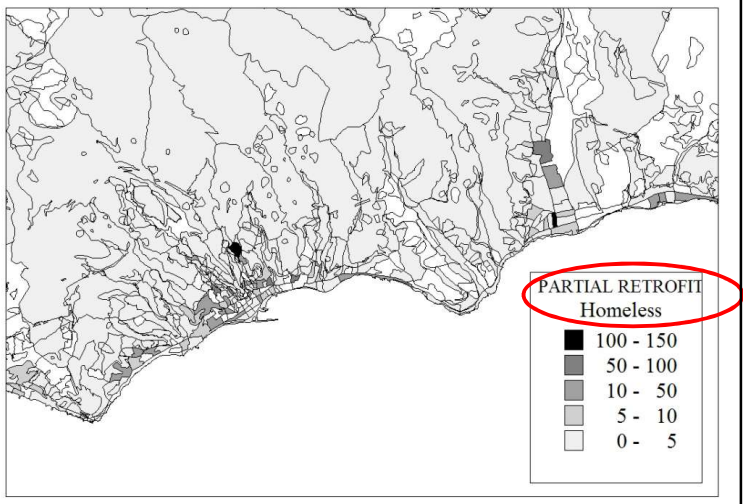

The European Green Deal
European Green Deal
Area 1: Increasing Climate Ambition: Cross sectoral challenges
Area 2: Clean, affordable and secure energy
Area 3: Industry for a clean and circular economy
Area 4: Energy and resource efficient buildings
Area 5: Sustainable and smart mobility
Area 6: Farm to Fork
Area 7: Eco-systems and Biodiversity
Area 8: Zero-pollution, toxic free environment
Area 9: Strengthening our knowledge in support of the European Green Deal
Area 10: Empowering citizens for the transition towards a climate neutral, sustainable Europe

Prof. Dr. Eng. Stefano Pampanin

RAISING THE BAR:
Proposal for a National Plan for the Integrated Rehabilitation of the Building Stock and Seismic Risk Reduction

- Risk Based Prioritization
- Long-term Duration: : 7-15-30 years
- Continuos Investment : 0.25-0.3% PIL (4-5 Billion Euro)/year





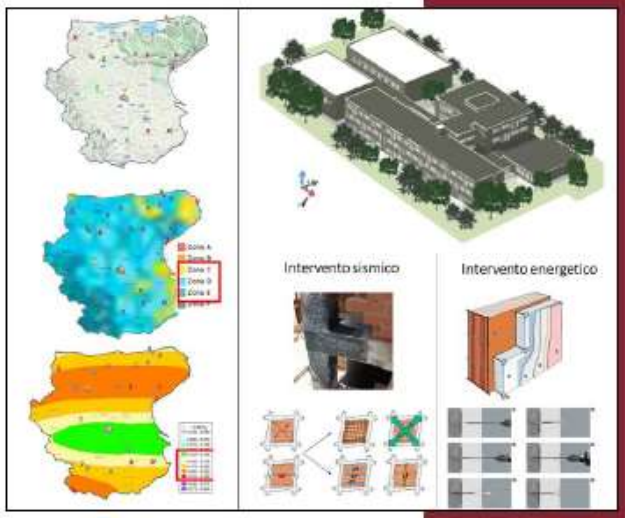
Giovinazzi & Pampanin, 2007/2008, 2017

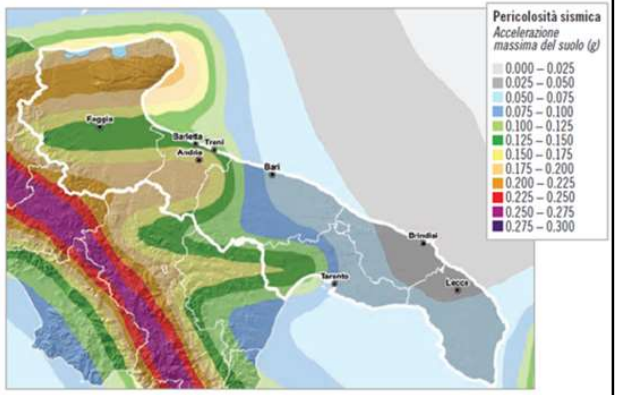
Terremoto 2002, immagine San Giuliano di Puglia

SAPIENZA
UNIVERSITÀ DI ROMA

Progetto UEFA/ELENA

Analisi sismo-energetiche di edifici pubblici nella provincia di Foggia e strategie di interventi integrati di miglioramento





REPORT FINALE

Prof. Ing. Stefano Pampanin
(Coordinatore Progetto)
Professore Ordinario di Tecnica delle Costruzioni
Dipartimento di Ingegneria Strutturale e Geotecnica

Prof. Ing. Andrea Vallati
(Responsabile Diagnosi Energetiche)
Professore Associato di Fisica Tecnica
Dipartimento di Ingegneria Aeronautica, Elettrica e Energetica

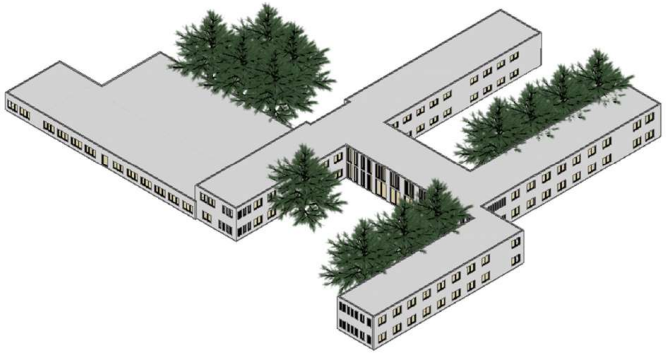
Prof. Edoardo Currà
(Responsabile Organismo Edilizio)
Professore Associato di Architettura Tecnica

Aprile 2020

Archetipi

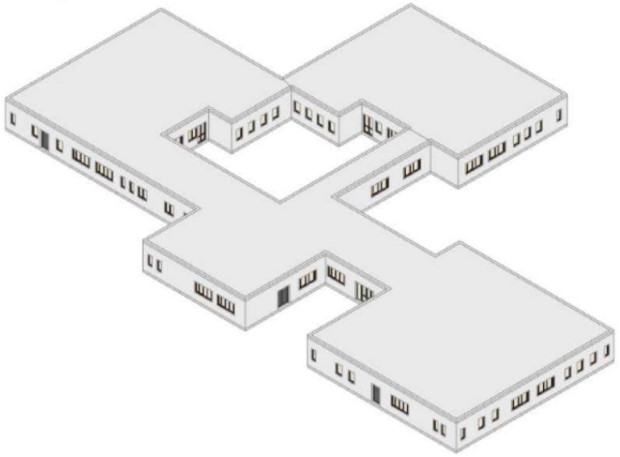
SCHEDA DI DIAGNOSI + INTERVENTI DI MIGLIORAMENTO

SCUOLA ID 38 – IPSIA Marrone/IPSSAR Bonghi – Lucera (FG)



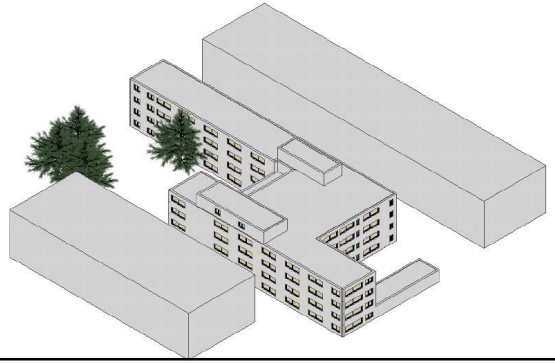
SCHEDA DI DIAGNOSI + INTERVENTI DI MIGLIORAMENTO

SCUOLA ID 68 – I.I.S. "A. Olivetti" succursale – Orta Nova (FG)



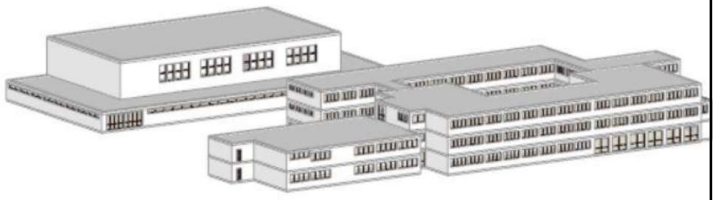
SCHEDA DI DIAGNOSI + INTERVENTI DI MIGLIORAMENTO

SCUOLA ID 04 – I.T.C. "Masi" – Foggia (FG)



SCHEDA DI DIAGNOSI + INTERVENTI DI MIGLIORAMENTO

SCUOLA ID 9 – "Marconi" (Palestra) – Foggia (FG)



Interventi alternativi di miglioramento energetico

CO. Chiusure verticali opache

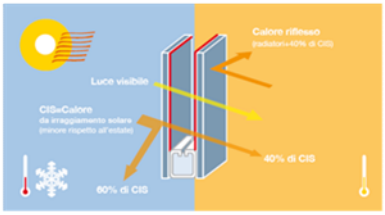
Cappotto termico

Insufflaggio in intercapedine

Intonaco isolante termico

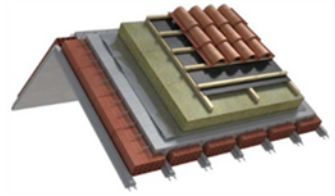
ST. Chiusure verticali trasp.

Infisso a taglio termico

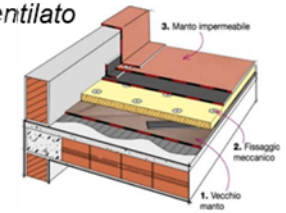


Vetro camera basso emissivo

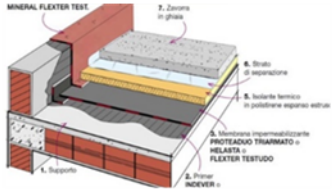
ST. Chiusure oriz. superiori



Tetto a falde caldo o ventilato



Tetto piano caldo praticabile



Tetto piano rovescio non praticabile

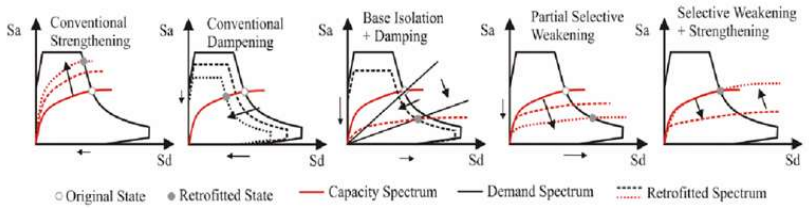
ST. Chiusure oriz. inferiori

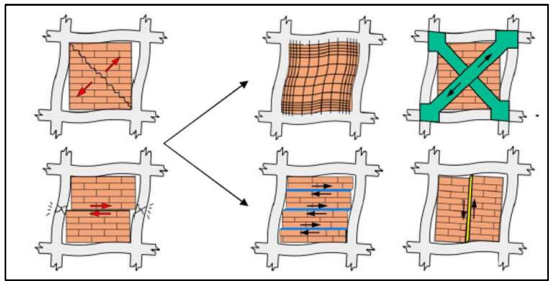
Isolamento da sotto

Isolamento da sopra

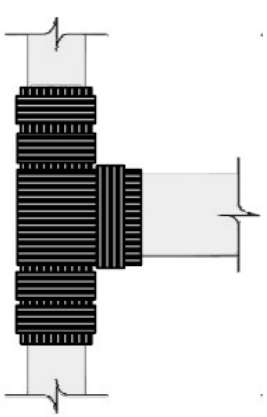
Strategie e tecniche d'intervento sismico

Strategie d'intervento

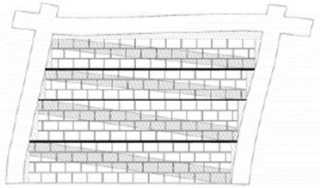


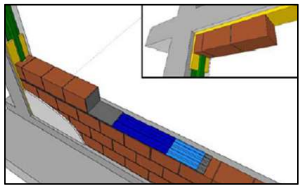


Tecniche d'intervento elementi strutturali

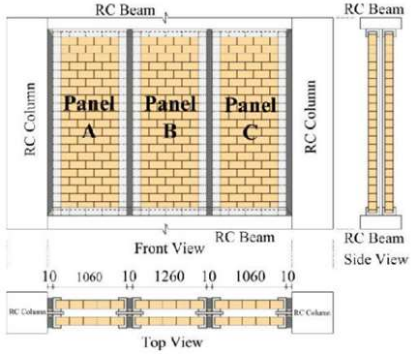


Tecniche d'intervento elementi non-strutturali





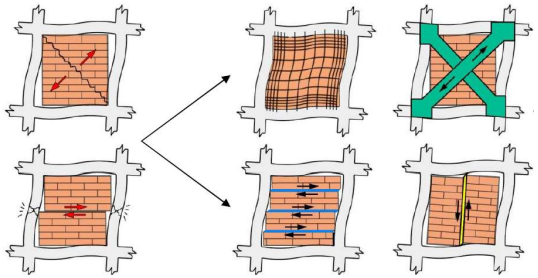
(Morandi et al 2015)



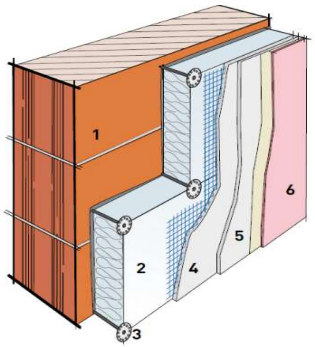
(Tasligedik et al 2017)

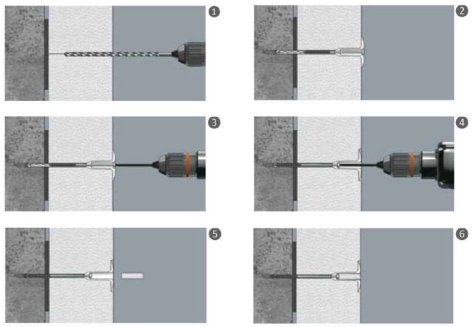
Soluzioni di miglioramento sismico, energetico ed architettonico integrate

Intervento sismico



Intervento energetico





Intervento architettonico

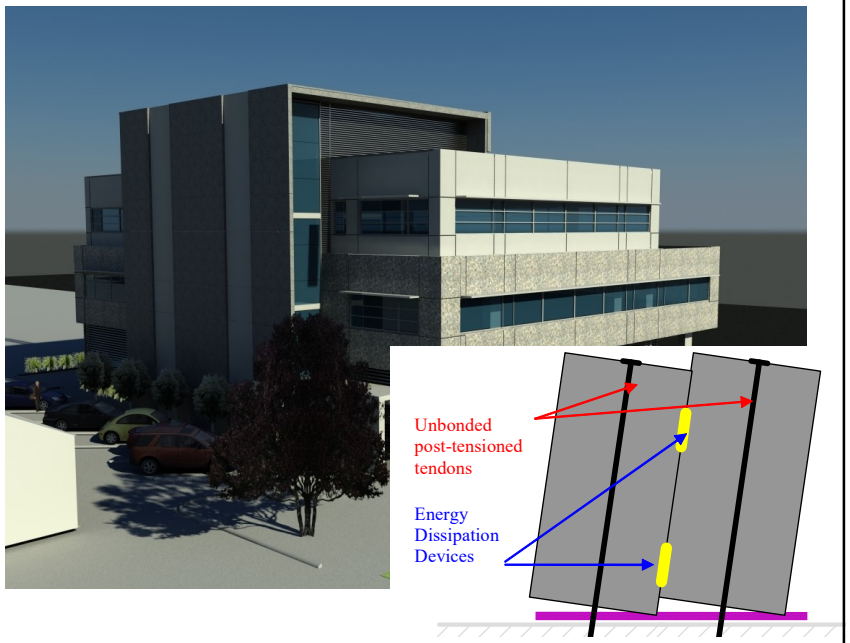
Towards a National Plan for Integrated Seismic and Energy Efficiency Rehabilitation of School
Raising the Bar to Enhance Community Resilience and Sustainability

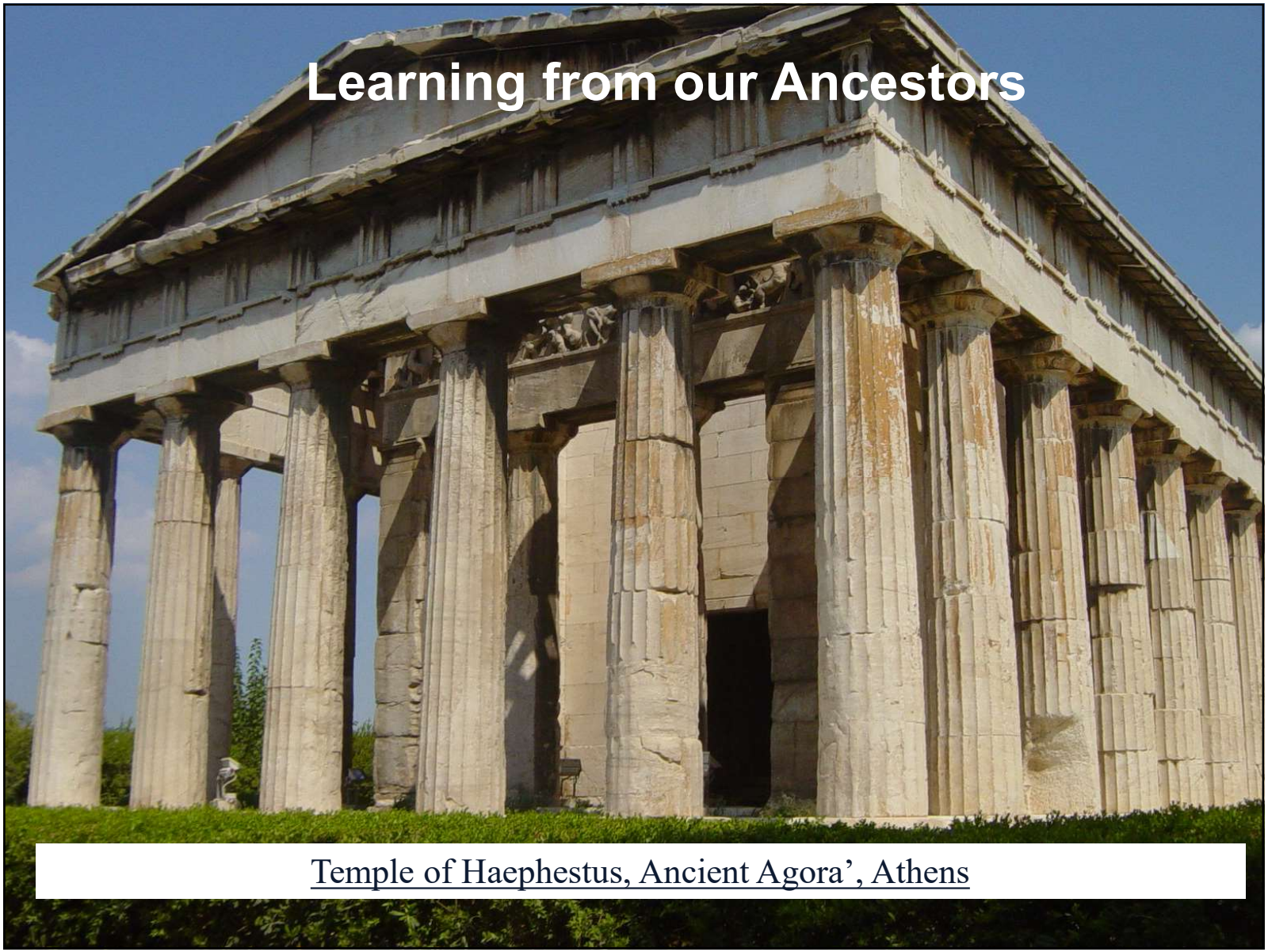
The Opportunity for the Future: Cost-efficient low-damage technology

Base Isolation

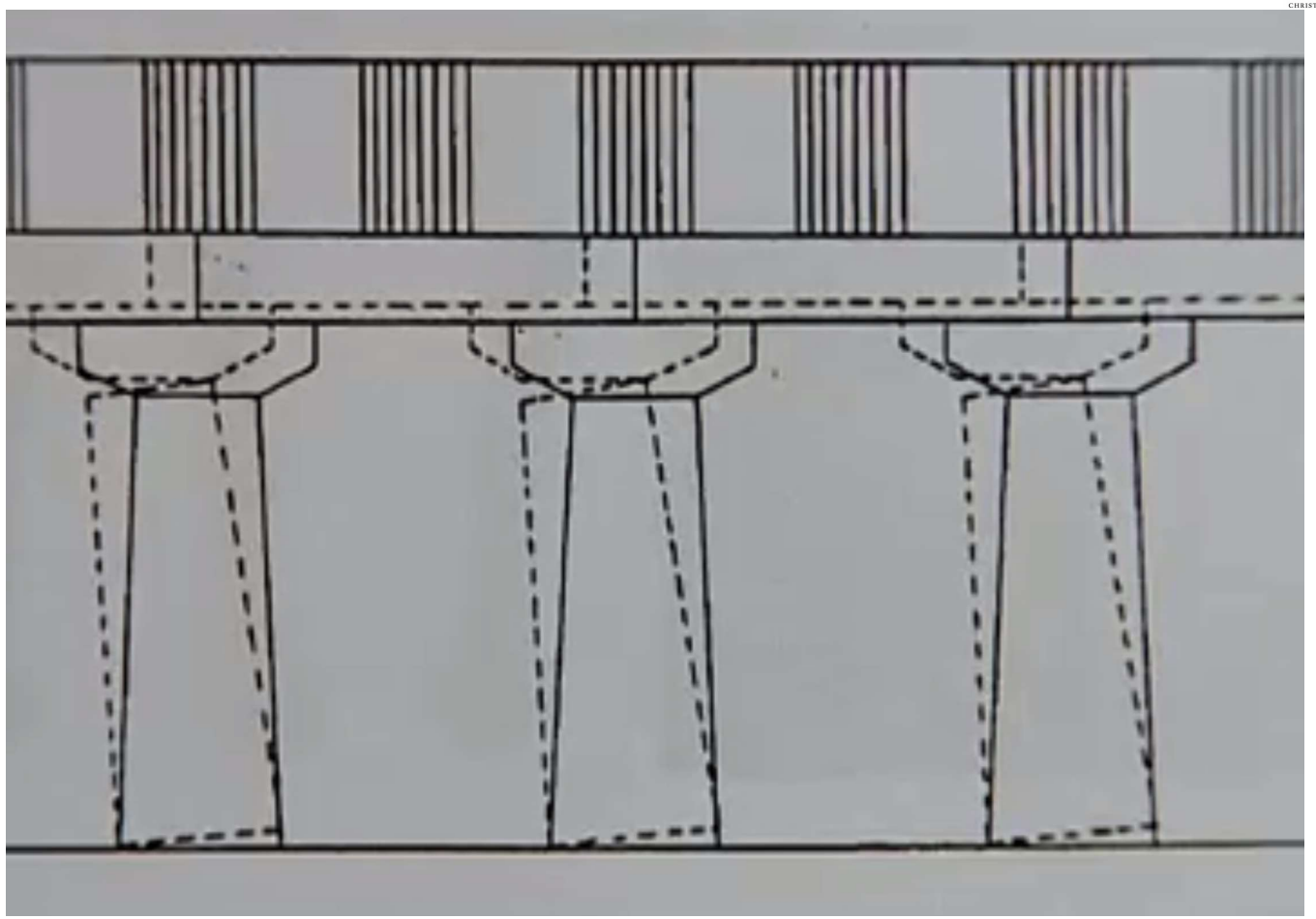
(Christchurch Women Hospital)

PRESSS-Technology (An Internal Isolation?)
(Southern Cross Hospital Endoscopy Building)

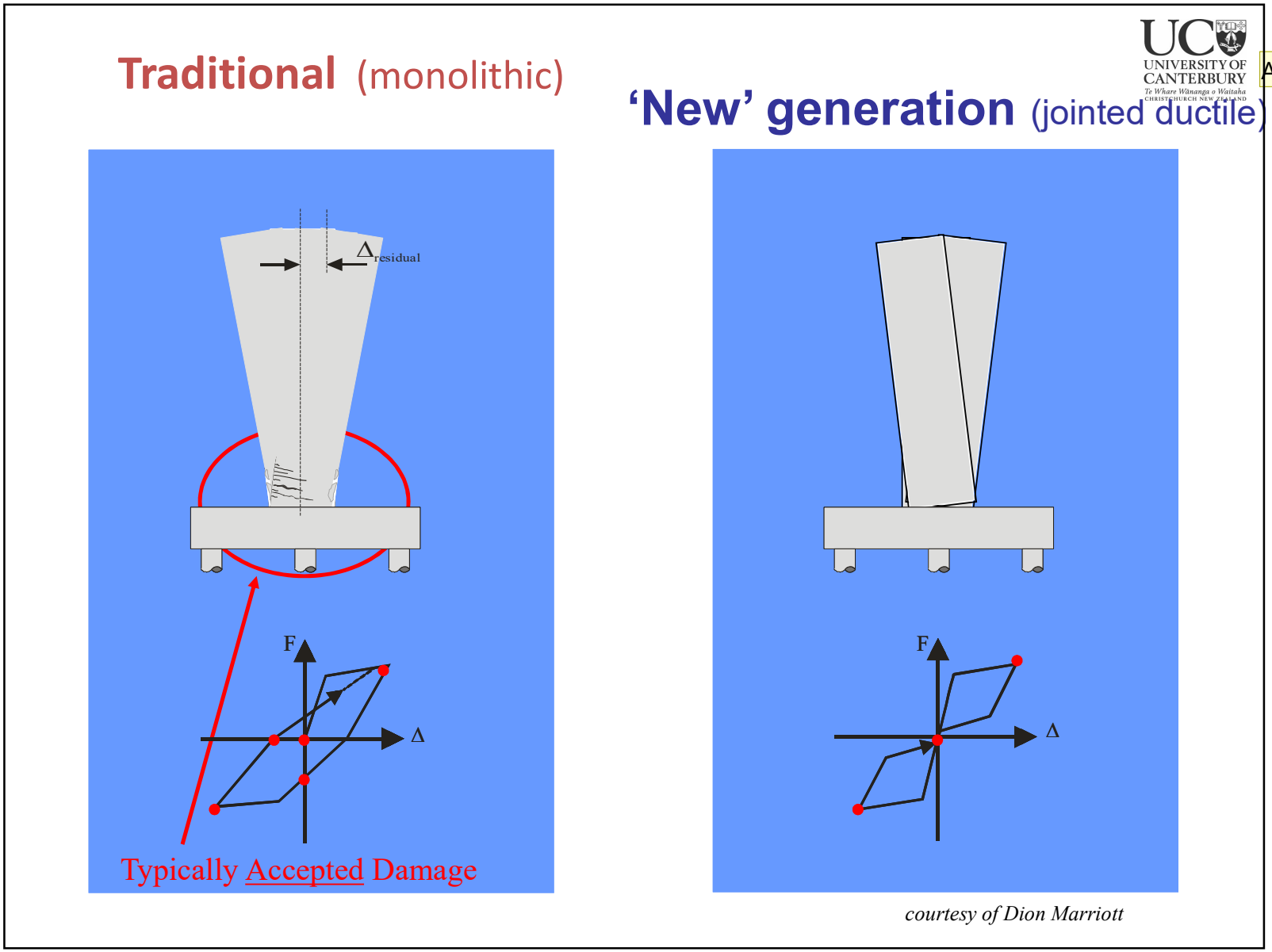




Prof. Dr. Eng. Stefano Pampanin



https://www.sciencelearn.org.nz/videos/864-learning-from-the-past

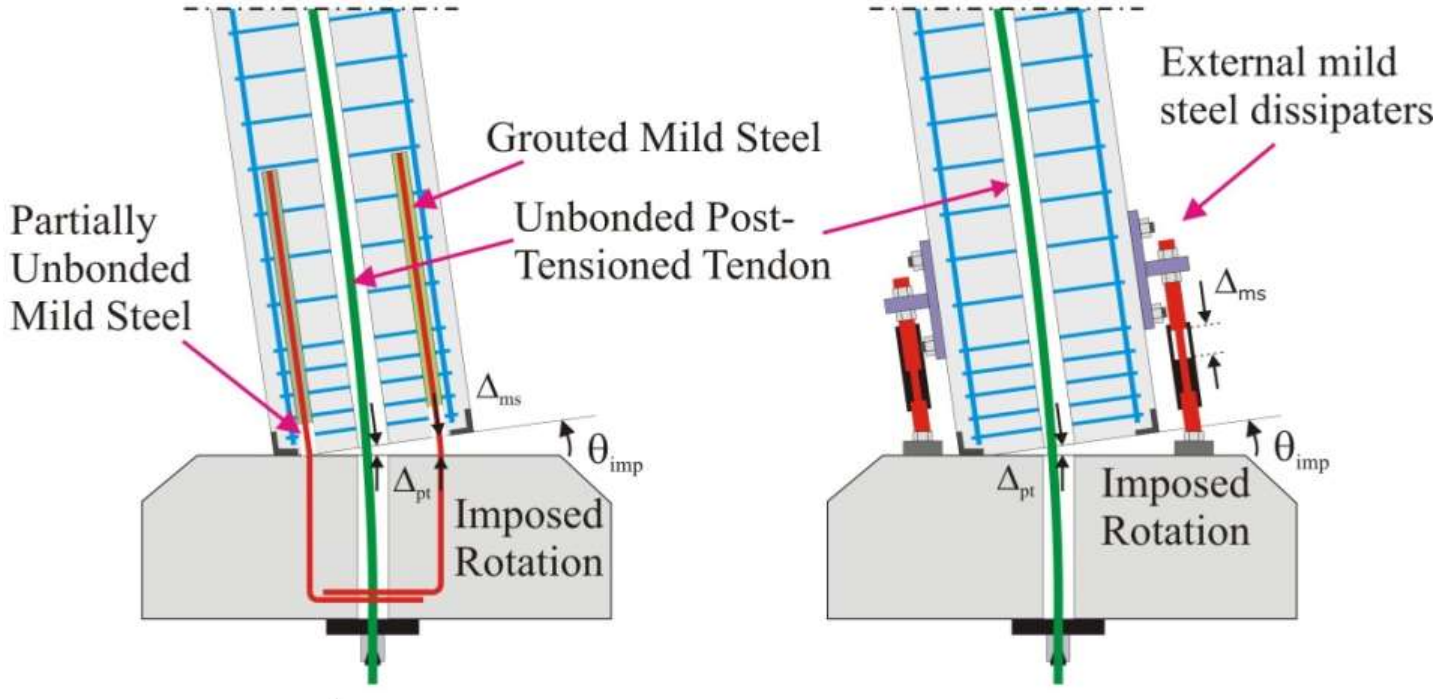

Traditional (monolithic)
'New' generation (jointed ductile)
UC UNIVERSITY OF CANTERBURY
A1
$\Delta_{residual}$
F
Δ
Typically Accepted Damage
F
Δ
courtesy of Dion Marriott

Diapositiva 43

A1 Autore, 16/10/2008

External &Repleacable Dissipaters ("Plug & Play")

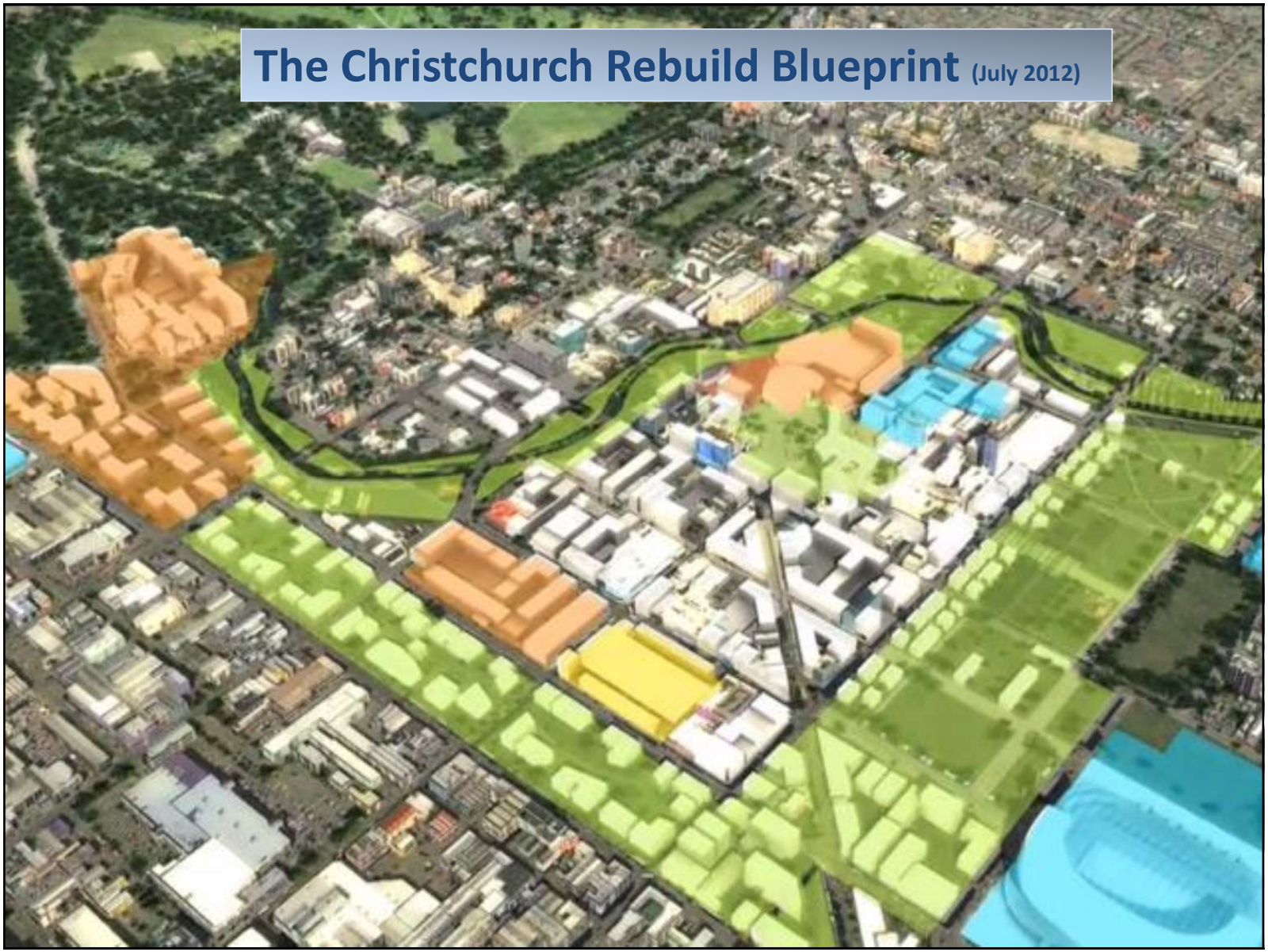
UC UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND



Marriott et al., 2008

Christchurch Vision 2050: Re-building a resilient city with low- damage technology

Prof. Dr. Eng. Stefano Pampanin


The Christchurch Rebuild Blueprint (July 2012)

Low-Damage Technologies

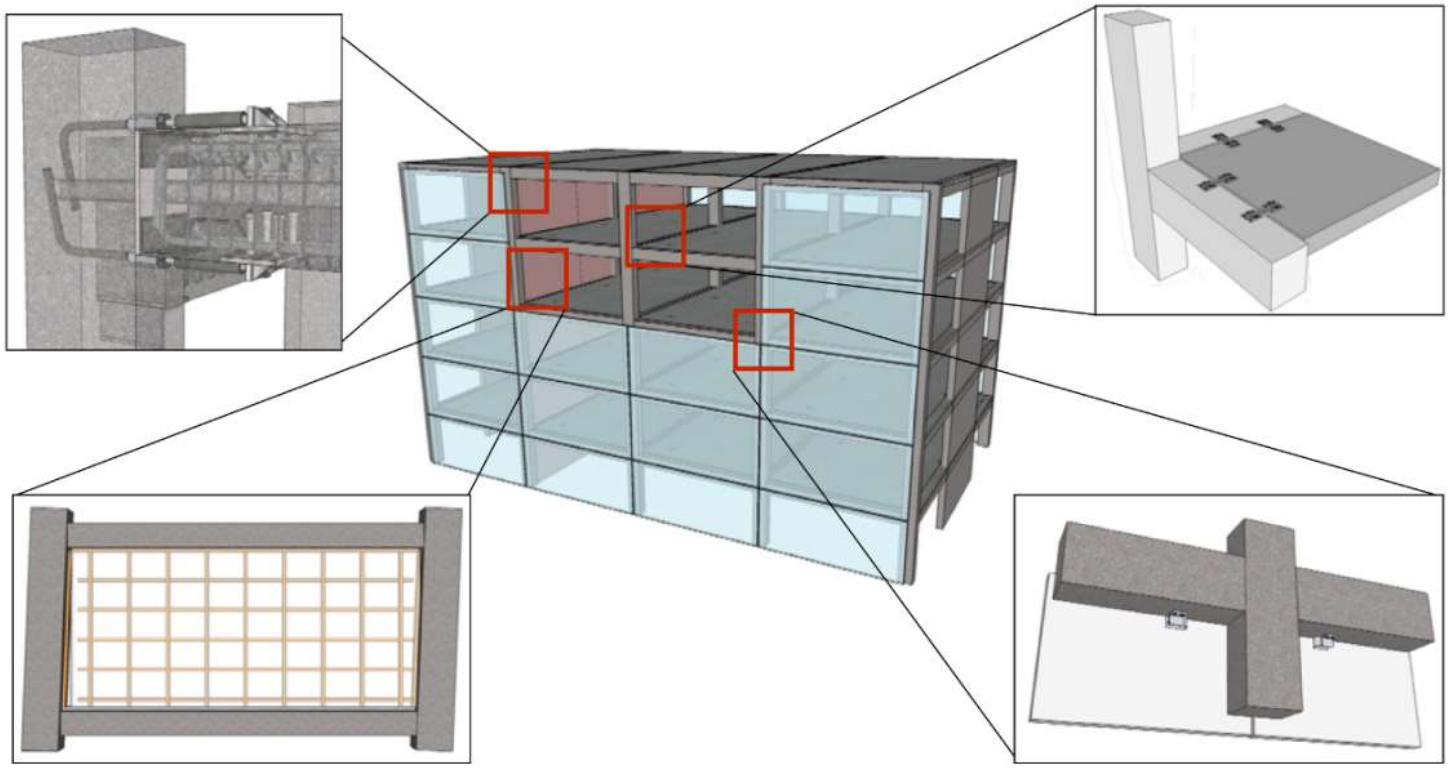
Concrete, Timber, Steel and combinations

Prof. Dr. Eng. Stefano Pampanin

Towards the "Ultimate Earthquake Proof-building"
Shake-table testing of an integrated low-damage system

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Johnston, Watson, Pampanin, Palermo (2013, 2014)

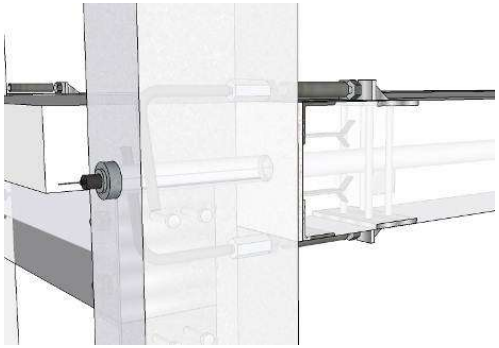


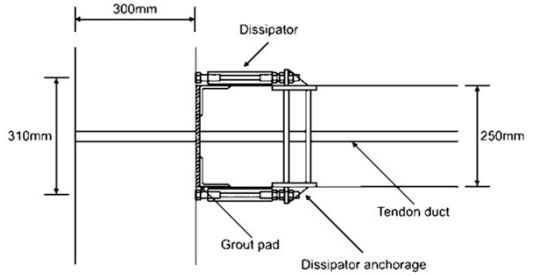
Next Generation of Integrated Low-Damage Building with dry jointed ductile connections

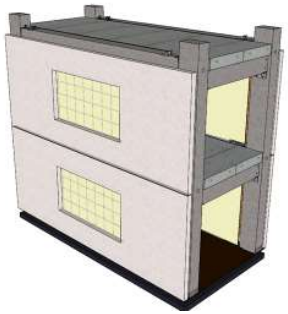
Shake-table testing of an integrated low-damage system

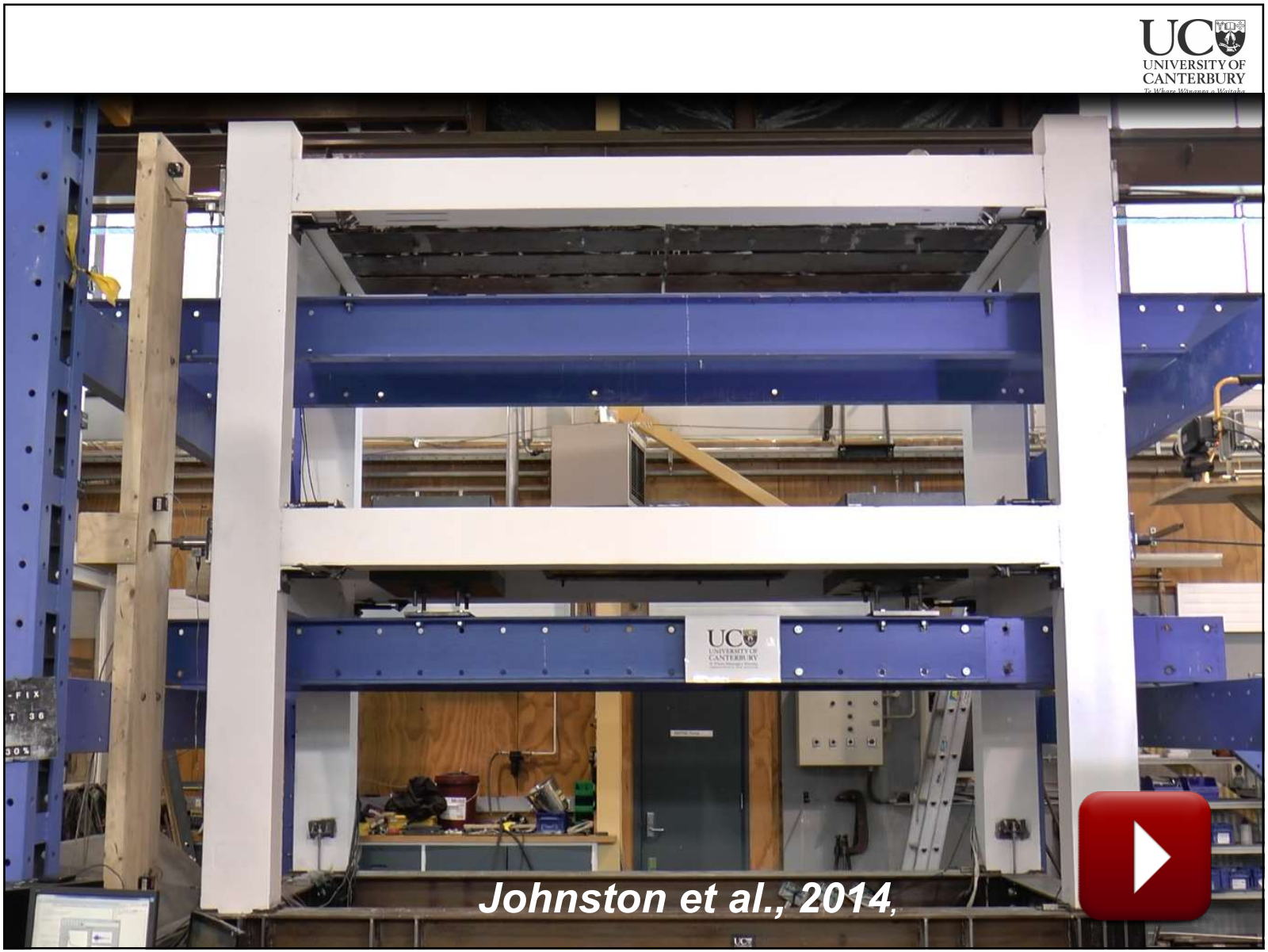
Johnston, Watson, Pampanin, Palermo (2013, 2014)

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND








UC
UNIVERSITY OF
CANTERBURY
Johnston et al., 2014

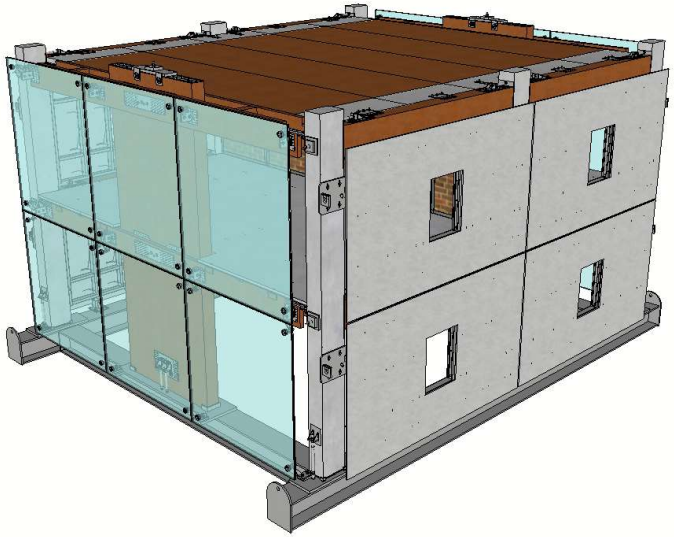
Prof. Dr. Eng. Stefano Pampanin

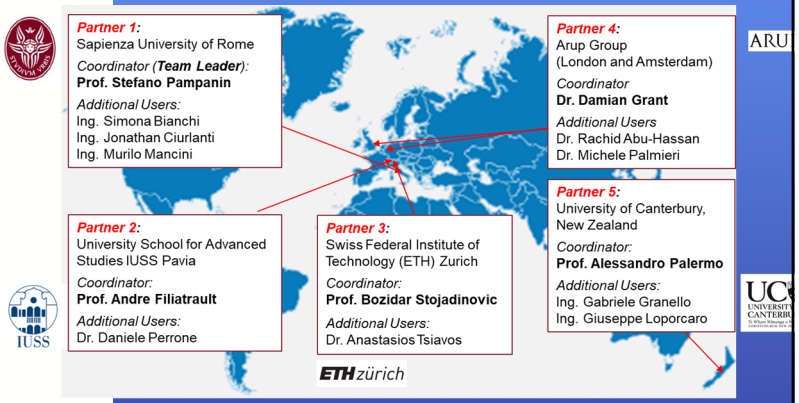

UC
00:03


NZSEE
2017
CONFERENCE
27 – 29 APRIL
WELLINGTON • NEW ZEALAND
New Zealand Society for Earthquake Engineering Annual Conference
and Anti-Seismic Systems International Society 15th World Conference
on Seismic Isolation Energy Dissipation and Active Vibration Control of Structures
Next Generation of Low Damage and Resilient Structures
What a brilliant legacy from our Ancestors
10:39 / 1:59:02
https://www.youtube.com/watch?v=elGijGMFtmo
UC UNIVERSITY OF CANTERBURY
Ingredients for a perfect Damage Control receipe
Design philosophy
Conventional design
Seismic isolation / Pure Rocking
Plastic hinging
Devices
Elastomeric bearings
Lead rubber bearings (Robinson, 1982)
Friction pendulum device (Zayas et al., 1990)
Plain sliding isolators (pot, disk, spherical bearing)
Mechanism
Free rocking (stepping & shallow foundation uplift)
Design strategy

An Overview of the SERA Transnational Project

Towards the Ultimate Earthquake Proof Building System: development and testing of integrated low-damage technologies for structural and non-structural elements





Pampanin et al.
31/08/2017

Pag. 5

Stefano Pampanin[a],,
Johnatan Ciurlanti, Simona Bianchi, Gabriele Granello, Daniele Perrone, Michele Palmieri, Damian Grant5, Alessandro Palermo, Andre Filiatrault, Alfredo Campos Costa, Antonio Correia

An overview of the design, construction and experimental 3D shake-table testing campaign can be found at:

https://www.youtube.com/watch?v=RHczItvneug&t=558s

1 August 2019 – Lisbon (PT)

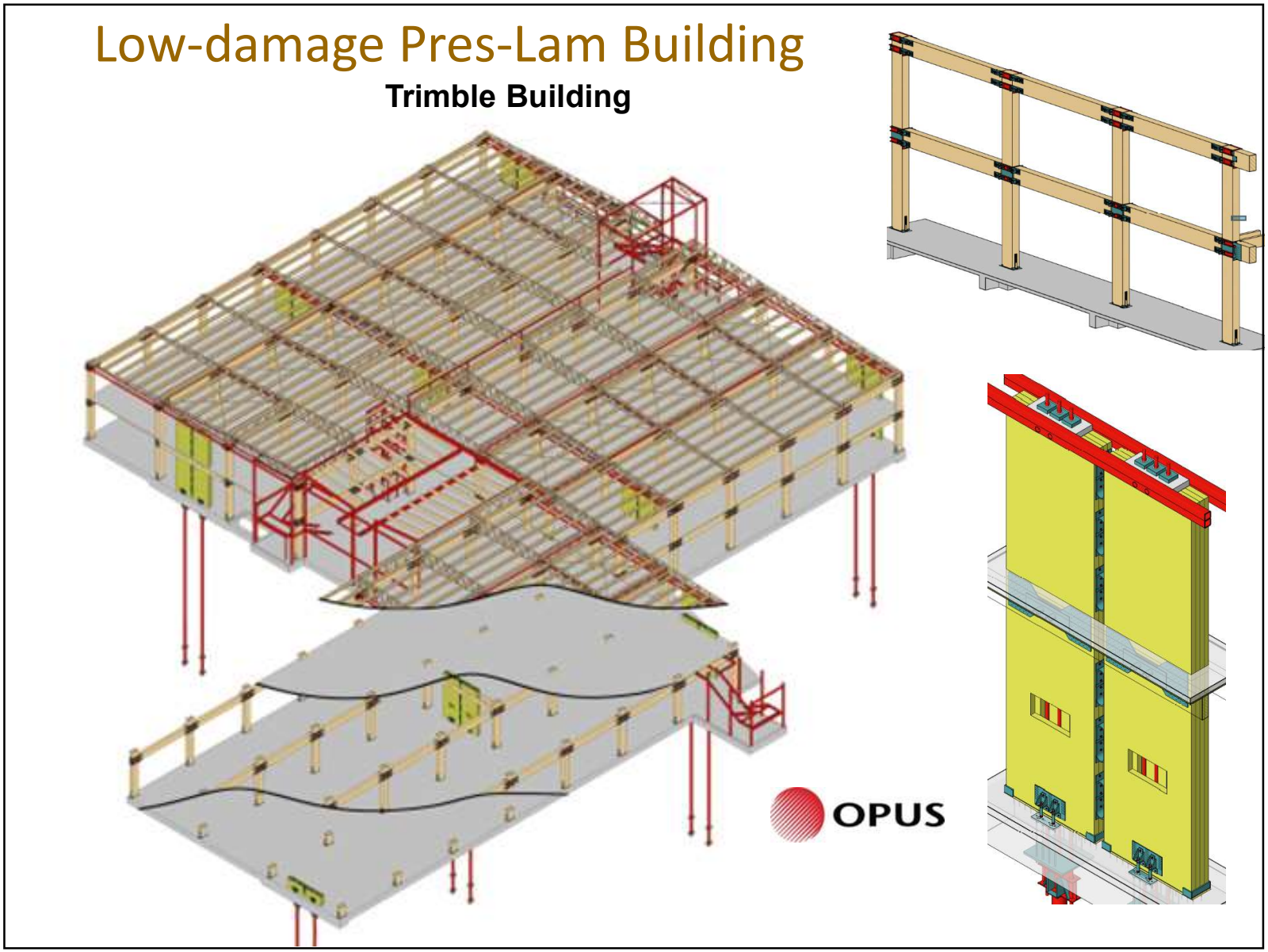
TRIDIRECTIONAL TEST XYZ
LIMIT STATE 4

Christchurch (NZ)
February 22, 2011
Mw = 6.3
Station = CCCC
Depth = 5 km
Distance = 3.8 km
Scaling Factor = 1.2
PGA = 0.58 g

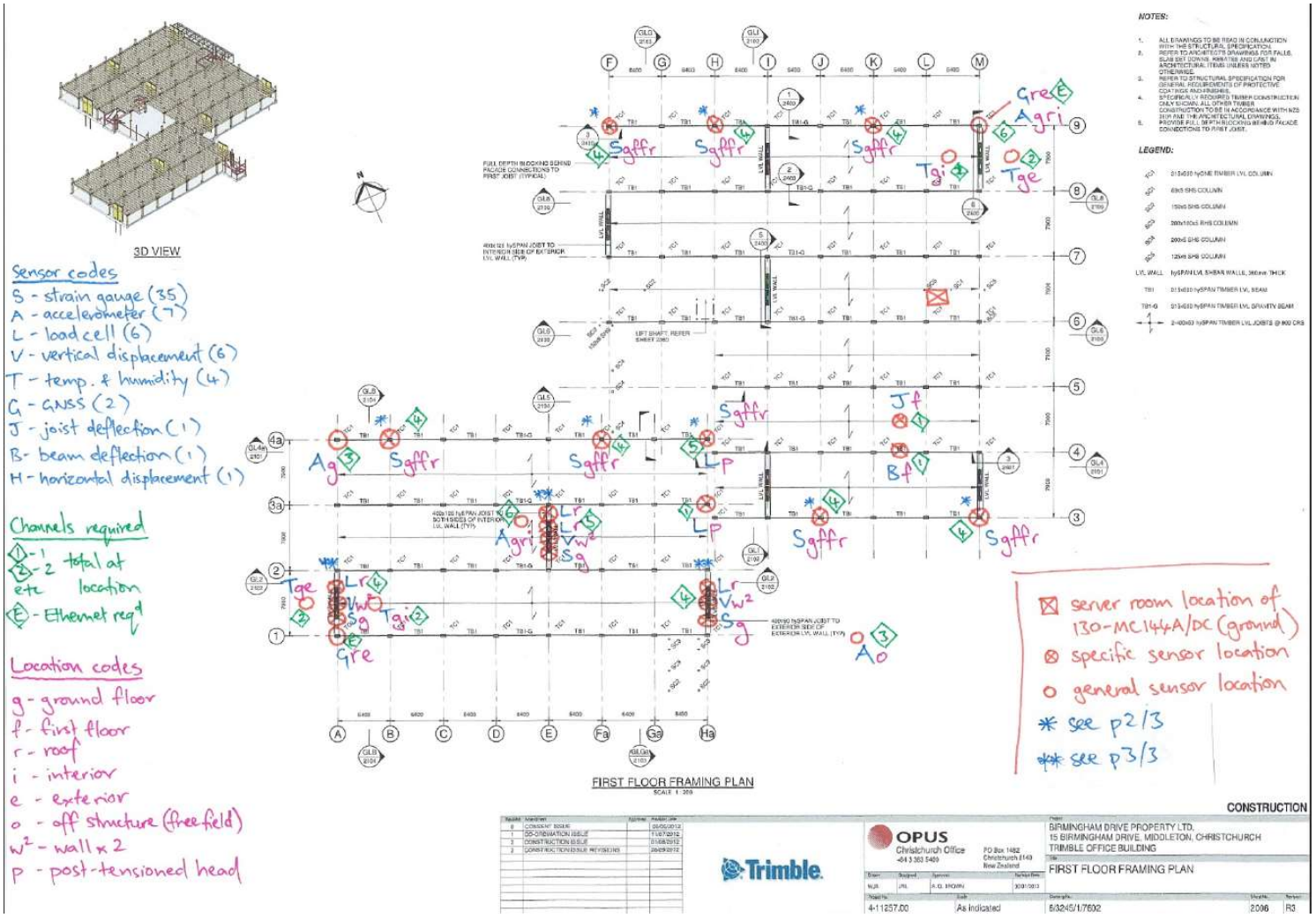
Towards a “S3 Design”
SAFER, SUSTAINABLE, SMART
Building Systems

(Pampanin et al., 2016-)

Prof. Dr. Eng. Stefano Pampanin


Low-damage Pres-Lam Building
Trimble Building
OPUS

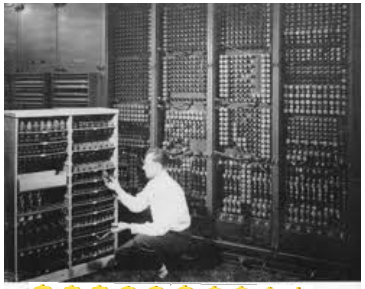
Trimble Building monitoring System

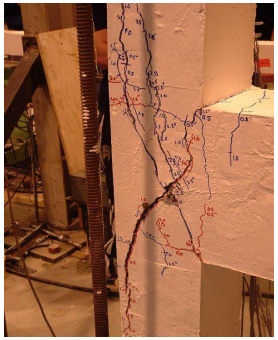
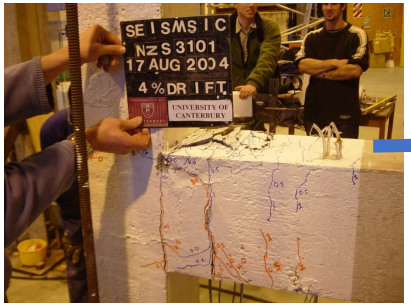


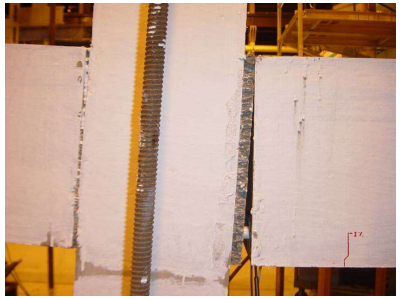
Prof. Dr. Eng. Stefano Pampanin

How much would it cost (vs. performance)?






The bar has been set to very high level
but the International Earthquake Engineering community is going to get there, together!
International Collaborators/Teams:
EERI (US), AIJ/JAEE (Japan),
EEFIT (UK), NCEER (Taiwan),
European Universities
TEAM ITALIA

Prof. Dr. Eng. Stefano Pampanin