Soutenu par
MINISTÈRE DE LA TRANSITION ÉCOLOGIQUE, DE LA BIODIVERSITÉ, DE LA FORÊT, DE LA MER ET DE LA PÊCHE
Liberté
Égalité
Fraternité

AFPCNT
Association Française pour la Prévention des Catastrophes Naturelles et Technologiques
Mieux comprendre, mieux prévenir

afps

En partenariat avec

USRC

Sant'Eusanio Forconese

Università degli Studi di Napoli Federico II

GRINS

reluis

"Build Back Better" post-séisme

"Retour d'expérience post-séisme incarné dans les communes de la province de L'Aquila et à Amatrice"

The C.A.S.E. Project: General Aspects and Seismic Safety

Mauro Dolce
President of ReLUIS
Professor of Structural Engineering, Università di Napoli, Federico II
Past Director of the seismic risk sector of DPC and Responsible for the Project C.A.S.E.

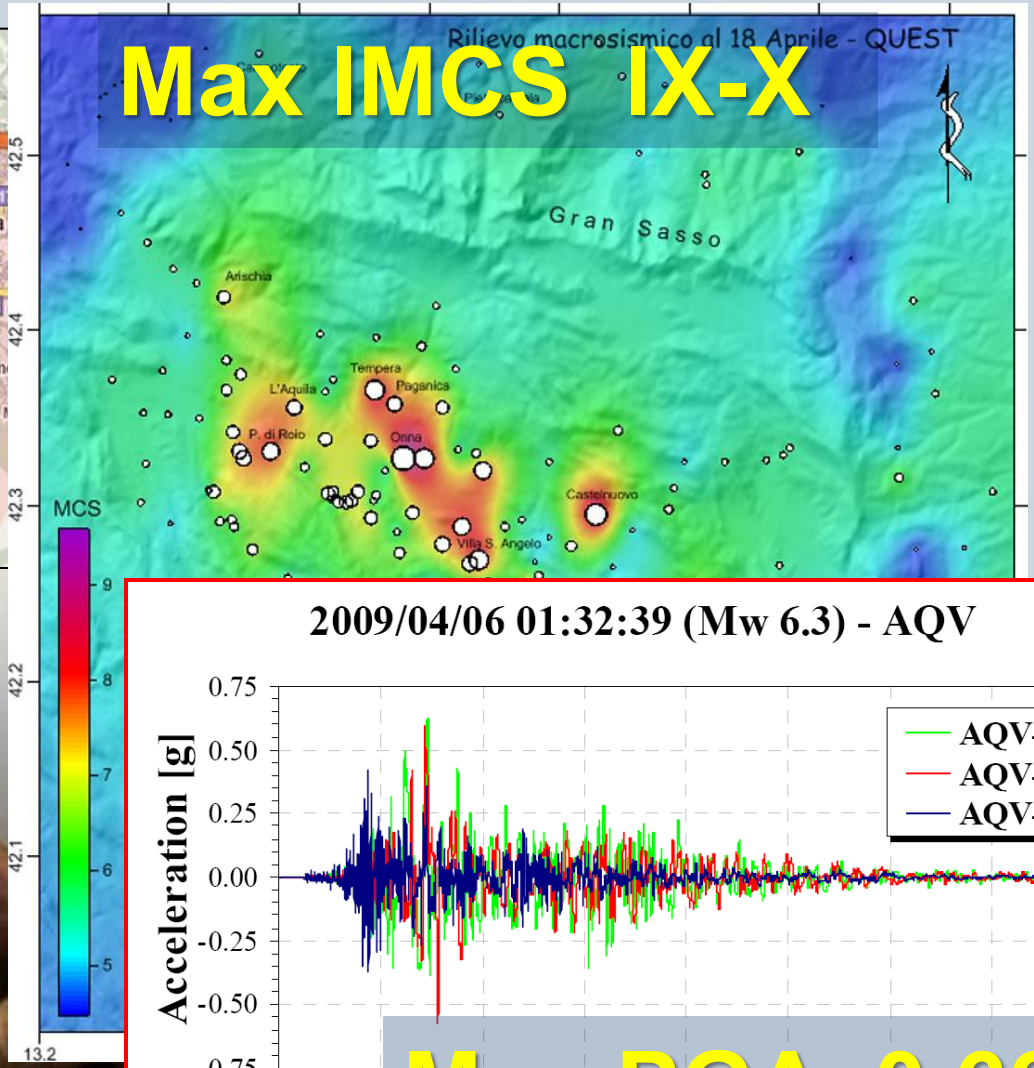
reluis

L'Aquila – September 18, 2025

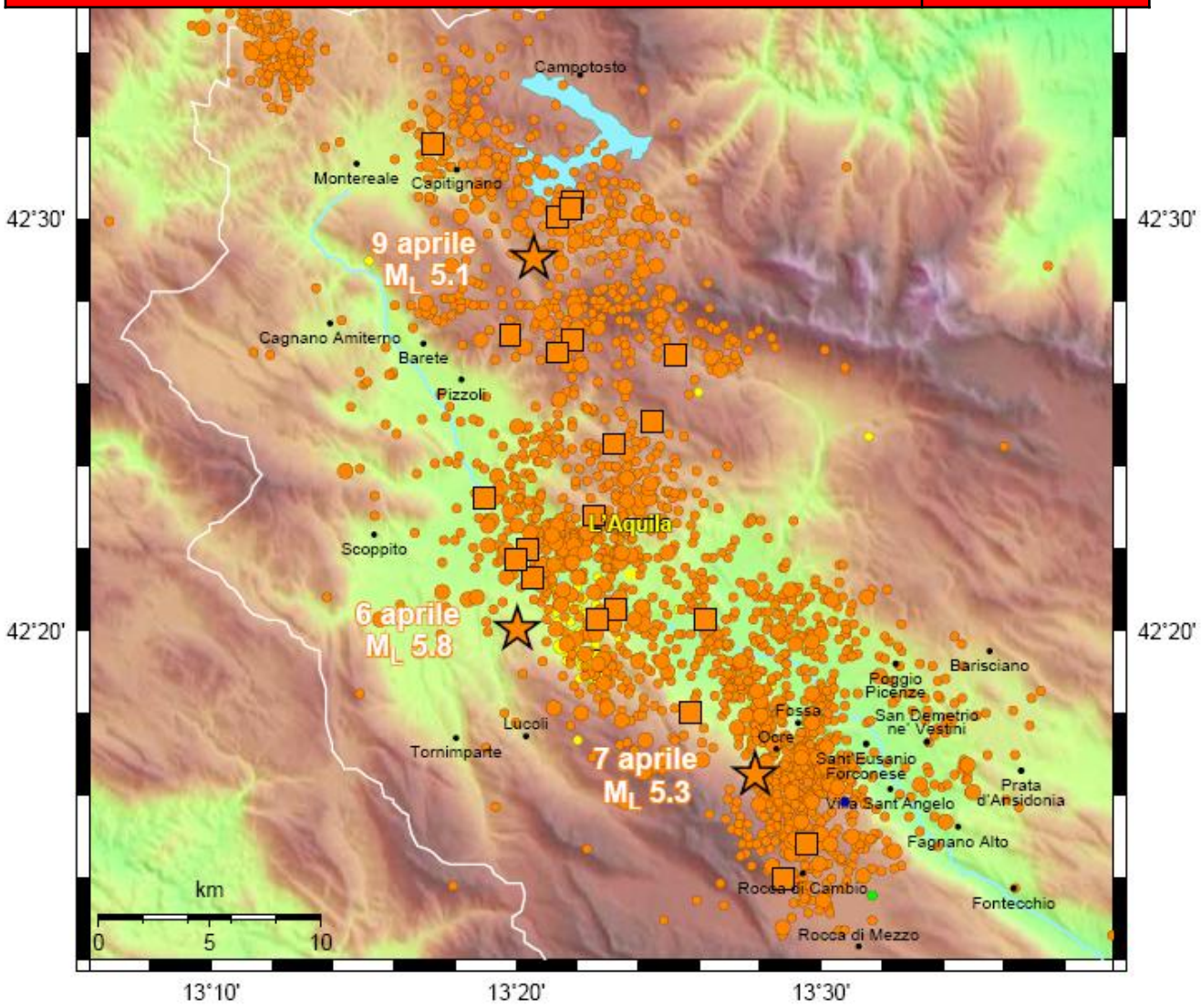
6 April 2009

H. 3.32

Ml 5.9 – Richter
Mw 6.3 - Moment



Total number of quakes in 3 months	9532
2.0≤M<3.0	1700
3.0≤M<4.0	190
4.0≤M<5.0	19
M≥5.0	3



INGV

PROTEZIONE CIVILE NAZIONALE

Sequenza sismica aggiornata al giorno 30 ottobre ore 07:00

Le localizzazioni sono aggiornate alle ore 06:00 UTC

Classificazione in base alla magnitudo M_L

- $2.0 \le M_L < 3.0$
- $3.0 \le M_L < 4.0$
- $4.0 \le M_L < 5.0$
- $M_L \ge 5.0$

Andamento della sequenza

- dal 01/12/2008 al 06/04/2009
- dal 06/04/2009 al 27/10/2009
- 28 ottobre
- 29 ottobre
- 30 ottobre

Onna

National Civil Protection Service *Mandate*

National Civil Protection Service aims at safeguarding human life and health, goods, national heritage, human settlements and the environment from all natural or man-made disasters.

It deals with:

- **Forecasting and Warning**
- **Prevention and Mitigation**
- **Rescue and Assistance**
- **Emergency overcoming**

PRESIDENZA DEL CONSIGLIO DEI MINISTRI
Dipartimento della protezione civile
Ufficio rischio sismico

RAPPORTO E.S.

Rapporto Emergenza Sismica

QUASI-REAL-TIME SIMULATION SCENARIO

Persons Involved in collapses: 200-2200
Homeless: 8700-54000
Collapsed or unusable houses: 6700-38000
→ Collapsed or unusable blds: 4000-24000

3

Scala di emergenza sismica

Evento sismico

Comune epicentrale L'Aquila (L'Aquila)

Data 06-04-09 Longitudine 13.33 Pr

Ora 03.32 Latitudine 42.33 Magnitudo Ml 5.8

Stime complessive

(Attenzione: scenario calcolato su una profondità media ipocentrale di 10 km)

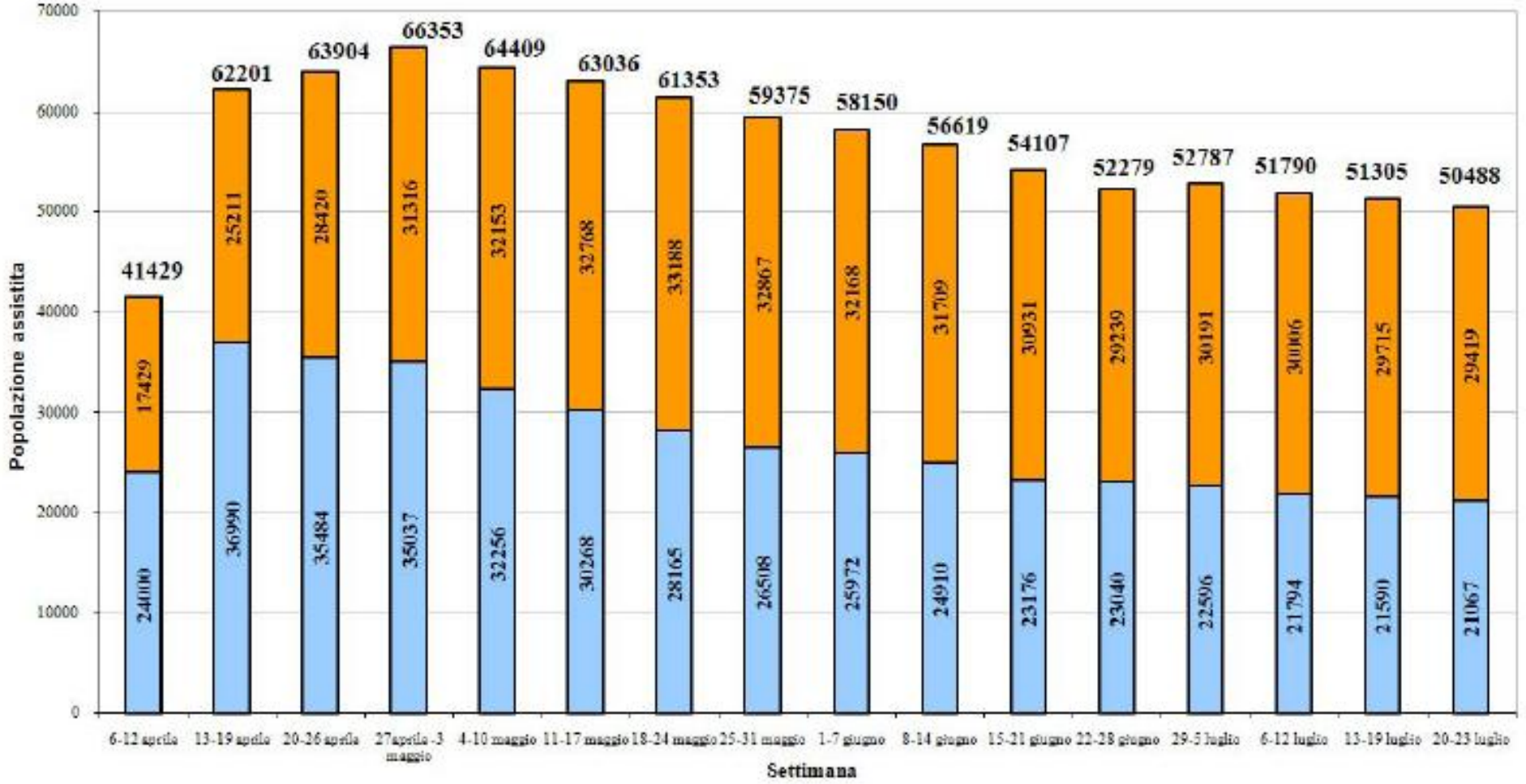
Probabili persone coinvolte in crolli (min-max)	200	2200
Probabili persone senza tetto (min-max)	8700	54000
Probabili abitazioni crollate o inagibili (min-max)	6700	38000
Probabili abitazioni danneggiate (min-max)	61000	207000
Probabile Intensità (MCS) massima raggiunta		VIII-IX
Probabili COM/Prefetture da allertare		16 (+ 46 con ES = 0)
Comuni afferenti ai COM		284 (+ 244)

TENT CAMPS

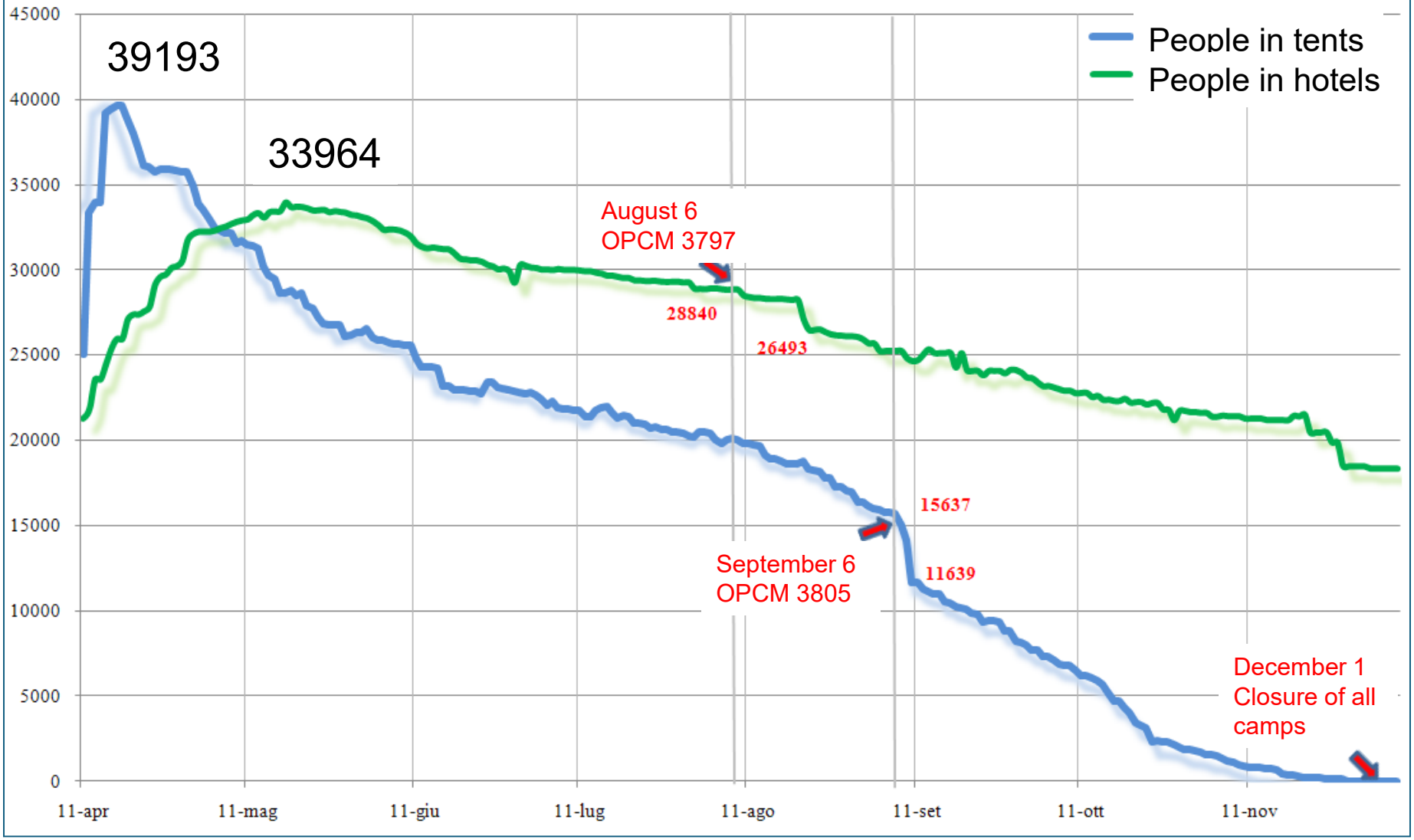
Over 66 000 people assisted at 1st May

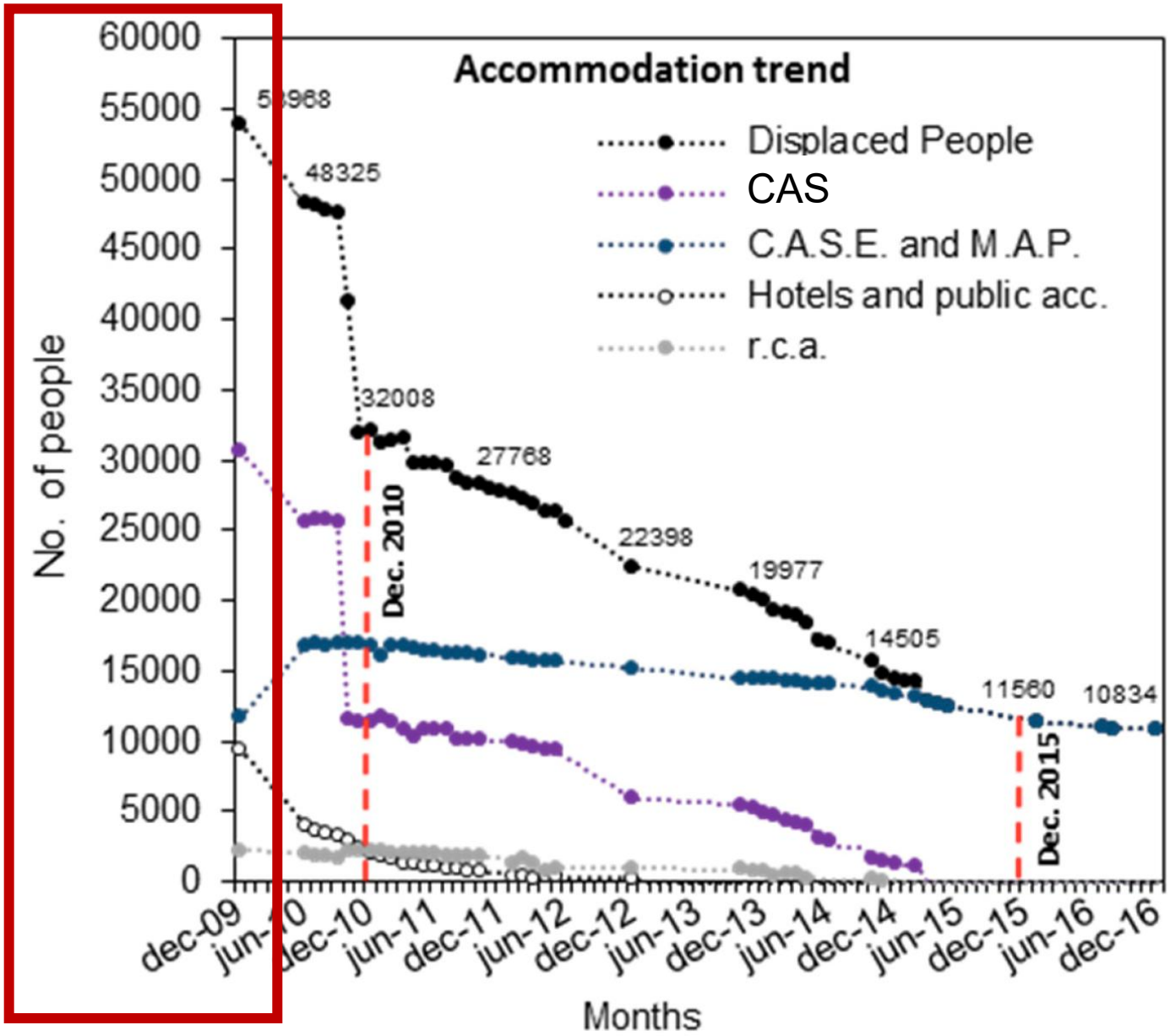
Weekly average of the people assisted

Updated 23.07.09



ASSISTED POPULATION




Accommodation trend
Displaced People
CAS
C.A.S.E. and M.A.P.
Hotels and public acc.
r.c.a.
No. of people
Months
60000
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
48325
32008
27768
22398
19977
14505
11560
10834
Dec. 2010
Dec. 2015
dec-09
jun-10
dec-10
jun-11
dec-11
jun-12
dec-12
jun-13
dec-13
jun-14
dec-14
jun-15
dec-15
jun-16
dec-16

POST-EARTHQUAKE DAMAGE/USABILITY ASSESSMENT

USABILITY

Post-earthquake usability evaluation is a quick and temporarily limited assessment, based on expert judgement of specially trained technical teams, on visual screening and on easily collected data, aimed to detect if, during the current seismic crisis, damaged buildings can be used, the human life being reasonably safeguarded.

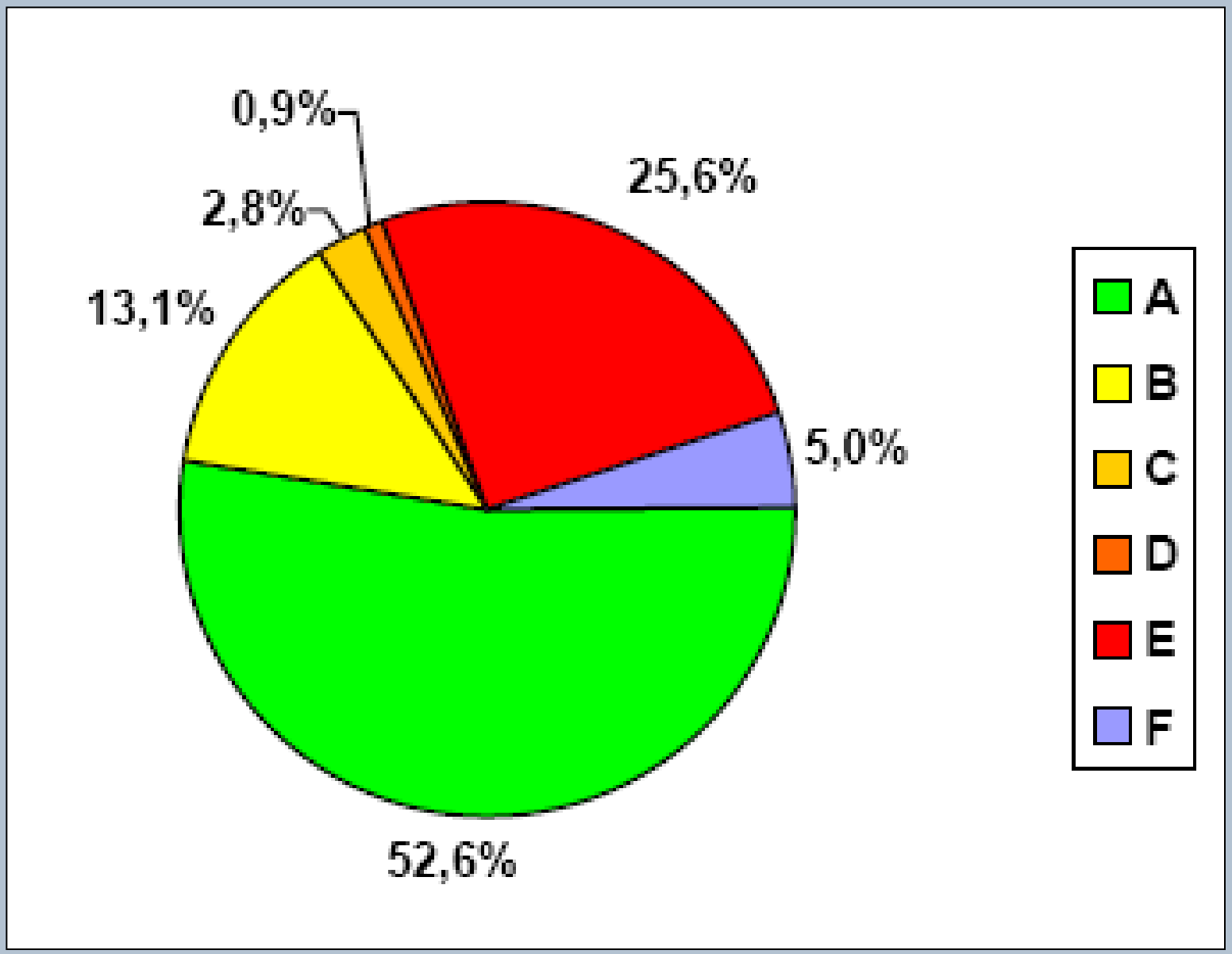
A) USABLE	**Building can be used without measures. Small damage, but negligible risk for human life.**
B) USABLE WITH COUNTERMEASURES	**Building is damaged, but can be used when short term countermeasures are taken**
C) PARTIALLY USABLE	**Only a part of the building can be safely used**
D) TEMPORARILY UNUSABLE	**Building to be re-inspected. Unusable until a new inspection.**
E) UNUSABLE	**Building can not be used due to high structural, non structural or geotechnical risk for human life. Not necessarily imminent risk of total collapse.**
F) UNUSABLE FOR EXTERNAL RISK	**Building could be used, but it cannot due the high risk caused by external factors (heavy damaged adjacent or facing buildings, possible rock falls, etc.)**

Damage and usability assessment
No. of inspections carried out

80 000

- *More than 5000 experts making inspections*
- *More than 300 experts involved in preparatory activities and in processing*

Statistics



POST-EMERGENCY – TEMPORARY TIMBER HOUSES

S. GIULIANO DI PUGLIA – 2002 earthquake

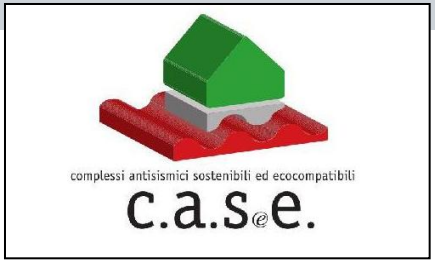
The Decree n.39 "Abruzzo" of 28 April 2009 *(converted to Law N.77 of 23 June 2009)*

MAIN POINTS

- Enforcement of the new National Technical Standards
- Funding seismic prevention: €1 billion in 7 years
- Provisions for repair and strengthening or reconstruction of private and public buildings
- Seismic safe temporary housing: Project C.A.S.E.

POST EMERGENCY STRATEGY FOR HOMELESS PEOPLE

IMMEDIATELY (weeks - months)	TEMPORARILY (2 - 5 - 10+ years reconstruction process)	FINAL
TENTS, HOTELS, disused barracks, rent-controlled apartment (RCA)	• CAS (Money contribution), • TIMBER HOUSES (MAP) HIGH STANDARD DWELLING BUILDINGS	REPAIRED OR RECONSTRUCTED BUILDINGS



For people leaving in heavily damaged buildings of the L'Aquila Municipality

A **census** (with interview) of people with **heavily damaged buildings** was carried out in **August 2009** to assess the **CASE demand** and the **family composition** (to decide the size of the apartments)

Temporary long-term housing solutions

~8000 houses for ~25000 homeless people available in few months

L'AQUILA

complessi antisismici sostenibili ed ecocompatibili

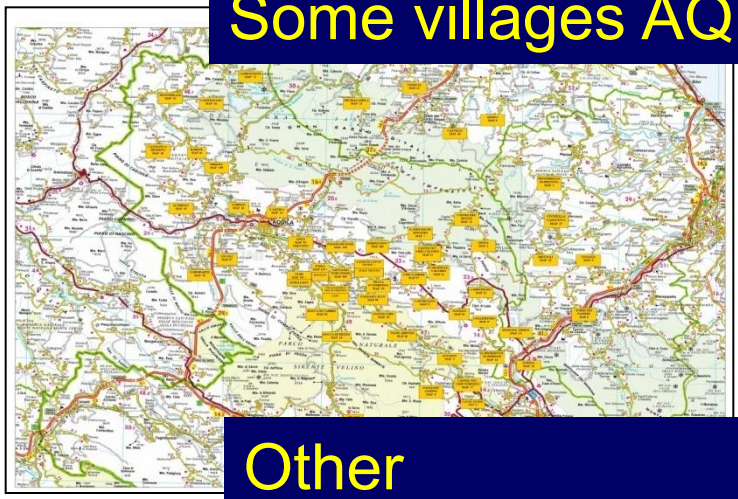
c.a.s.e.

4449 apartments

Some villages AQ

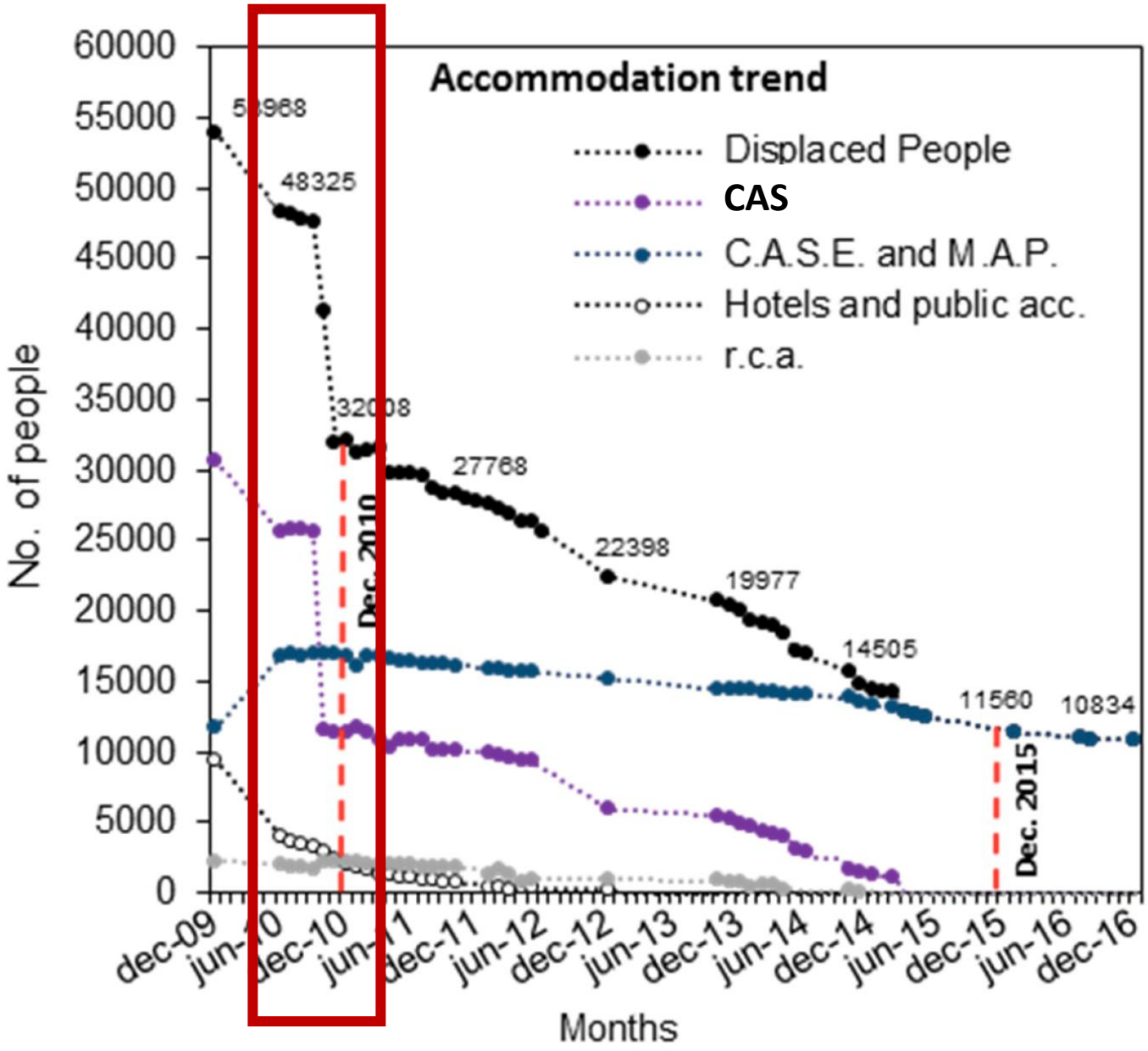
1273 apartments

MODULI ABITATIVI PROVVISORI M.A.P.



Other municipalities

2262 apartments


Accommodation trend
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jun-10
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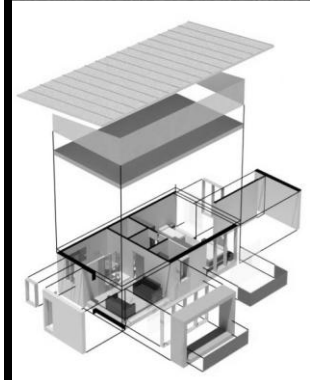
jun-11
dec-11
jun-12
dec-12
jun-13
dec-13
jun-14
dec-14
jun-15
dec-15
jun-16
dec-16

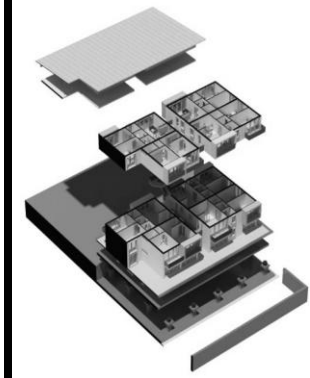
PROJECT C.A.S.E.

Complessi (Complexes)
Antisismici (Antiseismic)
Sostenibili (Sustainable)
Eco-compatibili (Eco-compatible)

complessi antisismici sostenibili ed ecocompatibili

c.a.s.e.




REQUIREMENTS AND OBJECTIVES OF PROJECT C.A.S.E.

- **Very strict time scheduling:** 4000→ 4700 houses in 6-7 months for 14000→18000 persons (living in the L'Aquila municipality)
- **Minimizing urbanization costs**
- **Compatibility with the landscape and the urban environment and proximity to the damaged built areas**
- **Maximum safety with respect to seismic actions**
- **High comfort standards**
- **High energy autonomy and eco-sustainability standards**
- **Furnished houses with all accessories for normal life**

FUNDAMENTAL ASPECTS OF THE DESIGN SOLUTION

- **Distribution on19 areas carefully selected,** near existing villages, devoting at least 30% of each area to services
- **Wide green areas with no car traffic**
- **Seismic isolation against earthquakes** (high protection, lower design prerequisites for foundation and building structures)
- **Shallow foundation** (lower soil characteristics requirements)
- **Double plate solution for the basement**
- **Three stories maximum for building elevation**
- **Prefabrication and design freedom over the upper plate** (several types with several structural materials)
- **Solutions for the energy autonomy** (solar and photovoltaic panels, etc.) **and the sustainability**

SELECTION OF AREAS AND SITES

- **Several (about 20) areas**, not a single “new town”
- Areas compatible with **urban planning and near existing settlements**
- Sites verified for:
  → **seismic** safety (surficial active faults, etc.)
  → **hydrogeologic** safety
  → **hydraulic** safety
  → **geotechnical** characteristics compatible with shallow foundation
- **Expropriations**

START OF AREA SELECTION → END OF APRIL
START OF WORKS → JUNE 8

0. RAPPORTO GENERALE C.A.S.E.

Consorzio forcase

c.a.s.e.

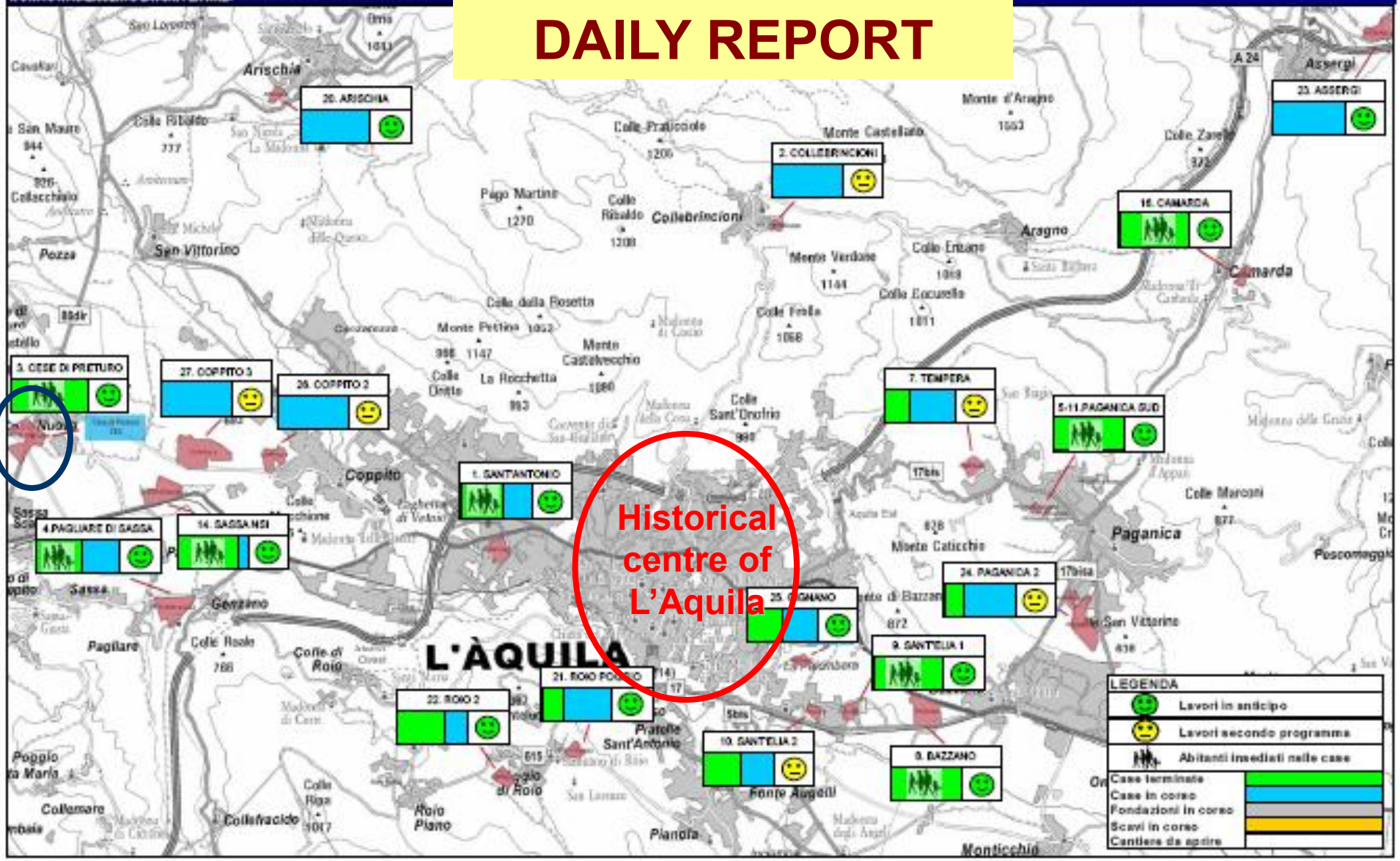
Rapporto giornaliero n 167 del 21/11/2009

2. METEO

Lu	Ma	Me	Gi	Ve	Sa	Do
16/11/2009	17/11/2009	18/11/2009	19/11/2009	20/11/2009	21/11/2009	22/11/2009
10/4°	13/5°	15/6°	13/7°	13/8°	10/6°	

1. STATO AVANZAMENTO LAVORI PER AREE

DAILY REPORT



Costruzione Case

- Lavori iniziati
- Strutture e tamponamenti terminati
- Impianti finiti
- Serramenti Finiti
- Finiture finite = casa ultimata
- Casa arredata
- A — Casa consegnata agli abitanti

BAZZANO

Bazzano - 5 July 2009

complessi antisismici sostenibili ed ecocompatibili

c.a.s.e.

Bazzano – 29 October 2009

CESE DI PRETURO

Cese di Preturo - 5 July 2009

complessi antisismici sostenibili ed ecocompatibili

c.a.s.e.

Cese di Preturo – 29 October 2009

complessi antisismici sostenibili ed ecocompatibili

c.a.s.e.

COPPITO 3

Lavori di fondazione
- Lavori non iniziati
- Scavi finiti
- Platea finita
- Pilastri finiti
- Solai finiti = piastra completata
- Muri ultimati
- Piastre senza muri

Costruzione Case
- Piastra consegnata
- Lavori iniziati
- Strutture e tamponamenti terminati
- Impianti finiti
- Serramenti Finiti
- Finiture finite = casa ultimata

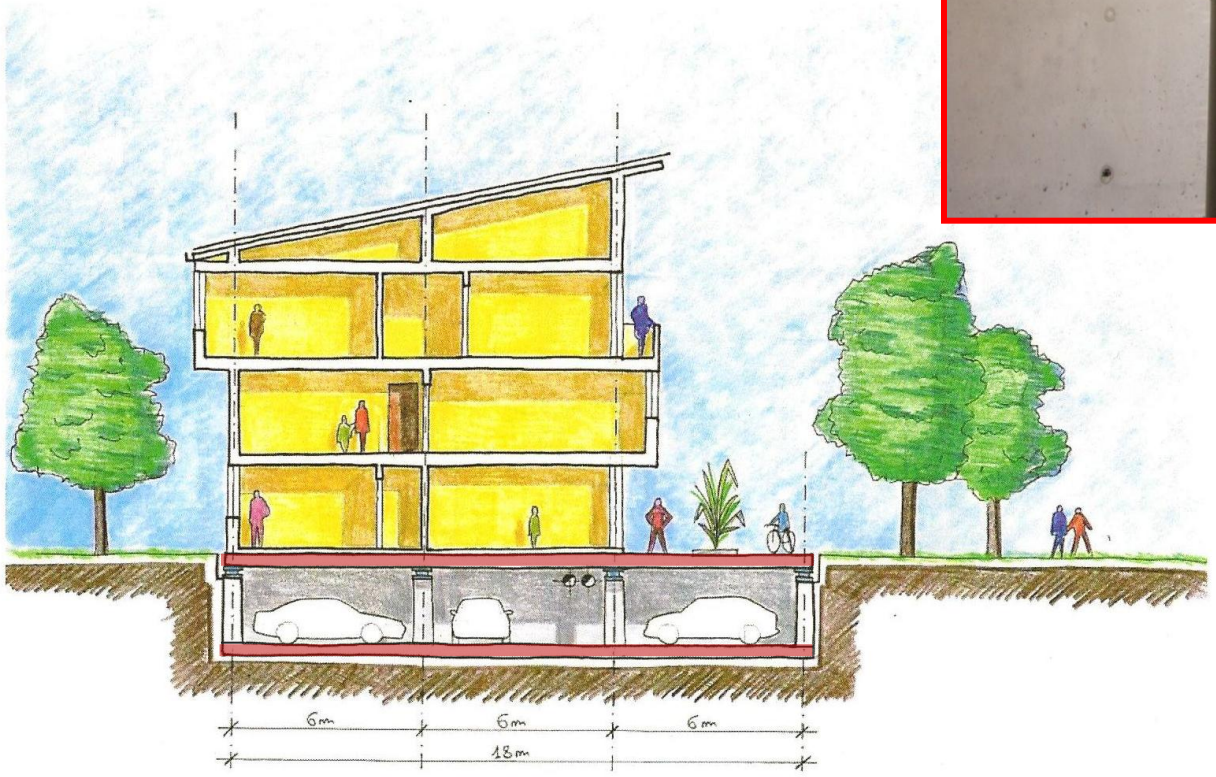
Coppito 3 - 29 Ottober 2009

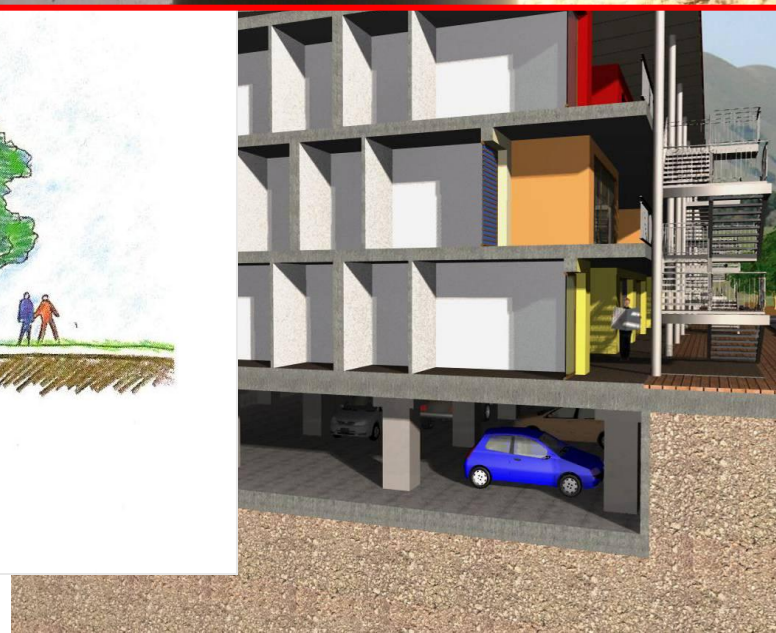
complessi antisismici sostenibili ed ecocompatibili
c.a.s.e.

SEISMIC SAFETY:

DOUBLE PLATE SEISMIC ISOLATION

- Abitazioni e quartieri disponibili in cinque/sei mesi
- Sicurezza antisismica di “isolato urbano”
- Elevato livello dello standard abitativo
- Elevato livello tecnologico orientato all’autosufficienza
- Sostenibilità ambientale e bioedilizia





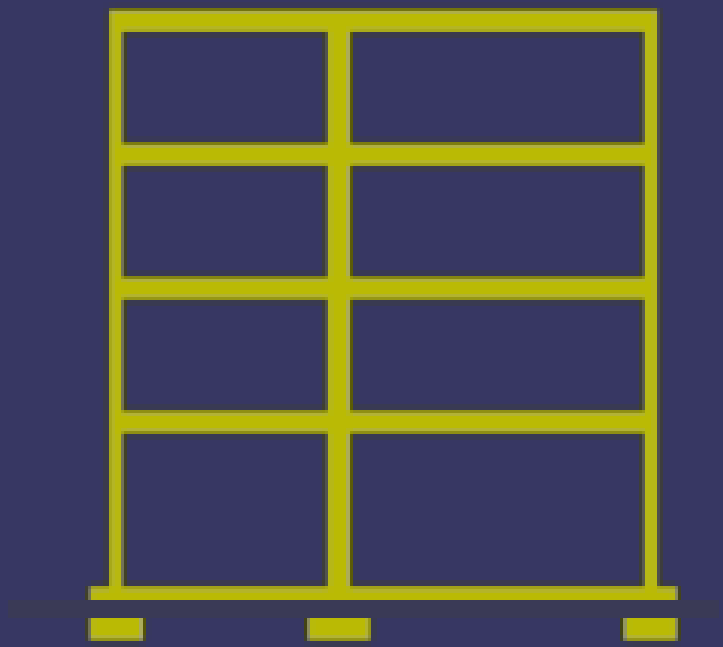
OUTPUT

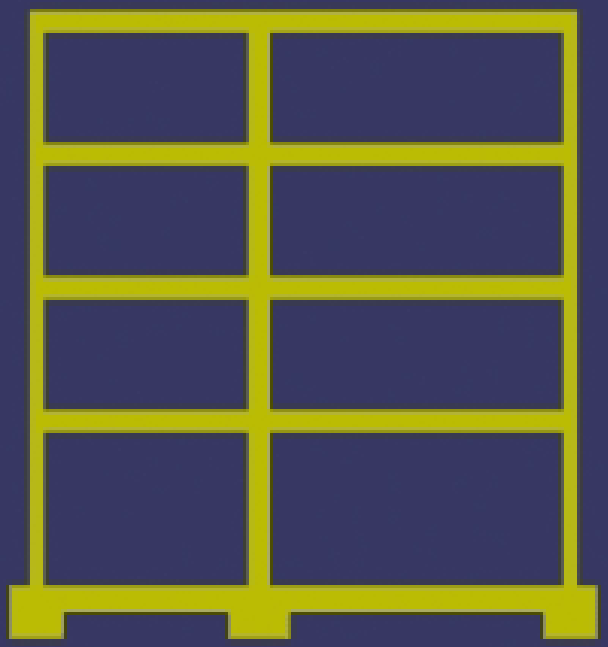
Interstory drift

Structure accelerations

BASE ISOLATED

FIXED AT THE BASE





INPUT

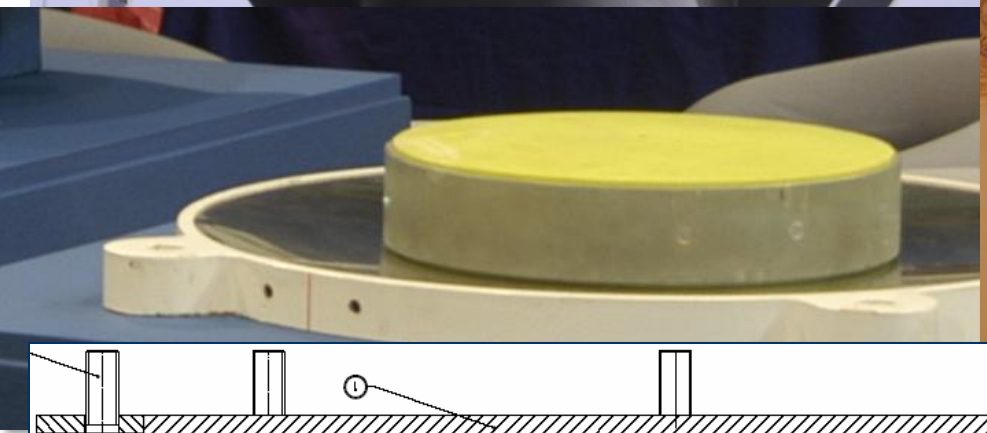
Ground accelerations

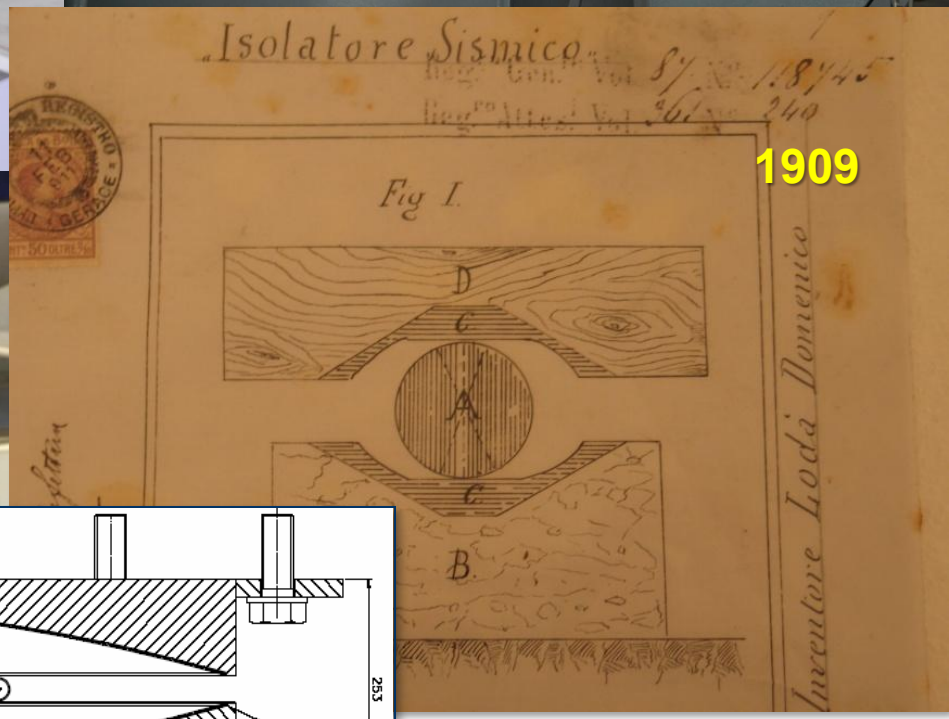
Project C.A.S.E.
Advantages of the double plate solution

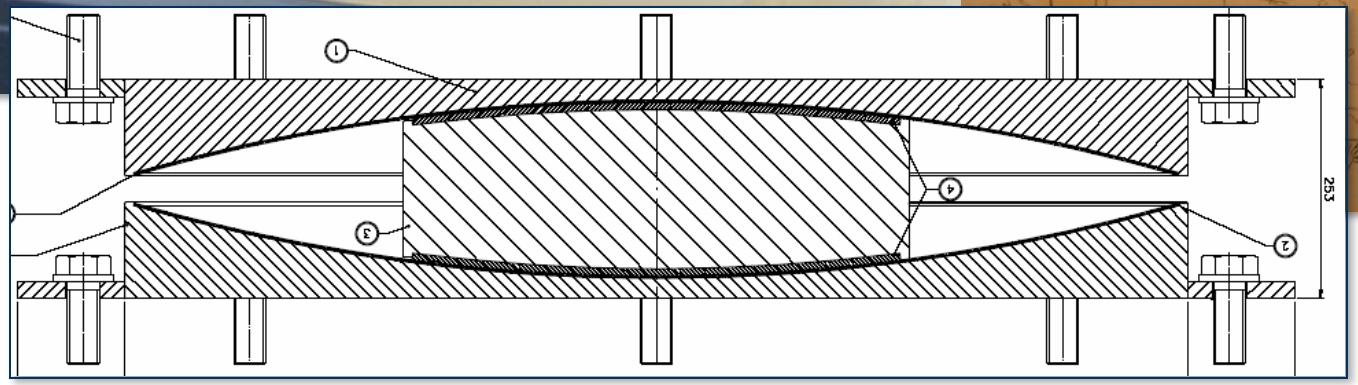
- **Standardisation** of the construction process
- **Decoupling** of the design and realisation problems
- Seismic isolation makes **seismic resistance** a **secondary** design problem
- **Freedom** in the **architectural** design solutions (plates are **58x21 m**, buildings are typically **50x12 m** in plan)
- **Freedom** in the **structural** design solutions
- Easy arrangement of the **equipment** distribution under the isolation plate

SINGLE SLIDING SURFACE PENDULUM ISOLATOR

DOUBLE SLIDING SURFACE PENDULUM ISOLATOR







QUALIFICATION AND ACCEPTANCE TESTS OF THE [7368] ISOLATORS

20% of the isolators tested →

~1400 devices:

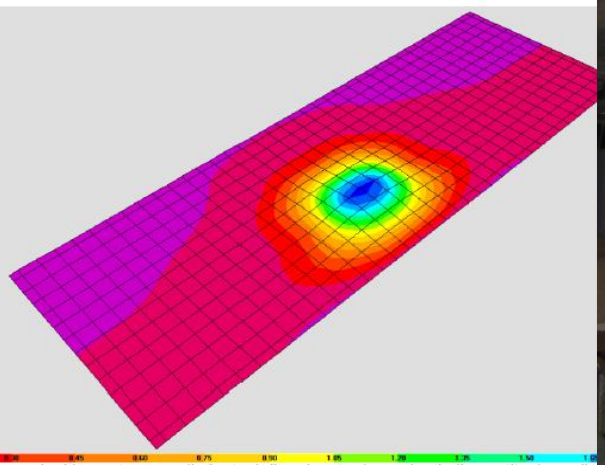
- 15% (~1050) devices tested under slow cycles (Italian norm)
- 5% (~350) devices tested under dynamic cyclic conditions (EN 15129)

SINGLE SLIDING SURFACE PENDULUM ISOLATOR DYNAMIC LAB TEST

DOUBLE SLIDING SURFACE PENDULUM ISOLATOR DYNAMIC LAB TEST

SUBSTITUTION OF AN ISOLATOR

Most of the isolators were still under production when the upper plate was realized



Start of works: 8 June 2009
First 400 houses delivery: 29 September 2009
Final delivery: 19 February 2010

185 (183eq.)	Platform/Buildings
4 450	Apartments
6 000	Underground car places
330 000 sqm	Apartments
220 000 sqm	Platforms (parking)
7 368	Isolators
7 000 sqm	Solar panels
35 000 sqm	Photovoltaic panels






GRUPPO EDIMO



BUILDINGS – TIMBER STRUCTURE

L'Aquila
2009

BUILDINGS – STEEL STRUCTURE

L'Aquila
2009

BUILDINGS – RC/PC STRUCTURE

L'Aquila
2009

26 giugno - Bazzano

complessi antisismici sostenibili ed ecocompatibili

c.a.s.e.

27 giugno - Bazzano

complessi antisismici sostenibili ed ecocompatibili

c.a.s.e.

24 giugno – Cese di Preturo

complessi antisismici sostenibili ed ecocompatibili
c.a.s.e.

Cese – Consegna Piastre 11 luglio 2009

complessi antisismici sostenibili ed ecocompatibili
c.a.s.e.

Cese – 15 luglio 2009

complessi antisismici sostenibili ed ecocompatibili
c.a.s.e.

Cese – 22 luglio 2009

complessi antisismici sostenibili ed ecocompatibili
c.a.s.e.

Bazzano 15 luglio 2009

complessi antisismici sostenibili ed ecocompatibili
c.a.s.e.

Bazzano 22 luglio 2009

complessi antisismici sostenibili ed ecocompatibili

c.a.s.e.

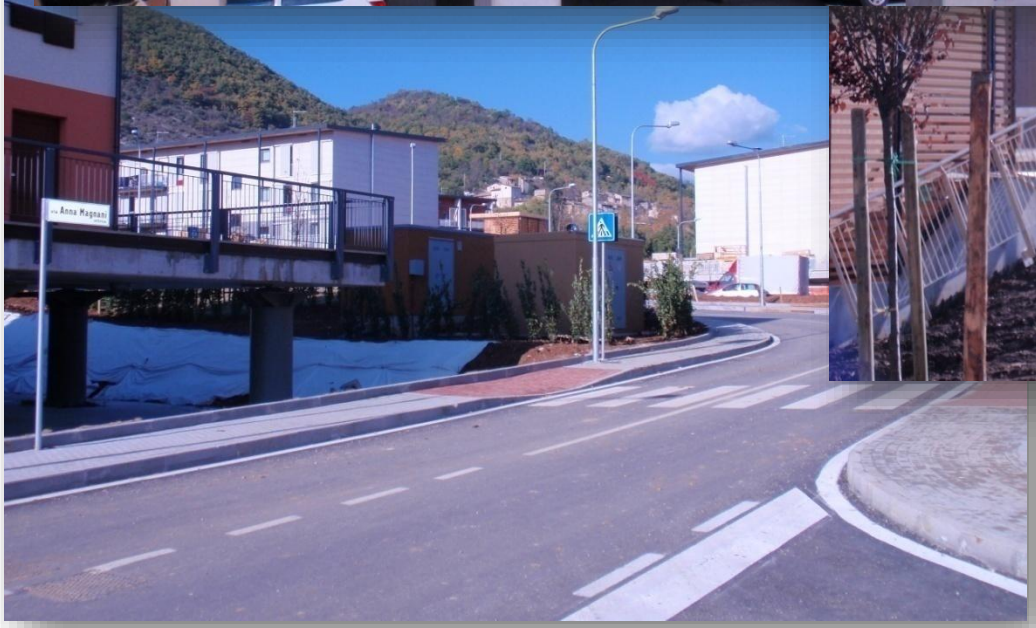
Progetto C.A.S.E. : rendering

SIMULAZIONI TRIDIMENSIONALI

complessi antisismici sostenibili ed ecocompatibili

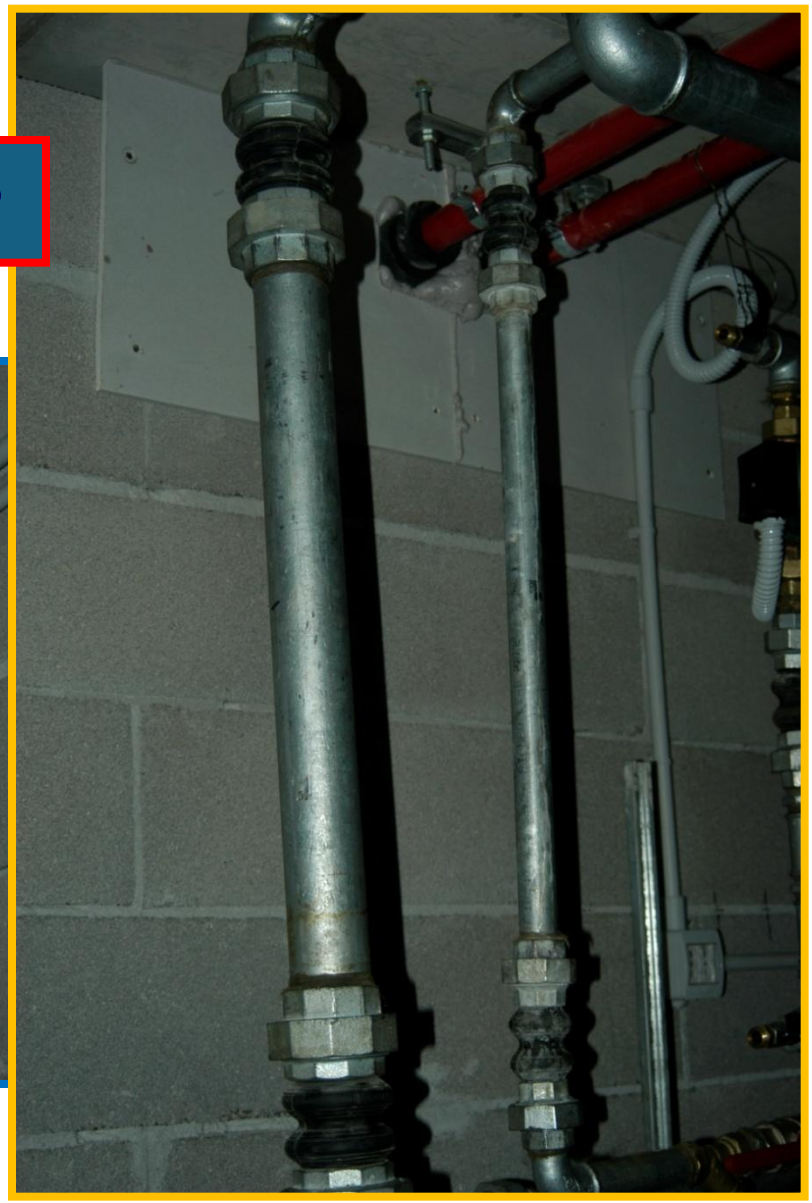
c.a.s.e.

September 29, 2009


Anna Magnani

Equipment details

Flexible pipe connections



Equipment details

Flexible pipe connections

Equipment details

Suspended equipments

FINAL EXPERIMENTAL CHECK OF THE STRUCTURES (PLATES+IS+BUILDINGS)

16 TEST SERIES ON 15 BUILDING-PLATE SYSTEMS

Tests were aimed at checking:

- **Functioning** of the isolation systems;
- **Strength** of the column-foundation plate
- **Dynamic characteristics** of the buildings

Tests were carried out by pushing and pulling statically (up to 200 mm) and dynamically (up to 100 mm) the isolation plate

600 isolators were involved in the in-situ tests

EXPERIMENTAL IN SITU TESTS

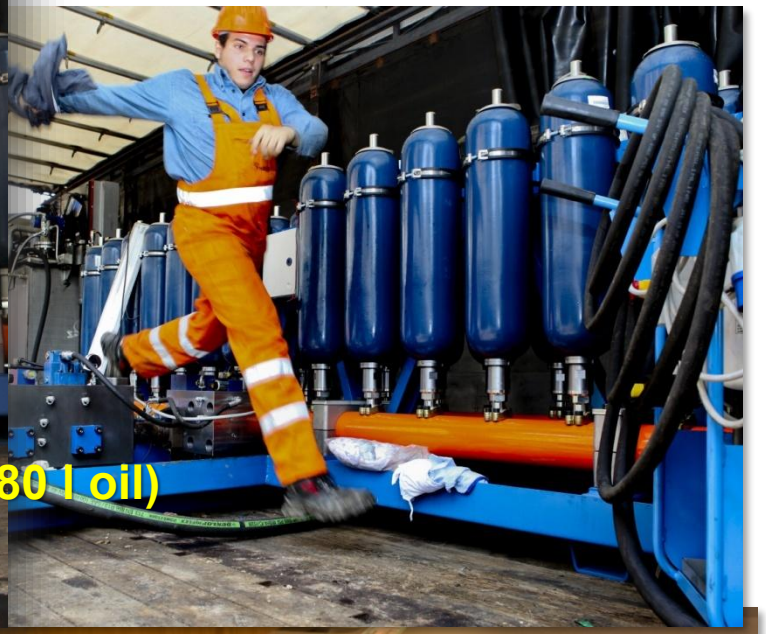
CARATTERISTICS OF THE TESTING SYSTEM

- n. 2 bracing reaction systems to be assembled in situ
- n. 2 servocontrolled oleodynamic actuators with +/- 260 mm stroke and +/- 2250 kN force
- n. 1 pumping system 250 liters/min
- n. 1 oil accumulation group 1200 liters (480 l oil)
- n. 1 real time control system
- n. 1 acquisition system 16 channels (for displacement transducers and accelerometers)
- n. 1 electrogenic group 250 kVA

*The system has been conceived to be easily **installed and uninstalled in three days**, including the test.*

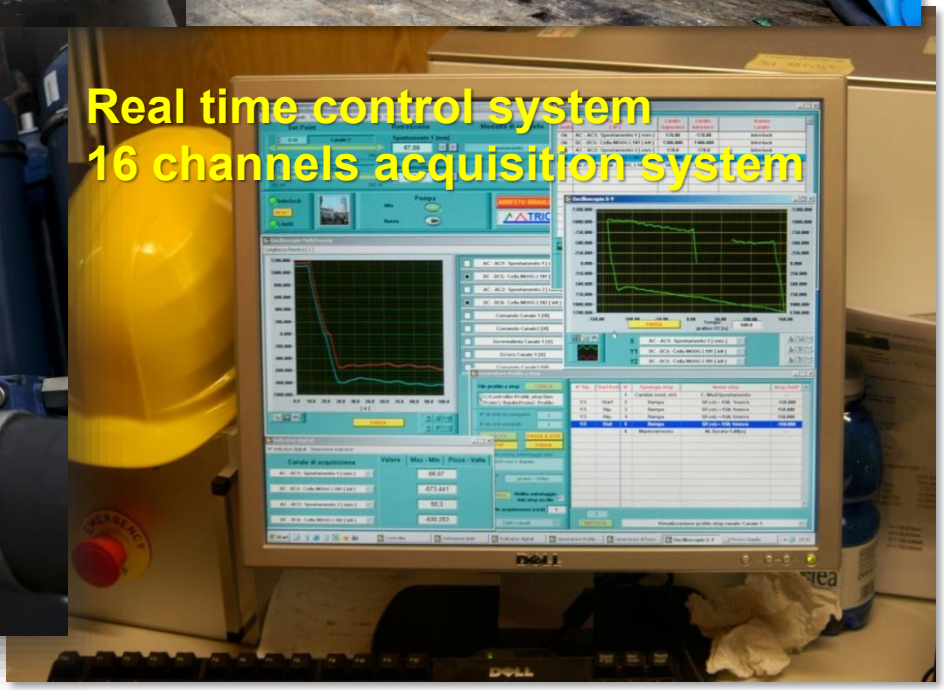
EXPERIMENTAL CHECK SET-UP

Accumulators 1200 l (480 l oil)

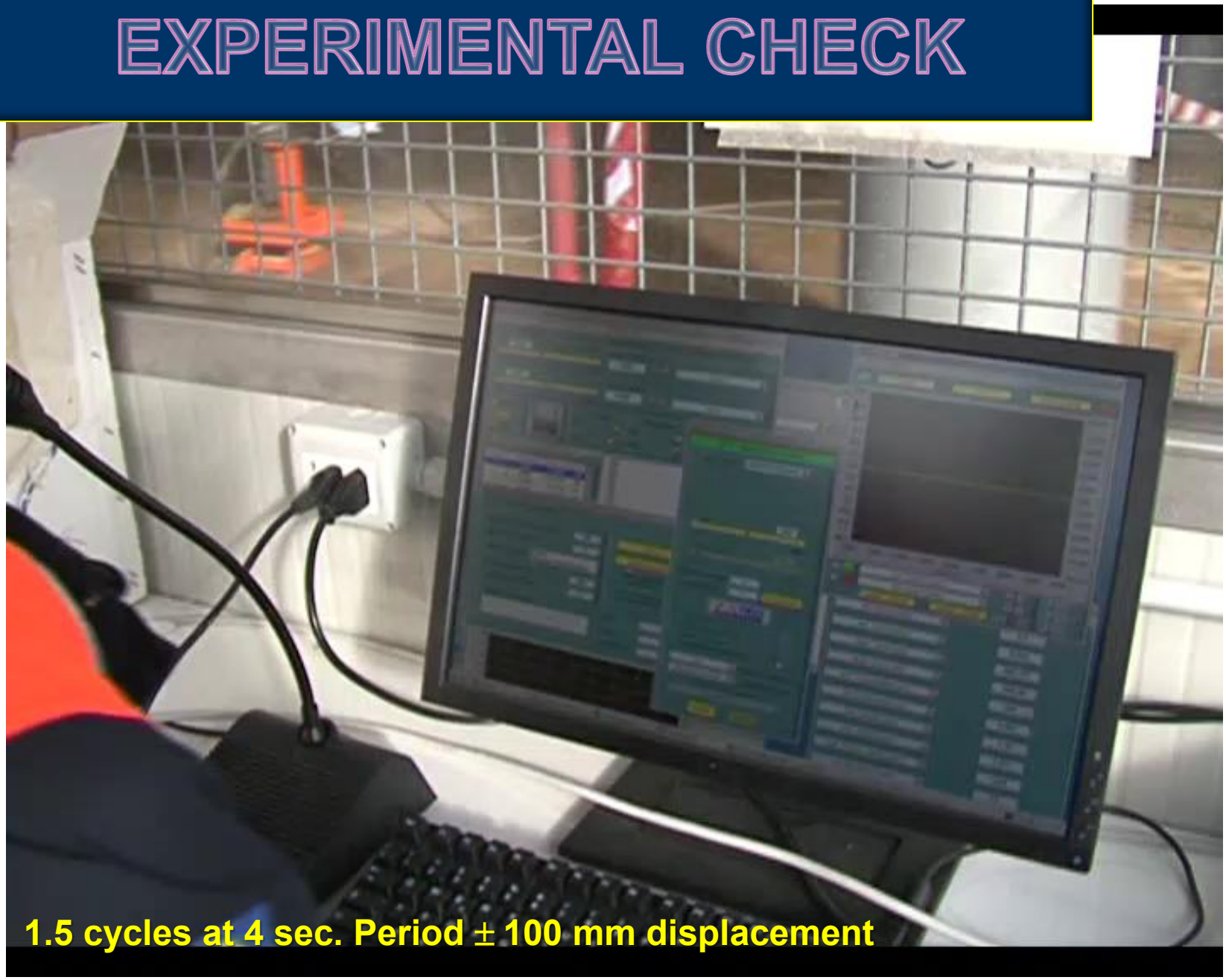


Oil pump 250 l/min

Real time control system
16 channels acquisition system



EXPERIMENTAL CHECK



1.5 cycles at 4 sec. Period ± 100 mm displacement

EXPERIMENTAL CHECK

1.5 cycles at 4 sec. Period ± 100 mm displacement

COSTS

(VAT EXCLUDED)

	TOTAL COST (M€)	AVERAGE COST BUILDING (183,29)	AVERAGE COSTO DWELLING (4449)	AVERAGE COST PER CONVENTIONAL AREA UNIT (mq. 2273 average per building)	AVERAGE COST PER AREA UNIT (1800 mq average per building)	PERCENT
DWELLINGS						
Excavations and foundations	136,0	€ 741.994	€ 30.569	**€ 326**	€ 412	18,75%
Seismic isolation devices	10,5	€ 57.286	€ 2.360	**€ 25**	€ 32	1,45%
Buildings over plates	404,9	€ 2.209.068	€ 91.009	**€ 972**	€ 1.227	55,83%
Total for dwellings	**551,4**	**3.008.347**	**123.938**	**1.324**	**1.671**	
INFRASTRUCTURE AND COMPLEMENTARY WORKS						
Primary urbanization and complementary works (retaining walls, drainage, roads, sewers, water systems, gas and energy supply, others)	77,5	€ 422.827	€ 17.420	**€ 186**	€ 235	10,69%
Green and urban furniture	14,7	€ 80.201	€ 3.304	**€ 35**	€ 45	2,03%
Architectonic barriers	16,5	€ 90.021	€ 3.709	**€ 40**	€ 50	2,28%
Dwelling furniture and cleaning	55,7	€ 303.890	€ 12.520	**€ 134**	€ 169	7,68%
Overheads	9,4	€ 51.285	€ 2.113	**€ 23**	€ 28	1,30%
Total general	**725,2**	**3.956.572**	**163.003**	**1.741**	**2.198**	**100,00%**

WORKERS' SAFETY (CASE, MAP, MUSP, etc.)

Project	Period	No. Work areas	No. Average workers / hour	Total work hours	Total accidents	No. Accidents per million of work hours
C.A.S.E. (up to 3 shift/d)	June '09 - March '10	19	4.000	19.584.000	18	**0,92**
M.U.S.P. (up to 2 shift/d))	August '09 - February '10	33	825	1.584.000	1	0,63
M.A.P. Fuori L'Aquila (up to 2 shift/d))	Agosto '09 - March '10	121	1.452	4.181.760	2	0,48
M.A.P. L'Aquila (up to 2 shift/d))	August '09 - March '10	19	400	809.600	1	1,24
TOTAL	**June '09 - March '10**	**194**	**6.802**	**26.284.960**	**22**	**0,84**

2008 NATIONAL VALUES	**January'08 - December'08**		**1.970.000**	**3.467.200.000**	**79.841**	**23,03**

THANKS

FOR YOUR ATTENTION