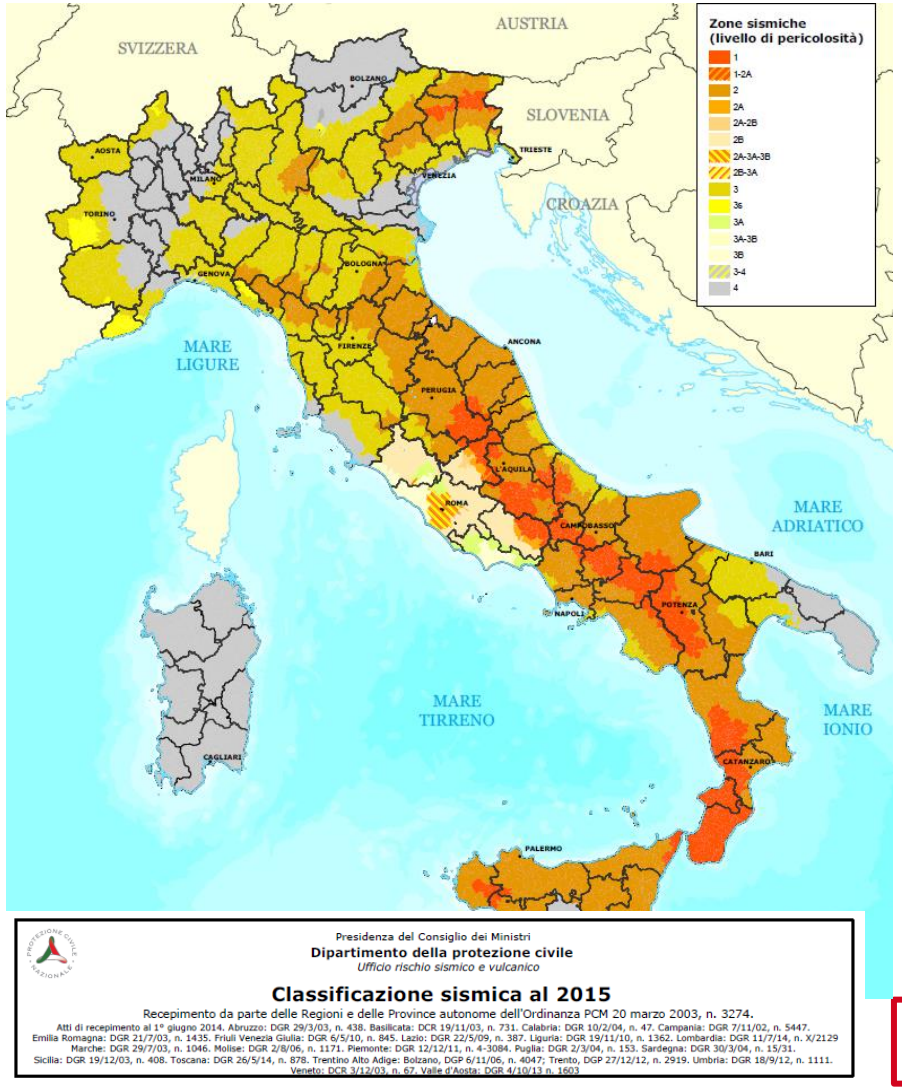
SEISMIC ACADEMY 2017
FIRE COMPARTMENTATION & SEISMIC MOVEMENTS

Peter Schulze
Oct 24, 2017
Milano

AGENDA

1. **Introduction**
2. **Compartmentation**
3. **Seismic movement of joint systems**
4. **Seismic movement of penetration systems**
5. **Summary**

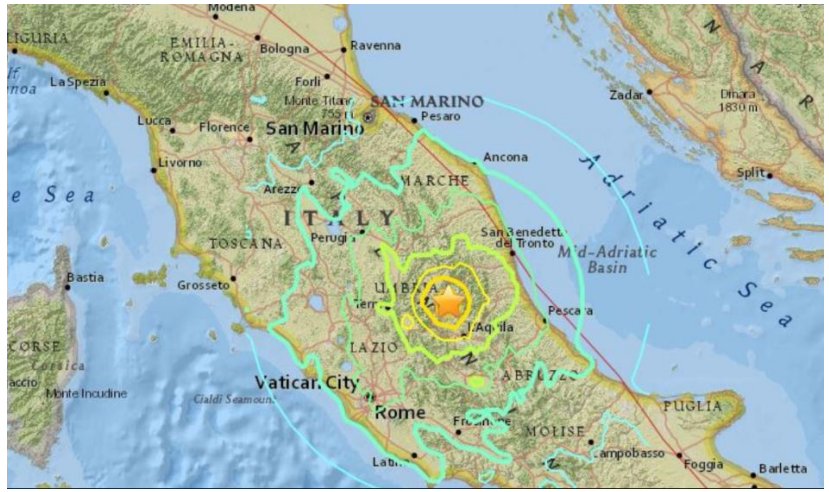
EARTHQUAKES ARE AN UNAVOIDABLE DISASTER AND ITALY IS HIGHLY CONCERNED



Presidenza del Consiglio dei Ministri
Dipartimento della protezione civile
Ufficio rischio sismico e vulcanico

Classificazione sismica al 2015

Recepimento da parte delle Regioni e delle Province autonome dell'Ordinanza PCM 20 marzo 2003, n. 3274.
Atti di recepimento al 1° giugno 2014. Abruzzo: DGR 29/3/03, n. 438. Basilicata: DCR 19/11/03, n. 731. Calabria: DGR 10/2/04, n. 47. Campania: DGR 7/11/02, n. 5447. Emilia Romagna: DGR 21/7/03, n. 1435. Friuli Venezia Giulia: DGR 6/5/10, n. 845. Lazio: DGR 22/5/09, n. 387. Liguria: DGR 19/11/10, n. 1362. Lombardia: DGR 11/7/14, n. X/2129 Marche: DGR 29/7/03, n. 1046. Molise: DGR 2/8/06, n. 1171. Piemonte: DGR 12/12/11, n. 4-3084. Puglia: DGR 2/3/04, n. 153. Sardegna: DGR 30/3/04, n. 15/31. Sicilia: DGR 19/12/03, n. 408. Toscana: DGR 26/5/14, n. 878. Trentino Alto Adige: Bolzano, DGP 6/11/06, n. 4047; Trento, DGP 27/12/12, n. 2919. Umbria: DGR 18/9/12, n. 1111. Veneto: DCR 3/12/03, n. 67. Valle d'Aosta: DGR 4/10/13 n. 1603



Earthquakes lead to huge economic and human losses

HOWEVER OFTEN FIRES FOLLOW EARTHQUAKES WHICH ALSO CAUSE SIGNIFICANT DAMAGES

EARTHQUAKE OCCURS:
Structural damage
Failure of fire-resistant construction,
Damage to installations (sprinklers, electrical circuits, communication circuits, water and gas pipes etc.)

↓

FIRES BREAK OUT
and spread faster, depending on building properties, wind, etc.., before firefighting teams arrive.

↓

RESULT:
In a specific building the fire may cause more serious damages than the earthquake.

Fire related to the earthquake of Northridge California, 1994

FIRE IS THE MOST COMMON POST EARTHQUAKE RISK

Multiple simultaneous ignitions: **50-75%** of the fires start **immediately after** the event

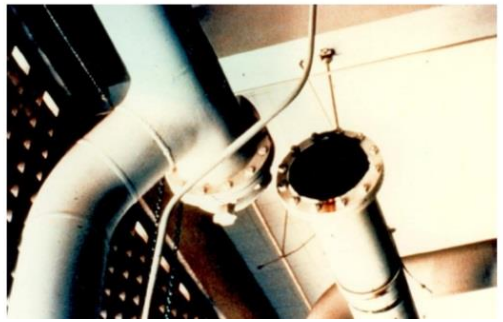
About 50% of the fires reported in the data occurred more than several hours (and up to several days) after the earthquake events

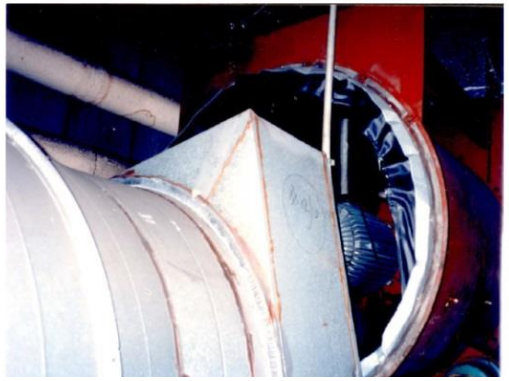
For example, after the earthquake of Northridge in 1994, there were a total of 466 fires reported after the earthquake, some of them were due because of the rupture of natural gas valves.

Sources: (1)A Method for Evaluating Fire After Earthquake Scenarios for Single Buildings. Elizabeth J. Kelly and Raymond N. Tell
(2) After the Shaking Stops: A Communitywide Approach to Managing Post-Quake Fires. Insurance Institute for Business & Home Safety
(3) Hospital Seismic Safety. California healthcare foundation January 2009

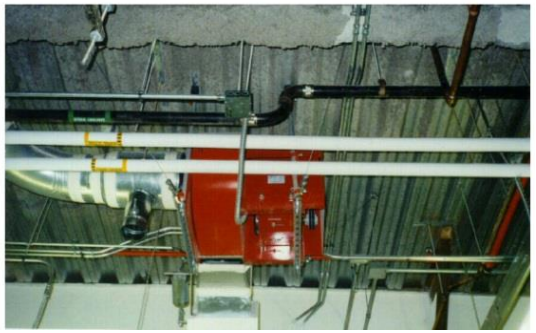
MOST FIRES AFTER SEISMIC EVENTS HAPPEN DUE TO DAMAGES IN ELECTRICITY AND GAS INSTALLATIONS

Mechanical





Electrical



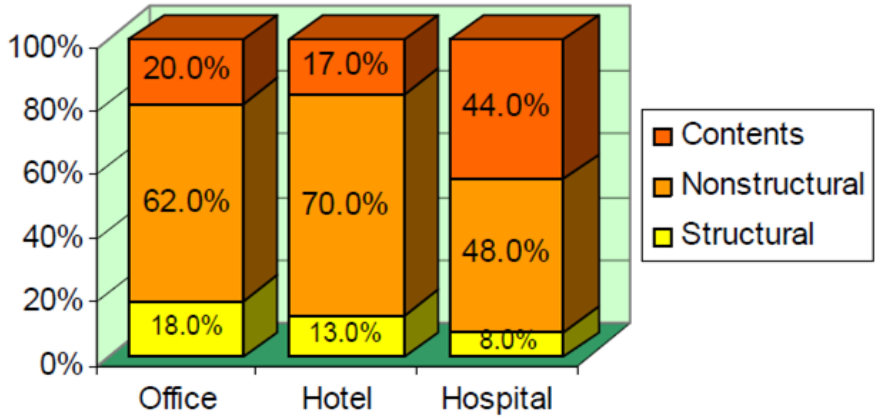
IF

Source: Reducing the Risks of Nonstructural Earthquake Damage – A Practical Guide
FEMA E-74 / January 2011

An additional level of reliability will ensure safety and reduce repair costs

DAMAGES TO NONSTRUCTURAL COMPONENTS CAN RESULT IN MAJOR ECONOMIC LOSS AND A THREAT TO LIFE SAFETY

In most buildings, the **non-structural** components account for **60 to 80 percent** of the value of the building. Mostly these non structural components are fragile, easily damaged and costly to repair or replace.



Typical investments in building construction (after E. Miranda)

Source: Earthquake effects on buildings. Christopher Arnold. FEMA Library, www.sponse.eu, www.italymagazine.com

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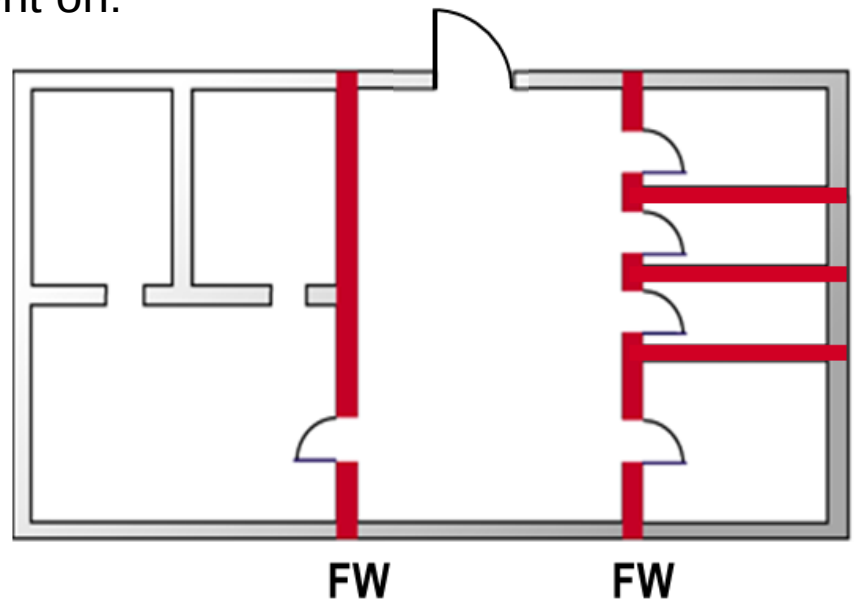
COMPARTMENTATION IS IMPORTANT TO KEEP THE FIRE IN ONE DEFINED SPACE

The spread of fire can be restricted by dividing a building into separate compartments with fire-resistive walls and floors—increasing the availability of escape routes for occupants.

The degree of sub-division that should be provided by fire compartmentation will be dependent on:

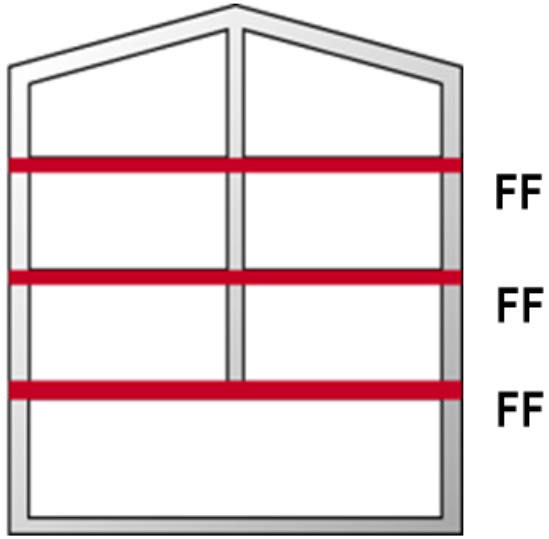
1. The use of the building.
2. The fire load in the building.
3. The height of the building.
4. The availability of a sprinkler system.

Fire walls



FW = Fire-Rated Wall

Fire floors

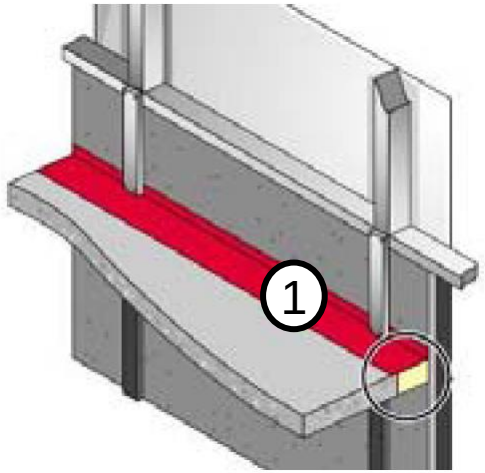


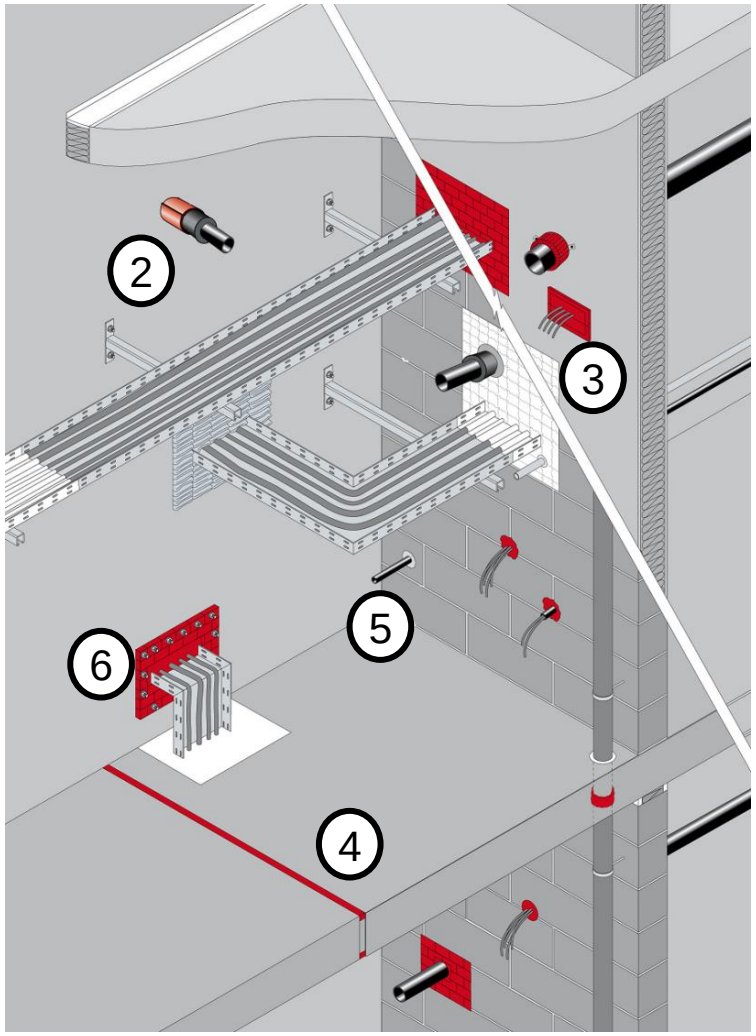
FF = Fire Rated Floor

HILTI FIRE STOP APPLICATION FOCUS: ENDANGERED OPENINGS IN BUILDINGS

All openings in fire rated walls and floors must be protected by seals with adequate fire resistance.

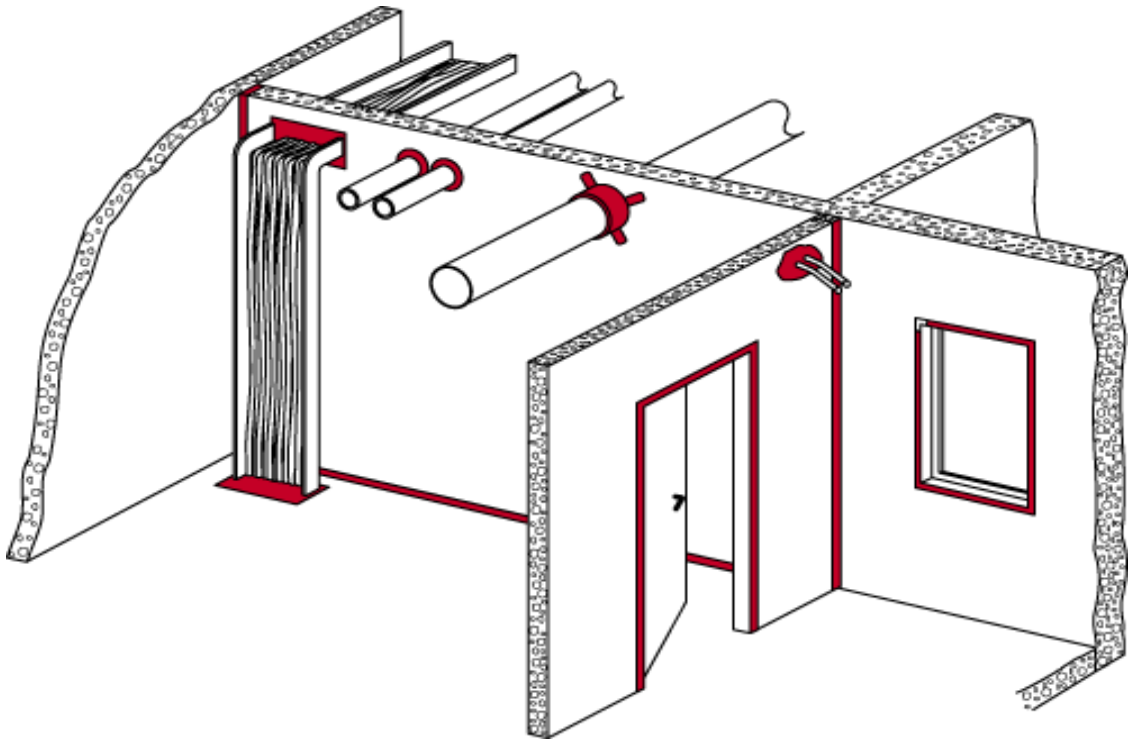
1. Curtain wall Joints
2. Penetrations of combustible and non-combustible pipes
3. Mixed penetrations (cables and pipes in one seal)
4. Joints
5. MLAR (small pipes and cables, separately regulated in Germany)
6. Cable penetrations





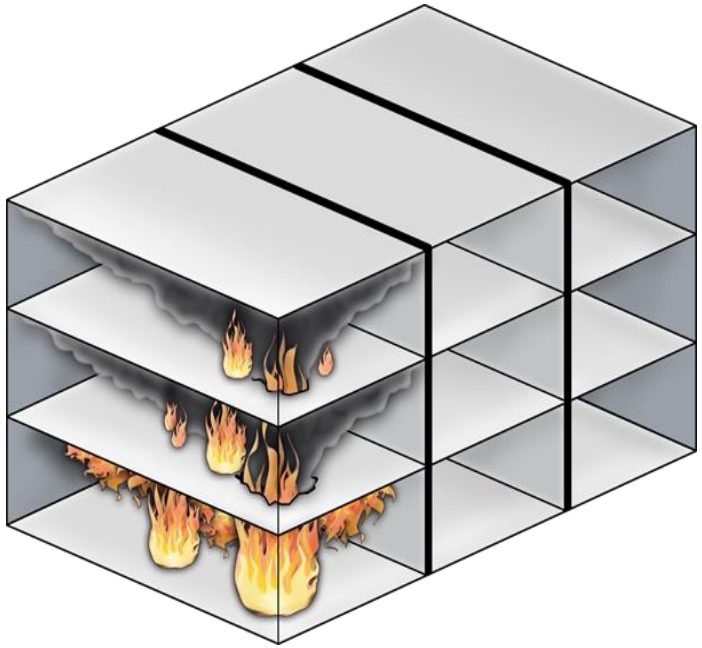
WE NEED TO ENSURE THAT PASSIVE FIRE PROTECTION FULFILLS ITS FUNCTION

Fire spread within buildings can be reduced by ensuring that passive fire protection systems have sufficient fire and movement resistance.



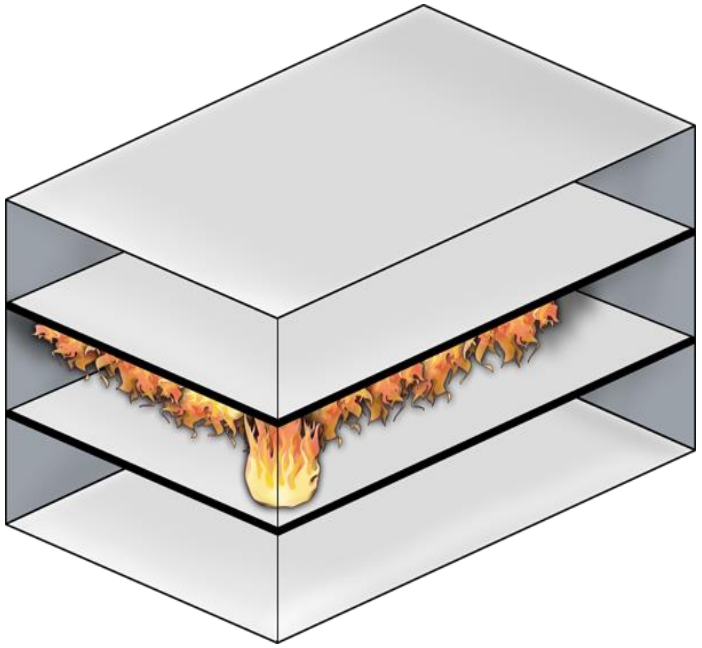
- Openings in fire-resisting walls & floors are areas of weakness
- Firestop maintains the integrity of compartments breached by services and other openings
- Reduces the **spread of fire and smoke**
- Goal of Firestop is to ensure **safe escape** (Time!)

VERTICAL AND HOTIZONTALCOMPARTMENTATION



Vertical compartmentation *by use of fire-resisting* ***walls****:*

Fire can spread vertically via openings in floors



Horizontal compartmentation *by use of fire-resisting* ***floors****:*

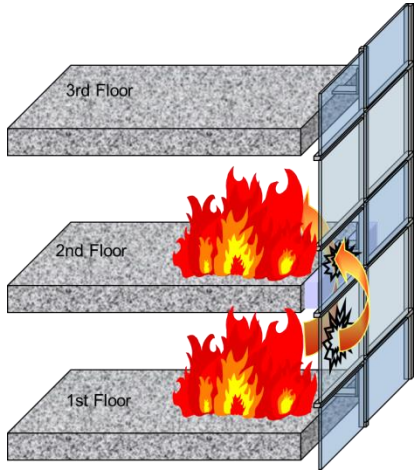
Fire can spread horizontally via openings in walls

Madrid Feb 2005 Windsor-Building

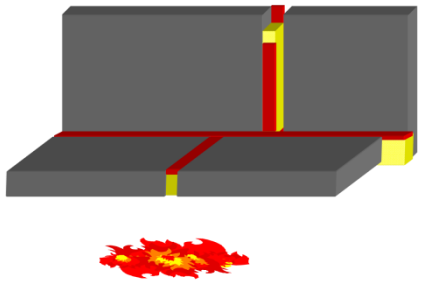
COMPARTMENTATION MUST WORK…
E.G. IN ITALY ALSO AFTER MOVEMENT

Joints

a

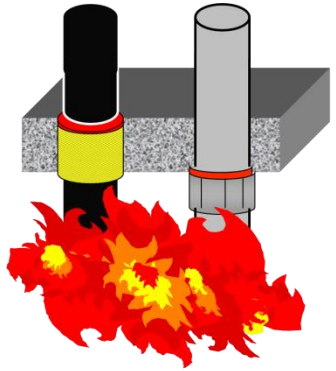


b



Through Penetrations

a



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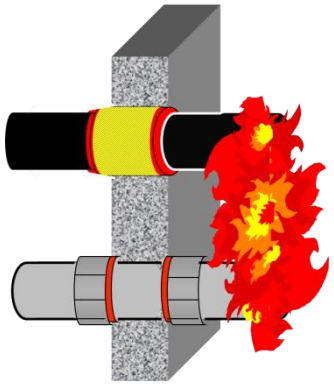

https://www.standard.co.uk/topic/grenfell-tower

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WE NEED TESTING STANDARDS TO SHOW THE PERFORMANCE IN AN OBJECTIVE WAY

<table>
<tr><th></th><th colspan="2">USA</th><th colspan="2">ETA</th></tr>
<tr><td>Movement</td><td colspan="2">ASTM E1399

TABLE 1 Cycling Requirements
<table><tr><th>Class</th><th>Movement</th><th>Minimum Number of Cycles</th><th>Cycling Rates (cpm)</th></tr><tr><td>I</td><td>Thermal</td><td>500</td><td>less than or equal to 1</td></tr><tr><td>II</td><td>Wind Sway</td><td>500</td><td>greater than or equal to 10</td></tr><tr><td>III</td><td>Seismic</td><td>100</td><td>greater than or equal to 30</td></tr><tr><td>IV</td><td>Combined</td><td>100
followed by
400</td><td>greater than or equal to 30
followed by
greater than or equal to 10</td></tr></table></td><td>Joint seals
EN 1366-4

Joint is expanded to maximum width before and during the fire test</td><td>Perimeter Seal
EN 1364-4

Joint is expanded to maximum width before and during the fire test</td></tr>
<tr><td>Fire</td><td>ASTM E2307 (CW)*</td><td>UL 2079 / ASTM E 1966 (joints)*</td><td colspan="2">Joint seals
EN 1363-1</td></tr>
</table>

No cyclic movement of joints / perimeter seals in ETA required

MOVEMENT TESTS FOR JOINTS
US CLASSIFICATION ACC. TO ASTM E 1966 / UL 2079

Movement joint with fire classification

- 500 movement cycles of joint according to ASTM E 1399 before the fire test
- Customer declares the maximum joint width
- After the movement a normal fire test is done
- Movement result is in the UL-Listing

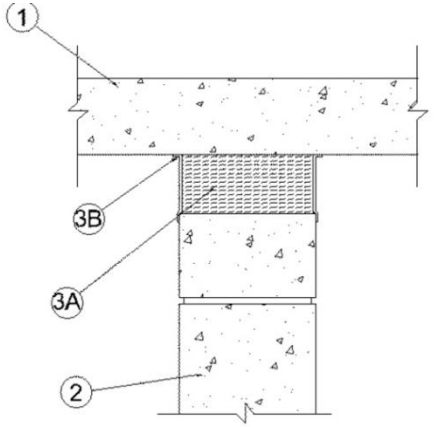
System No. HW-D-1058

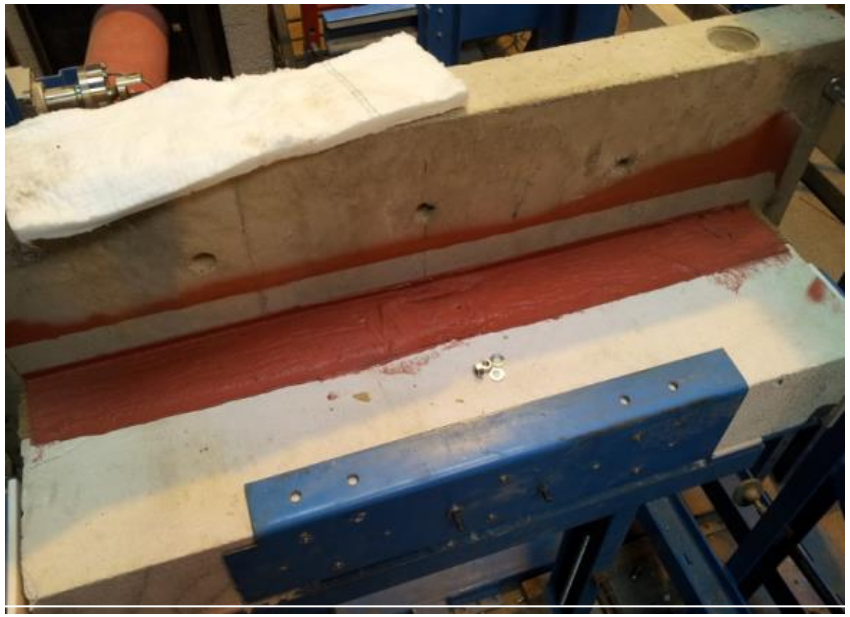
June 07, 2010

Assembly Rating — 3 Hr

Nominal Joint Width — 3-1/4 In.

Class II Movement Capabilities — 25% Compression or Extension





Results

The result of the movement test depends on the configuration and can be up to +/-50%.

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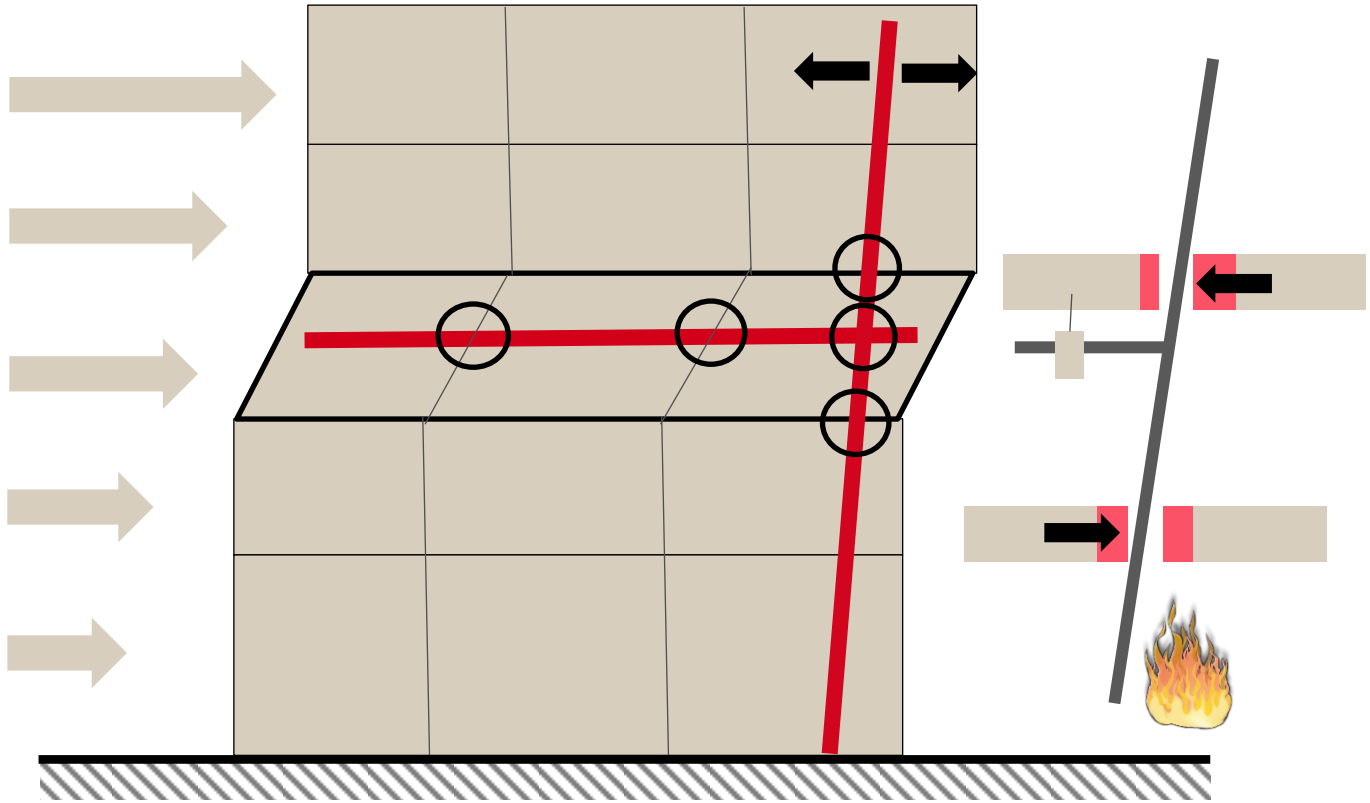
BUILDING MOVEMENT THROUGH EARTHQUAKES



Example: Movement of wall / floor

- Pipes and cables are fixed to the ceiling or a wall. During an earthquake the penetrants can move in a different direction than the walls or the floors
- All crossing points in the walls and floors are critical
- Undefined movement of pipes/cables within firestop penetrations is very likely
- Movement of pipes/cables will damage stiff firestop products like sealants or coated boards
- Risk of toxic smoke or fire to pass through the opening

Different product types for each application available: Cables, cable trays and pipes

IN 2016 THE GAP IN THE TESTING STANDARDS FOR MOVEMENT WAS FILLED

	USA	ETA
Movement	**ASTM E3037-2016** *Test Method for Measuring relative movement capabilities of Through-Penetration Firestop systems*	**By definition no movement**
Fire	ASTM E814 / UL 1479	EN 1366-3

The standard was developed by the industry and published in Nov 2016.

ASTM E3037: MOVEMENT CAPABILITIES OF THROUGH-PENETRATION FIRESTOP SYSTEMS

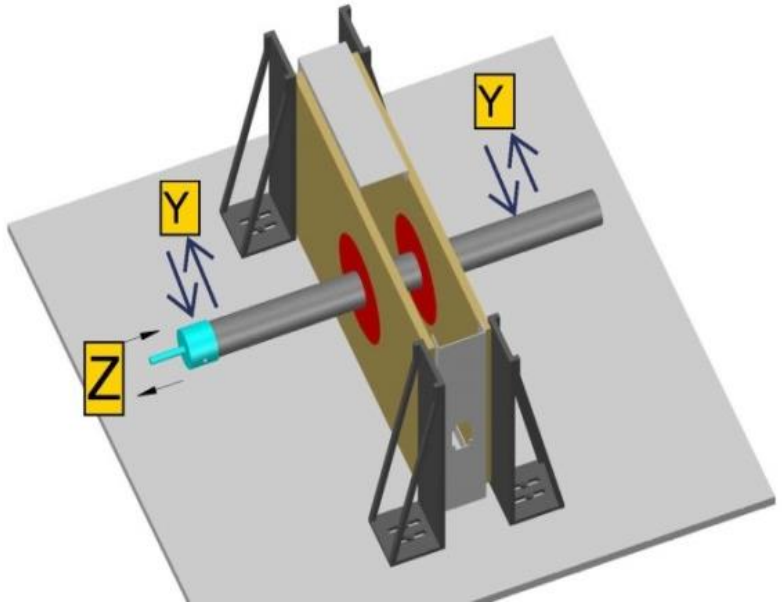
Movement test

- Two independent **cyclic tests** (direction Y and Z)
- Y direction: 16 cycles
  Z direction: 15 cycles
- 10 repeats in 1st cycle
  3 repeats in rest of cycles
- **Result:** classification (A, B,C…) in 2 directions. Class A being the best performance

+

Fire test

- Fire test
- Hose stream test

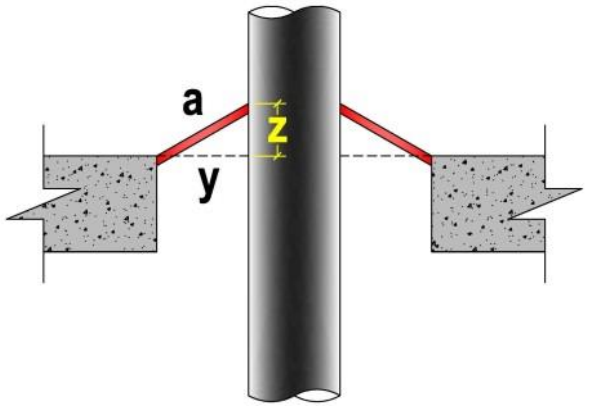


PERFORMANCE IN BOTH DIRECTIONS IS CLASSIFIED ACC. TO CLASSES – “A” BEING THE BEST

Nomenclature permitted to be used	Y-direction (% of annular space)	Z-direction (absolute movement)
Class A	≥ 50%	
Class B	≥25%	
Class C	< 25%	
Class A		≥ 1 inch (25 mm)
Class B		≥0.5 inch (13 mm)
Class C		< 0.5 inch (13 mm)

Annular space dependant

Not annular space dependant



For different annular spaces than tested, **the ratio should be constant**. This will provide us with the movement capability in both directions.

PREFORMED DEVICES LEAD TO BETTER RESULTS WHEN TESTED ACCORDING TO ASTM E 3037

Sealants, Coated Boards

Foams & Sprays

Preformed devices

- **Easy and fast installation**: no room for human mistakes!
- **Simple inspection** at jobsite: firestop is already integrated in the device
- **Code compliant and reliable:** with published UL listings

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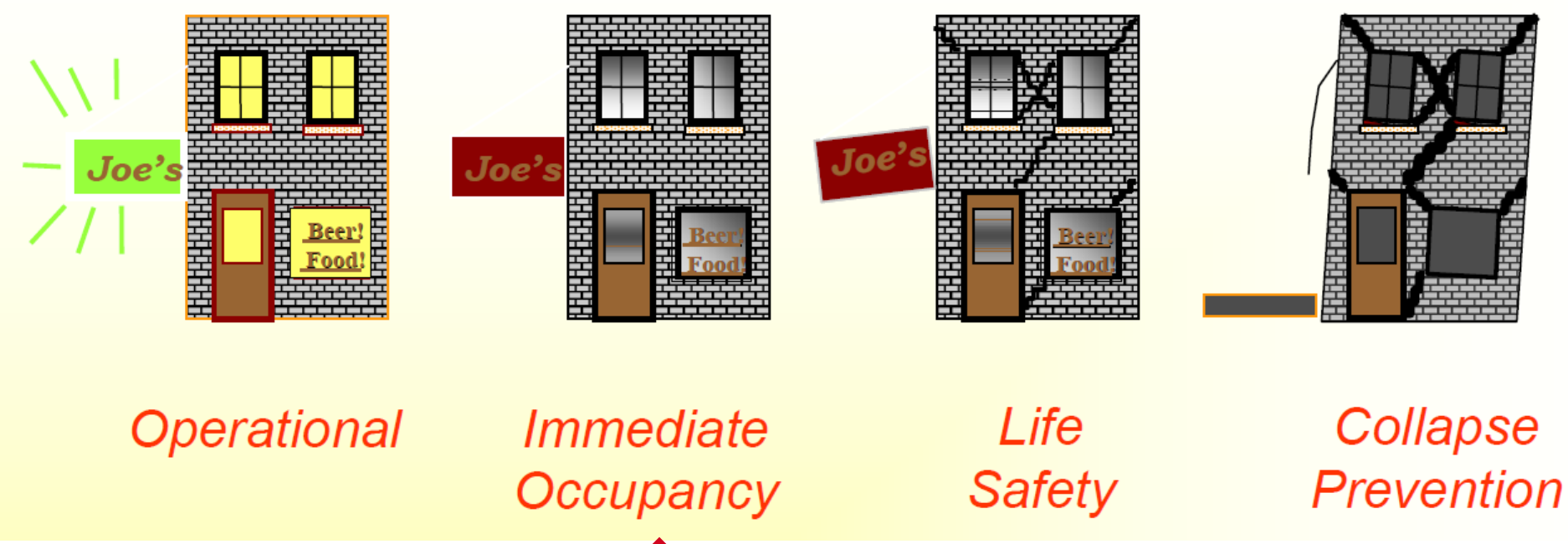
SEISMIC REQUIREMENTS VARY DEPENDING ON TYPE OF BUILDING

Social and public buildings should keep operative after an earthquake

STRUCTURAL DAMAGE IN BUILDINGS – NO REGULATIONS

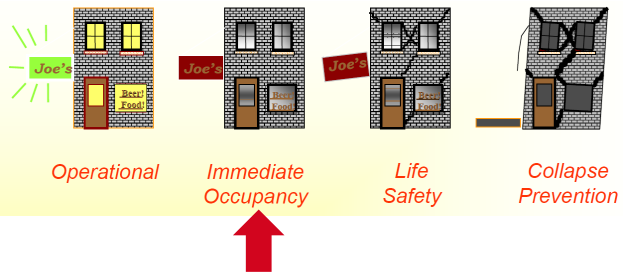
Regulations regarding structures of buildings follow general principles of earthquake resistant design:

- ✓ Prevent all elements of buildings from any damage in **low intensity quakes**
- ✓ Limit the damage in structural and non-structural elements to repairable levels in **medium-intensity earthquakes**
- ✓ Prevent the overall or partial collapse of buildings in **high-intensity quakes** in order to avoid the loss of life



The ATC-58 Project Development Of Next-Generation Performance-Based Seismic Design Criteria For Buildings
http://www.cosmos-eq.org/technicalsession/TS2007/presentations/Hamburger_2007.pdf

STRUCTURAL DAMAGE IN BUILDINGS – FIRESTOP



What if the penetration firestop is compromised but the rest of the building is ok and ready for „Immediate Occupancy“?

- ✓ Time and cost intensive search and evaluation
- ✓ High repair cost due to difficult installation

The only solution should be: Close the building as the firestop is compromised./???

Prominent example from Sept 2017:

- ✓ A building in Dortmund was evacuated in Sept 2017 because of massive violations of firestop regulations.
- ✓ 400 apartments, 750 people

A seismic/movement standard in Europe is needed for non-structural firestop products to ensure the quality also after a seismic event

Brandschutz - Stadt Dortmund evakuiert Hochhaus | Aktuelle Stunde | 21.09.2017 | 03:19 Min. | Verfügbar bis 21.09.2018 | WDR

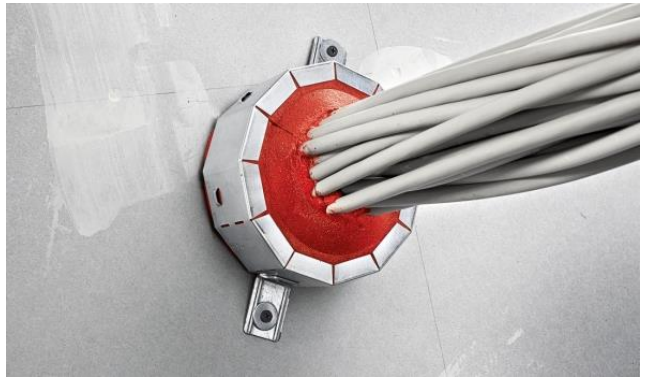
Hochhaus in Dortmund wegen Brandgefahr geräumt

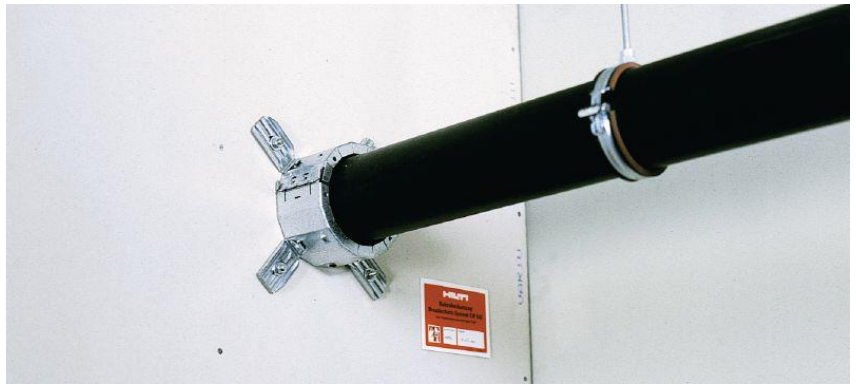
- Hochhauskomplex "Hannibal II" ist geräumt.
- Schwere Brandschutzmängel festgestellt.
- Etwa 750 Menschen betroffen.
- Die meisten bei Verwandten, über 120 übernachteten in Turnhalle.

Im Hochhauskomplex "Hannibal II" im Stadtteil Dortmund-Dorstfeld sind schwere Brandschutzmängel festgestellt worden. Akute Gefahr bestehe zwar nicht, dennoch musste das Gebäude mit rund 400 Wohnungen am Donnerstagabend (21.09.2017) sicherheitshalber evakuiert werden. Am späten Abend waren nach WDR-Informationen alle Wohnungen geräumt und versiegelt.

SUMMARY

Best firestop performance after seismic events is achieved by using **preformed devices and flexible foams**





GRAZIE MILLE

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