

# Lessons from Wenchuan 512 for Building Seismic Resilience in China

## 从512地震看中国的抗震

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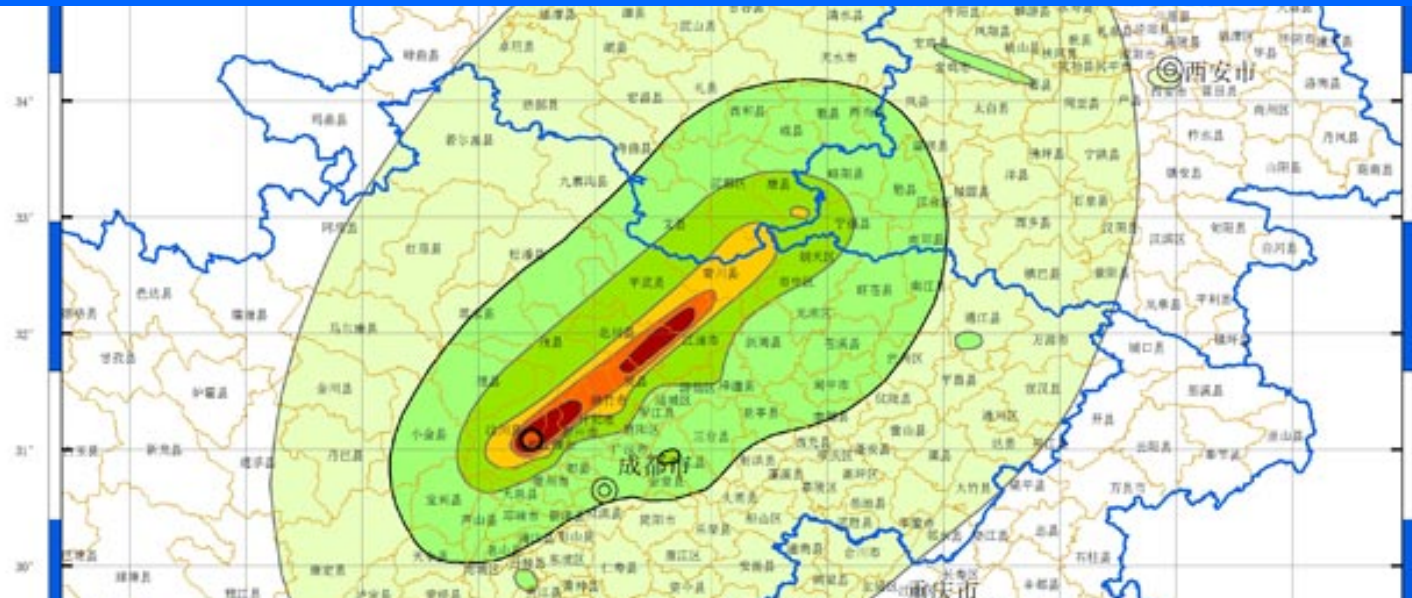
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# Estimated Mercalli Intensity - Wenchuan

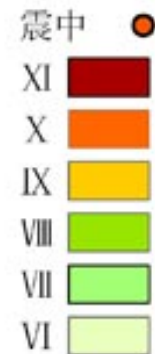
512

## 汶川8.0级地震烈度分布图

The area exceeding the design intensity of the Chinese Building Design Code – VII or higher – is 20,000 km<sup>2</sup>, approximately 0.2% of the area of China



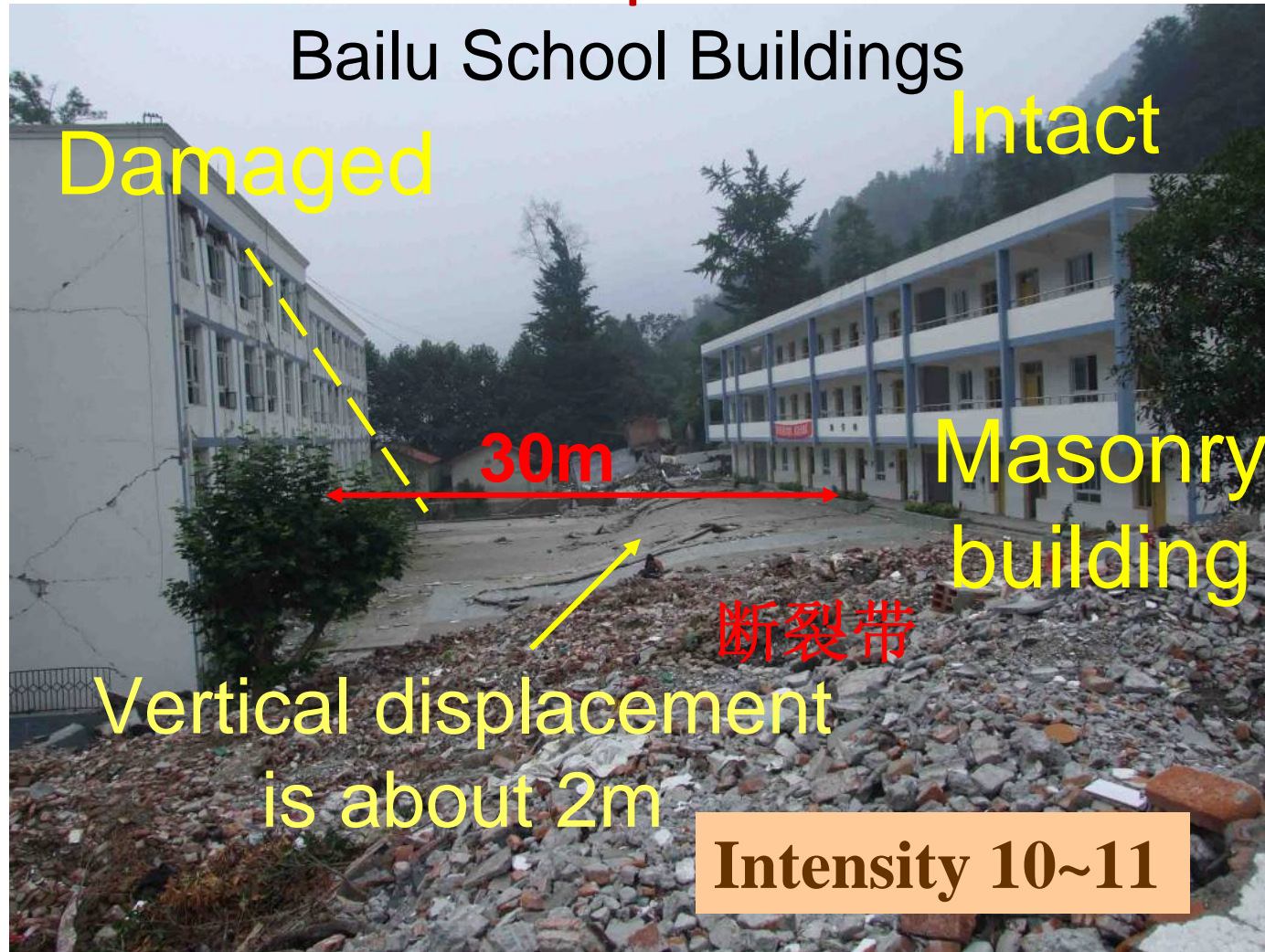
图例



The area experiencing intensity greater than V – with potential to cause damage – is ~350,000 km<sup>2</sup>, approximately 3.6% of the area of China

100 200 Km

# Structures can survive the worst earthquakes

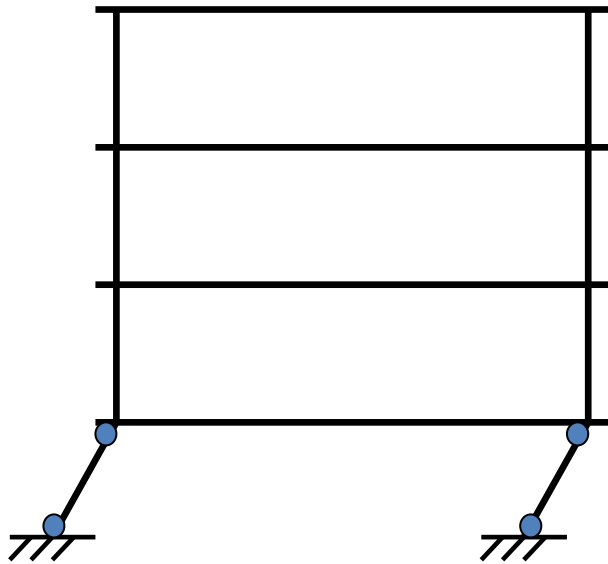


# Common Deficiencies

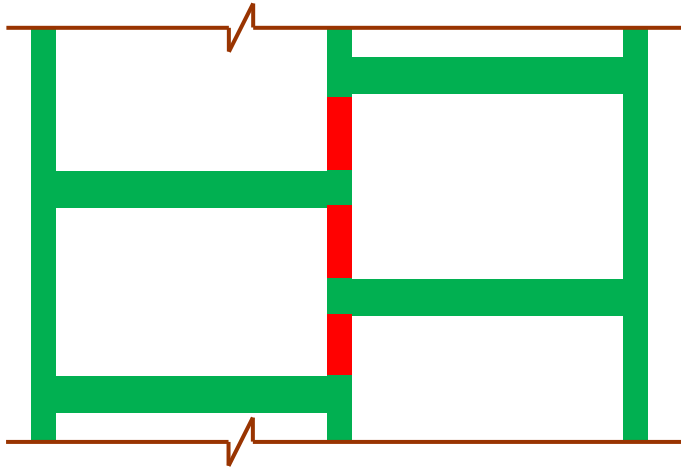
## 常见缺陷

1. 'Strong beam – weak column' instead of 'weak beam – strong column'
2. Soft storey
3. Short columns attracting shear
4. L- and T-shaped floor plans instead of rectangular
5. Pounding of adjacent buildings
6. Staircases not integrated into seismic resistance

# Soft storey



# Short columns attracting shear



短柱 = 剪力大

# Performance of staircases



The staircase collapsed during the earthquake. Many students lost their lives in the stairwell, while the main structure stood. Staircases were designed for gravity loads only, not seismic forces.

楼梯的破坏

楼梯破坏的原因

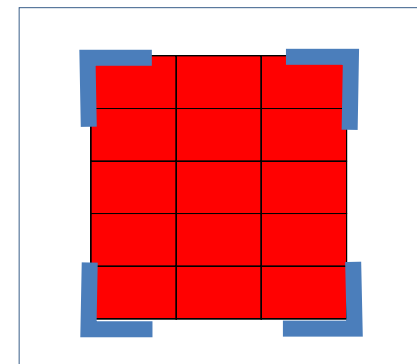
# Masonry confined by steel – an Example of Ductility

100m from fault at Hanwang  
Building stands while others  
around collapse

Masonry columns reinforced  
with tied corner steel angles  
make the structure ductile

**Brittle structures can be made ductile  
and earthquake resistant!**

增加延性的例子



# Japanese reports on seismic retrofitting of schools

**Seismic Retrofitting Quick Reference**  
**School Facilities that**  
**Withstand Earthquakes**  
Examples of Seismic Retrofitting

<http://www.nier.go.jp/shisetsu/pdt/e-taishinjirei.pdt>

Case Studies of **Seismic Nonstructural** Retrofitting in

School Facilities

<http://www.nier.go.jp/shisetsu/pdf/e-jirei.pdf>

**Introduces Structural Seismic Performance Index,  $I_s$ ,**  
**for risk assessment based on**  
***strength, ductility, structural balance* and *age***

日本规范

结构抗震表现因子

# Japanese Retrofit Examples

## 日本加固的例子



After retrofit (outside view)



After retrofit (Inside view)

Steel bracings (diagonal)

Wall girder



Before retrofit (outside view)

# Criteria for Structural Seismic Performance Index, $I_s$

- $I_s < 0.3$  high risk of collapse in earthquake
- $0.3 \leq I_s < 0.6$  potential risk of collapse
- $I_s > 0.6$  low risk of collapse

Target for schools:  $I_s > 0.7$

对学校, 结构抗震表现因子 **>0.7**

Experience needed in determining  $I_s$

# Post disaster function

Are the schools safe?

学校安全吗？

Are the communications robust?

通讯系统可靠吗？

Are the hospitals super safe?

医院特别安全吗？

# Some essentials for achieving seismic resilience across P.R. China by 2012

- The whole community engaged in disaster risk reduction planning and development
- Dialogue between local communities and institutions, government, professional engineers and builders
- Research and professional courses in structural risk assessment of damaged and undamaged buildings
- Research and professional development courses in design of seismic retrofitting of buildings
- Emergency response planning and practice

**2012年欲达抗震能力的基本方针**

Thank you  
谢谢

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<http://www.nier.go.jp/shisetsu/pdf/e-taishinjirei.pdf>

<http://www.nier.go.jp/shisetsu/pdf/e-jirei.pdf>

(Japanese school safety websites)