Reconstruction Experience after May 12, 2008 Wenchuan Earthquake

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Contents

- Glance at the disaster
- Technical support
- Planning
- One-to-one assistance
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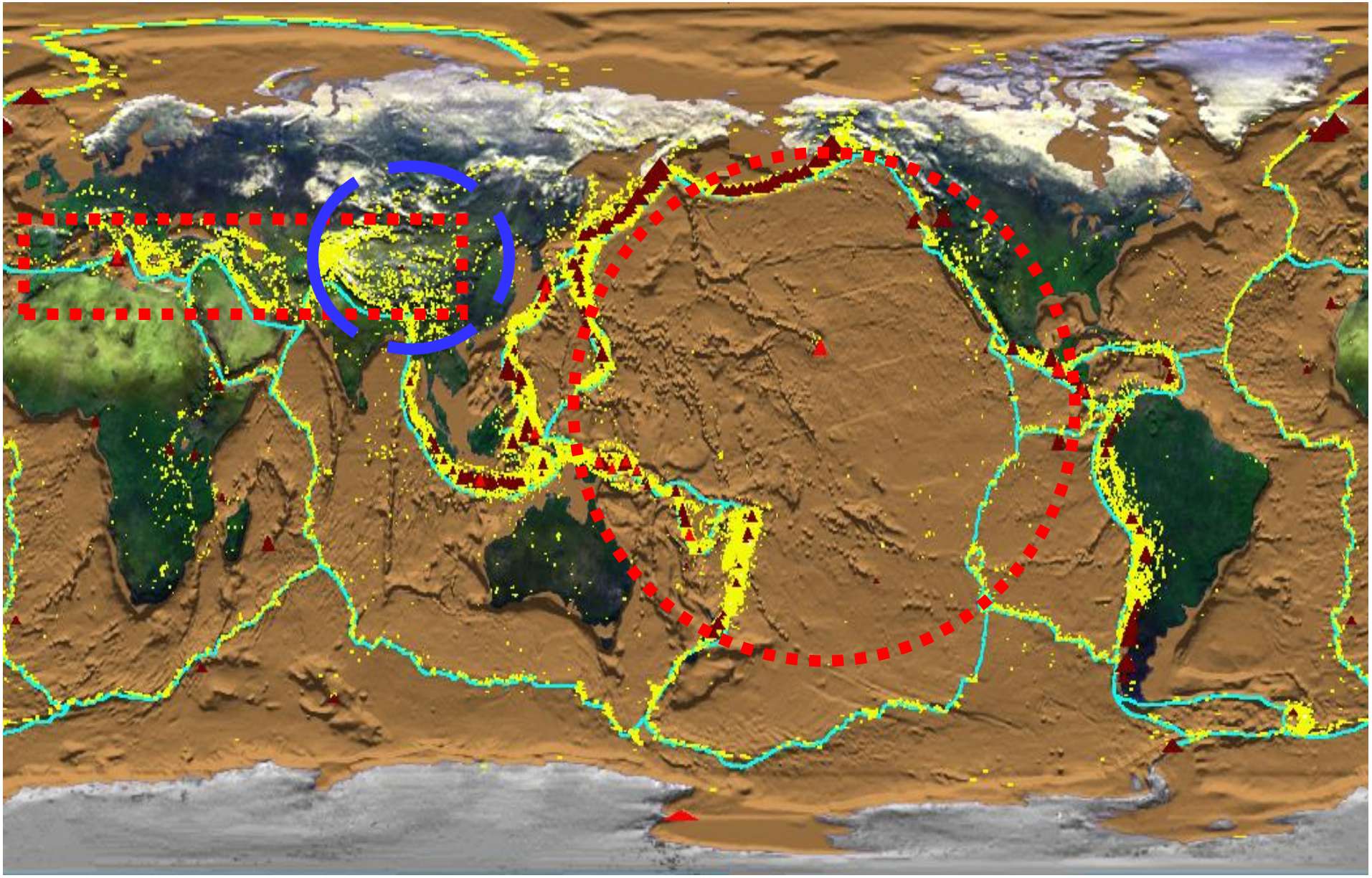
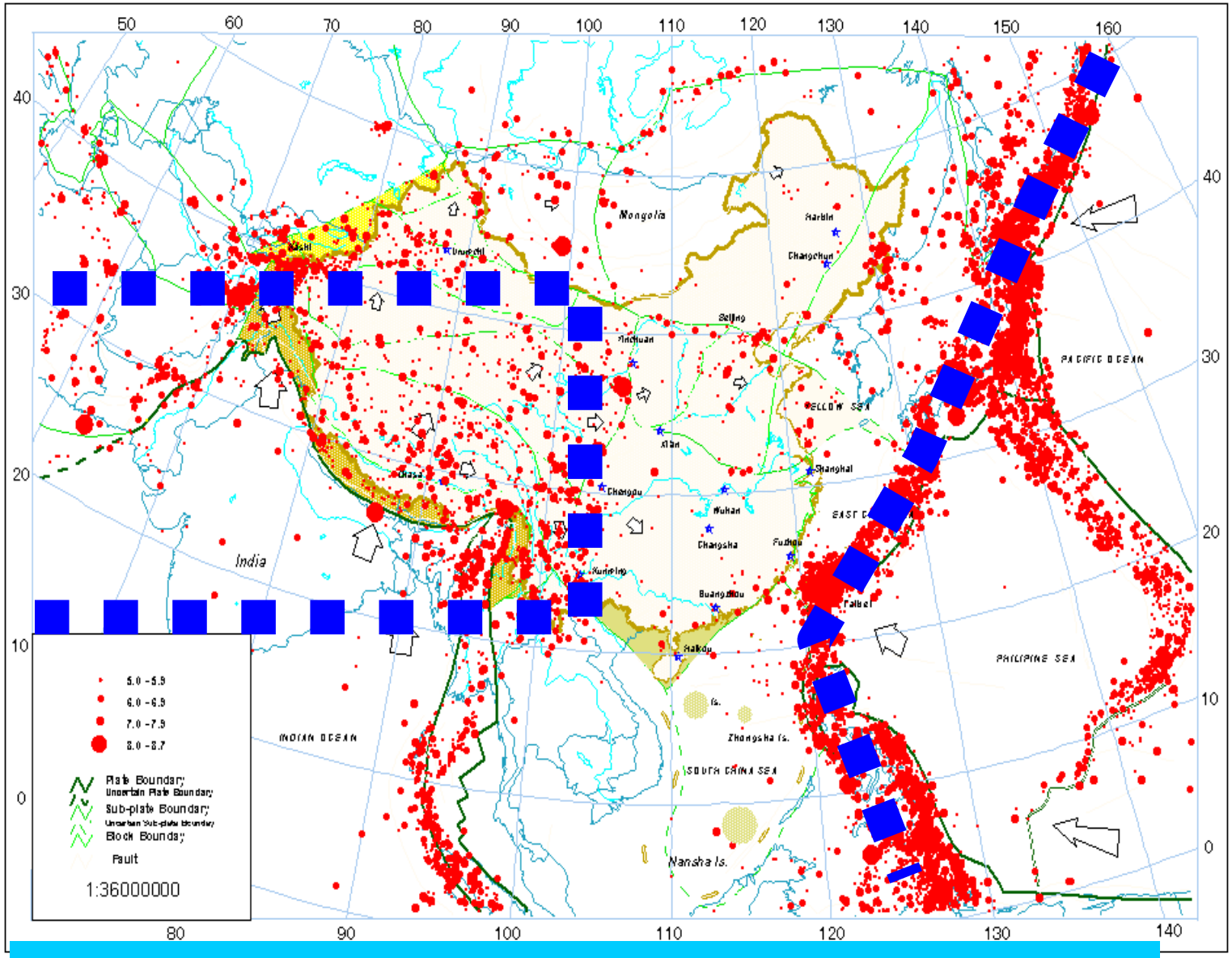
- Conclusions remarks

Glance of the disaster of Wenchuan earthquake

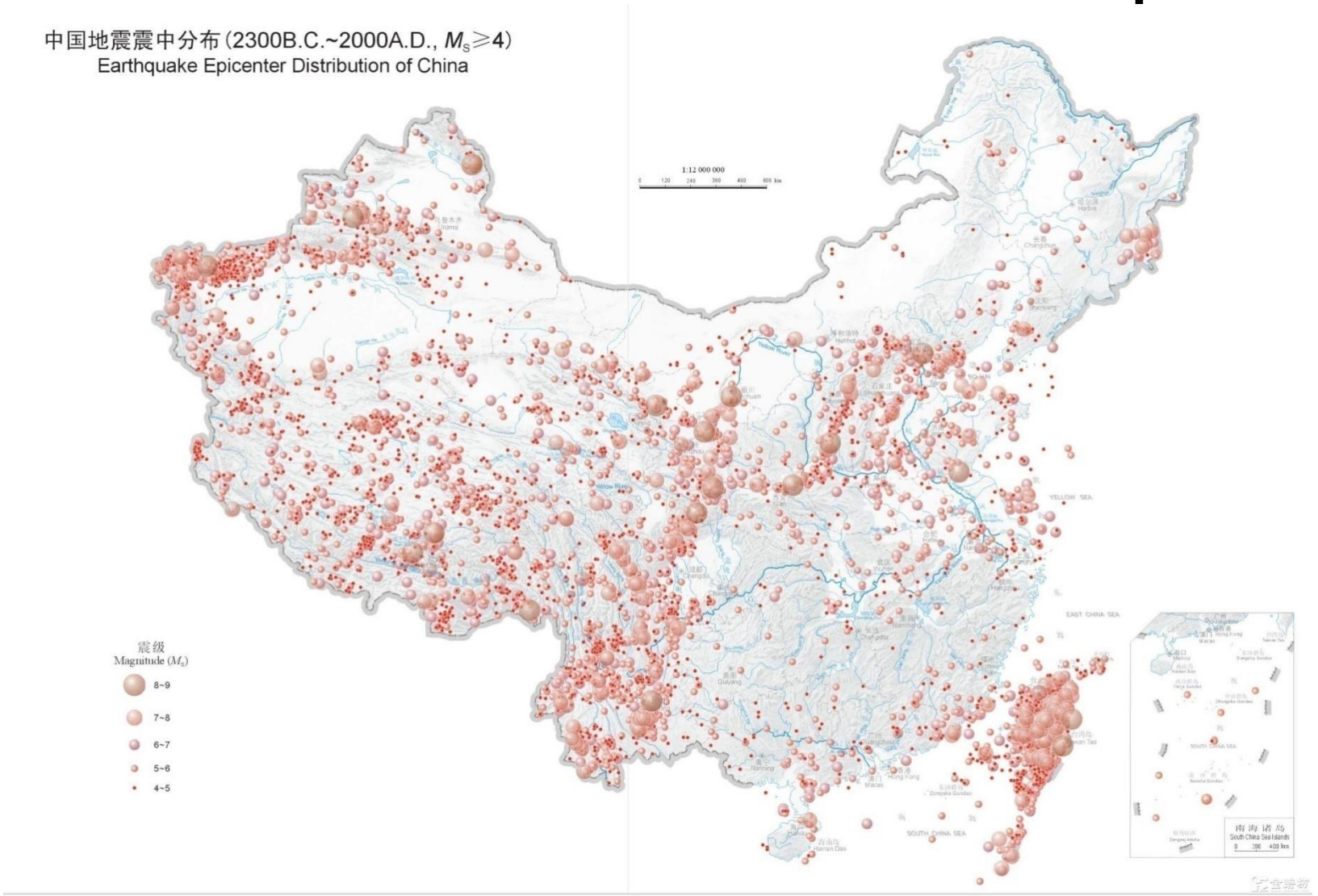


Two seismic belts in the world

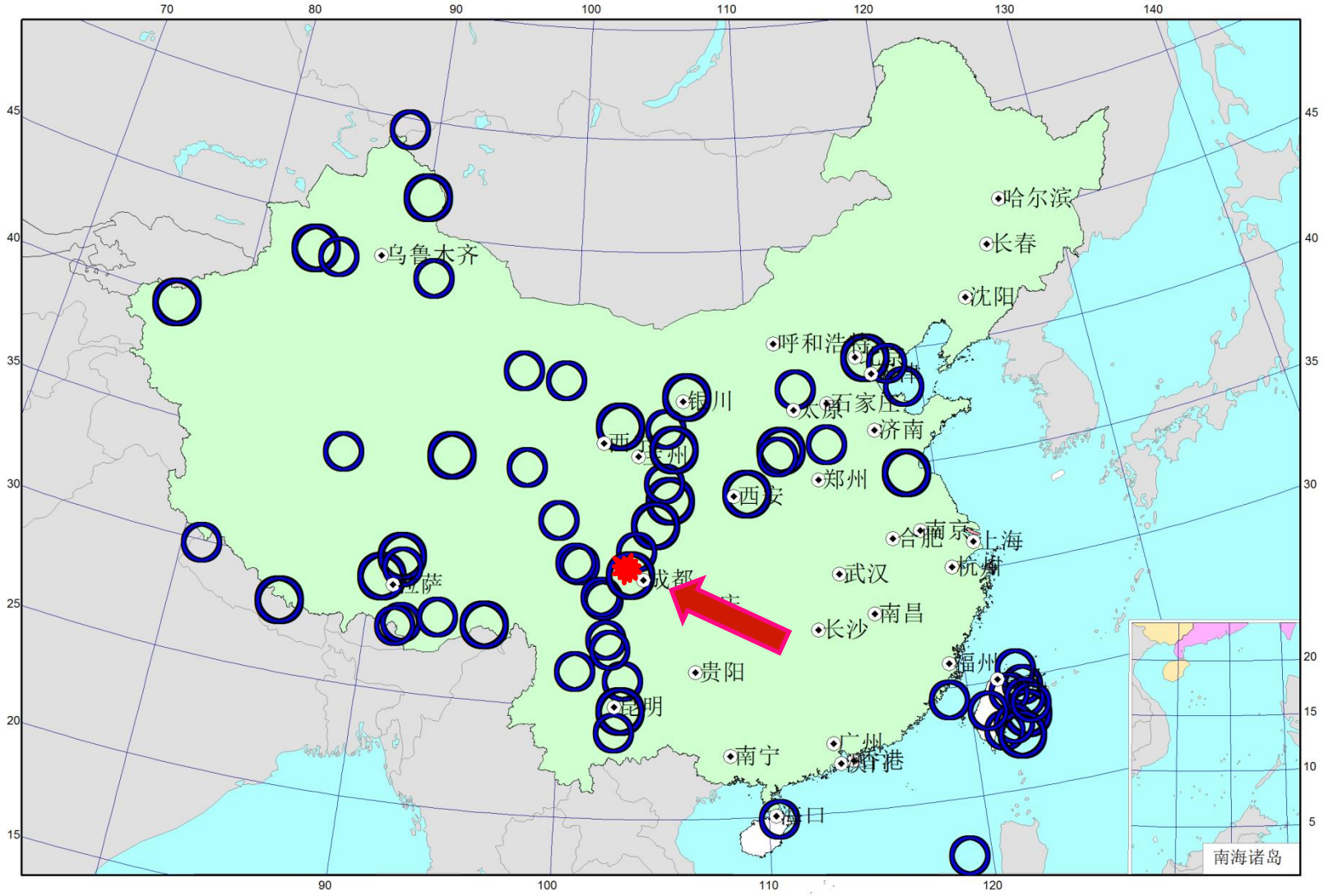


China suffers from both seismic belts

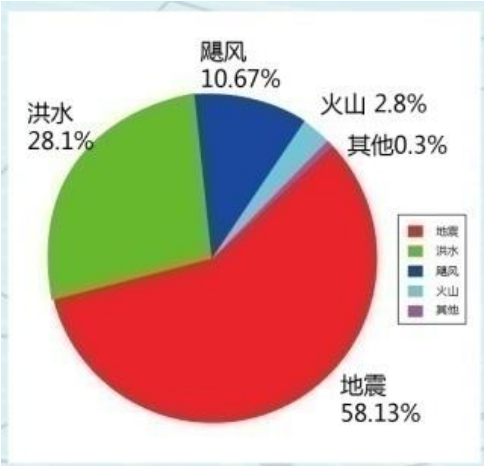
Distribution of historical earthquakes



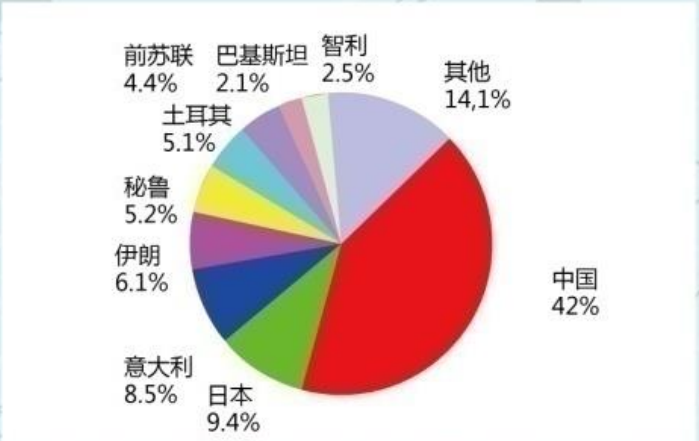
Earthquake epicenter distribution, large than M7.5



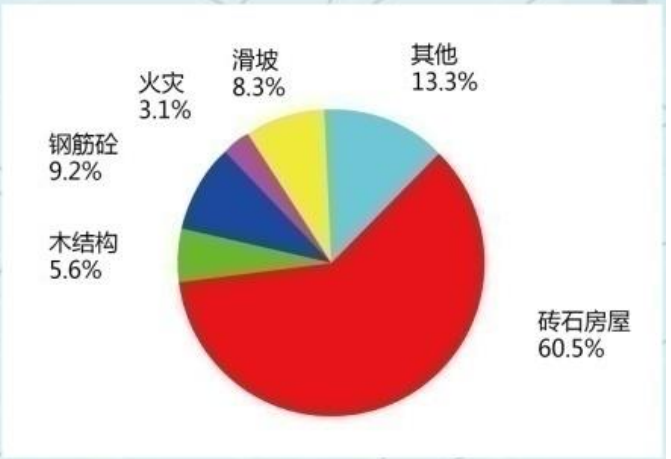
Highest life lost ratio in China



自然灾害伤亡人数统计（1900~1976），地震伤亡人数居首。

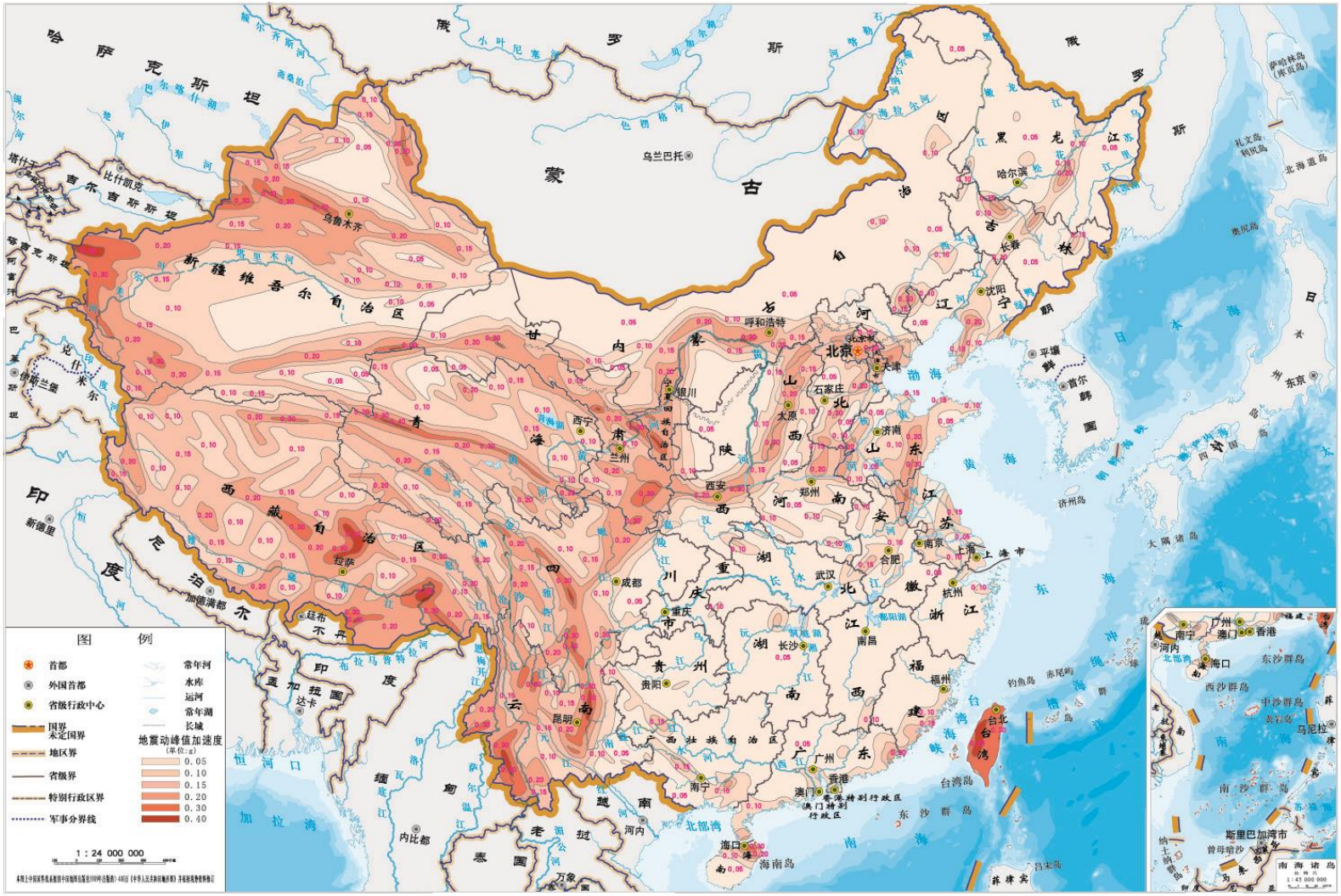


自然灾害伤亡人数统计（1900~1989），按国家统计地震伤亡人数，中国居首。



按照建筑结构类型统计地震伤亡人数，不抗震的砖石房屋居首。

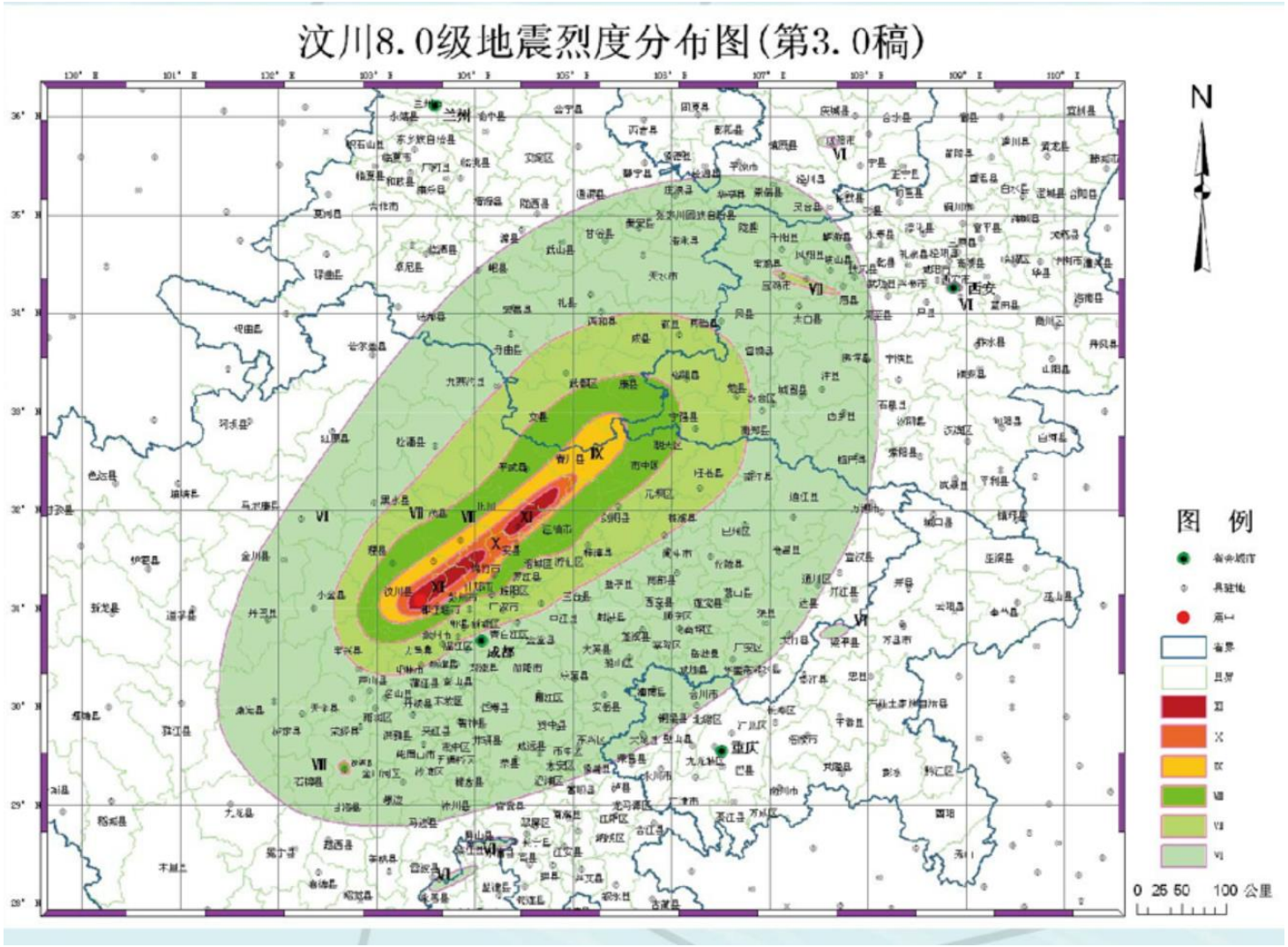
Seismic zonation map of China



Earthquake parameters

May 12, 2:28pm
M8.0
N 031.00
E 103.40

Intensity map of Wenchuan EQ



Total loss

Casualties: 87,000

Properties: $110 Billion

About 80% of the buildings collapsed around epicenter

PGA is estimated as 1.5g

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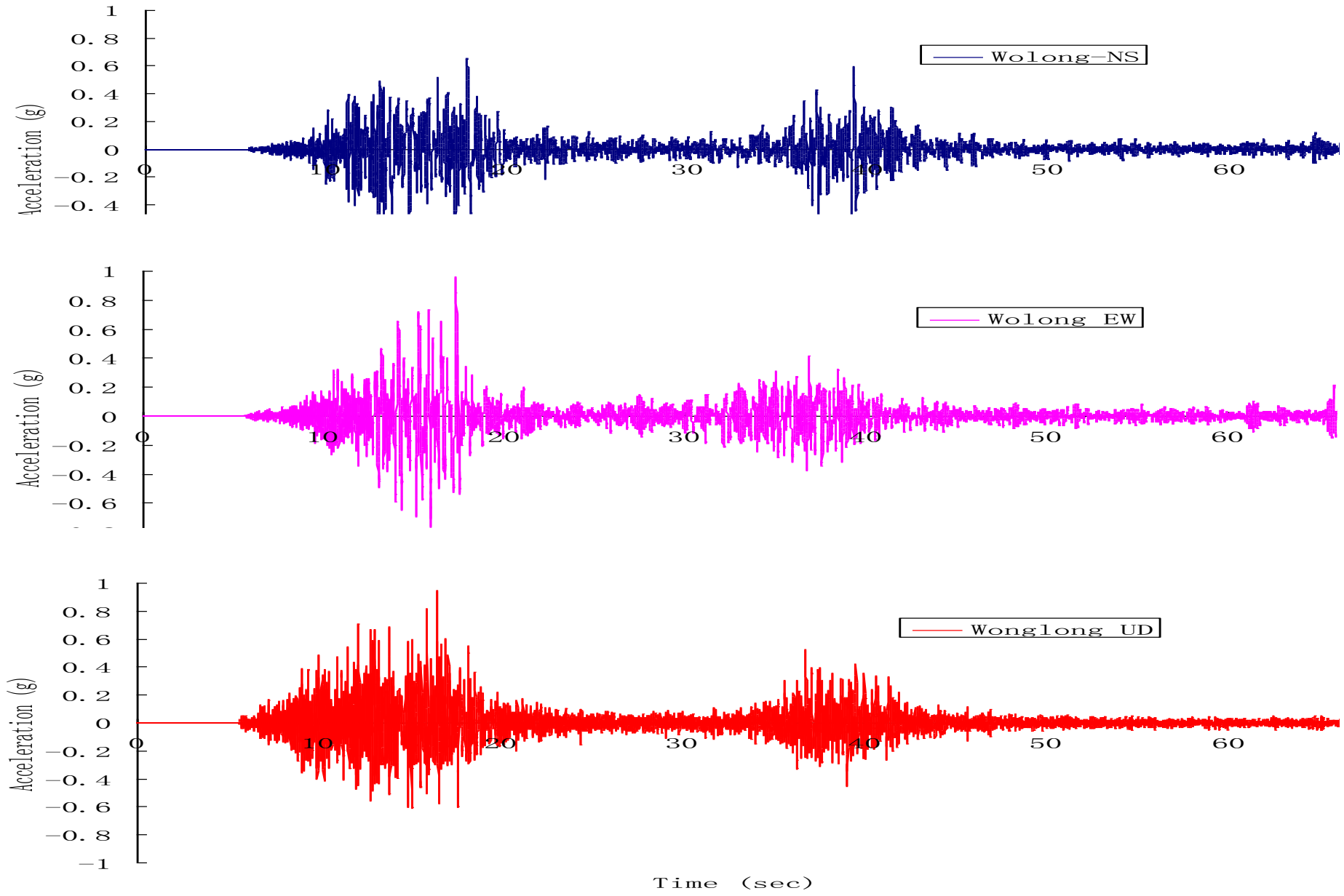
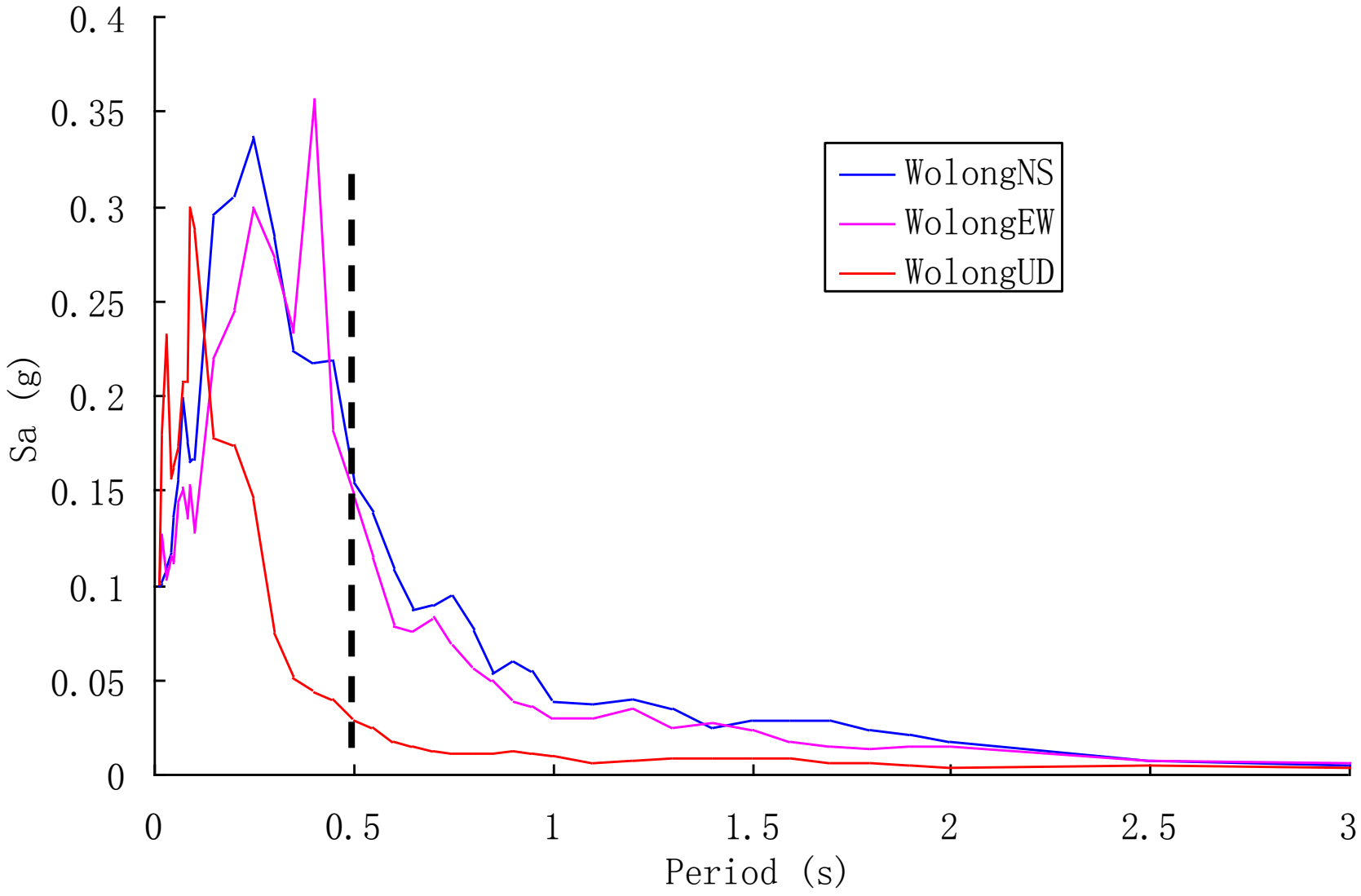


Strong ground motion recorded at Wolong with PGA=0.96g

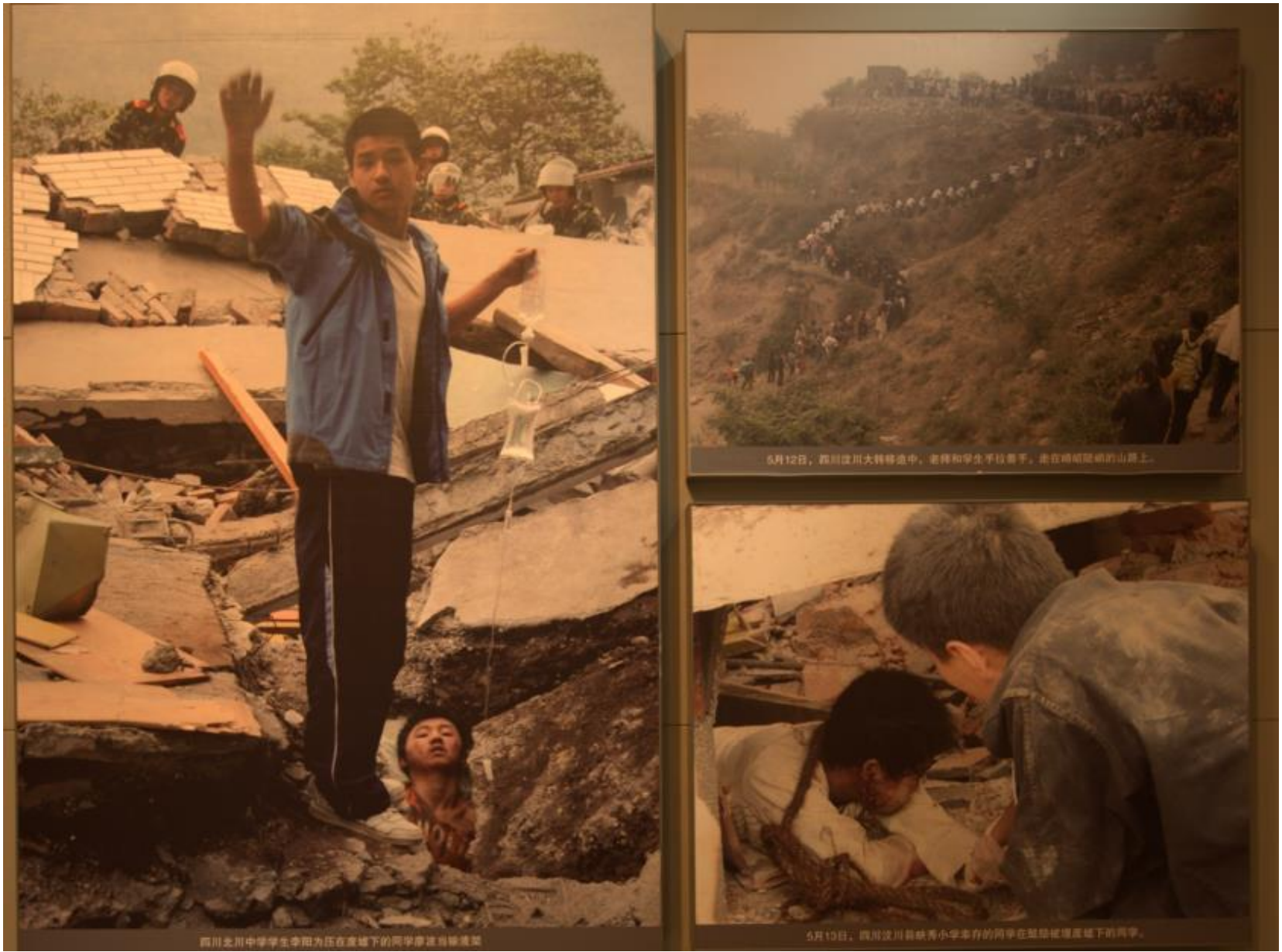
Response Spectrum



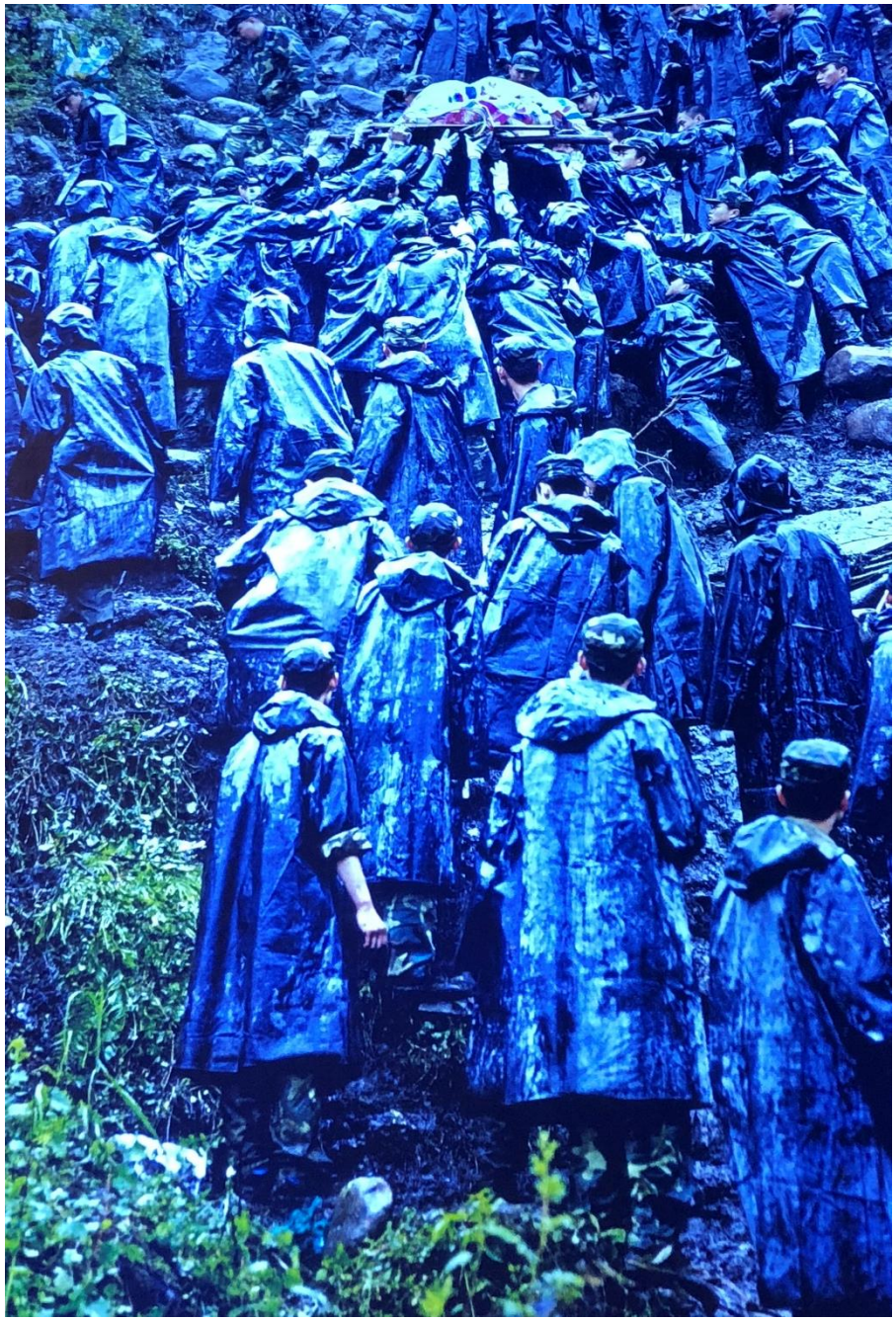
Premier Wenjiabao visited field site

Self and mutual rescue in the first time

Self and mutual rescue in the first time



PLA soldiers acted as a bridge



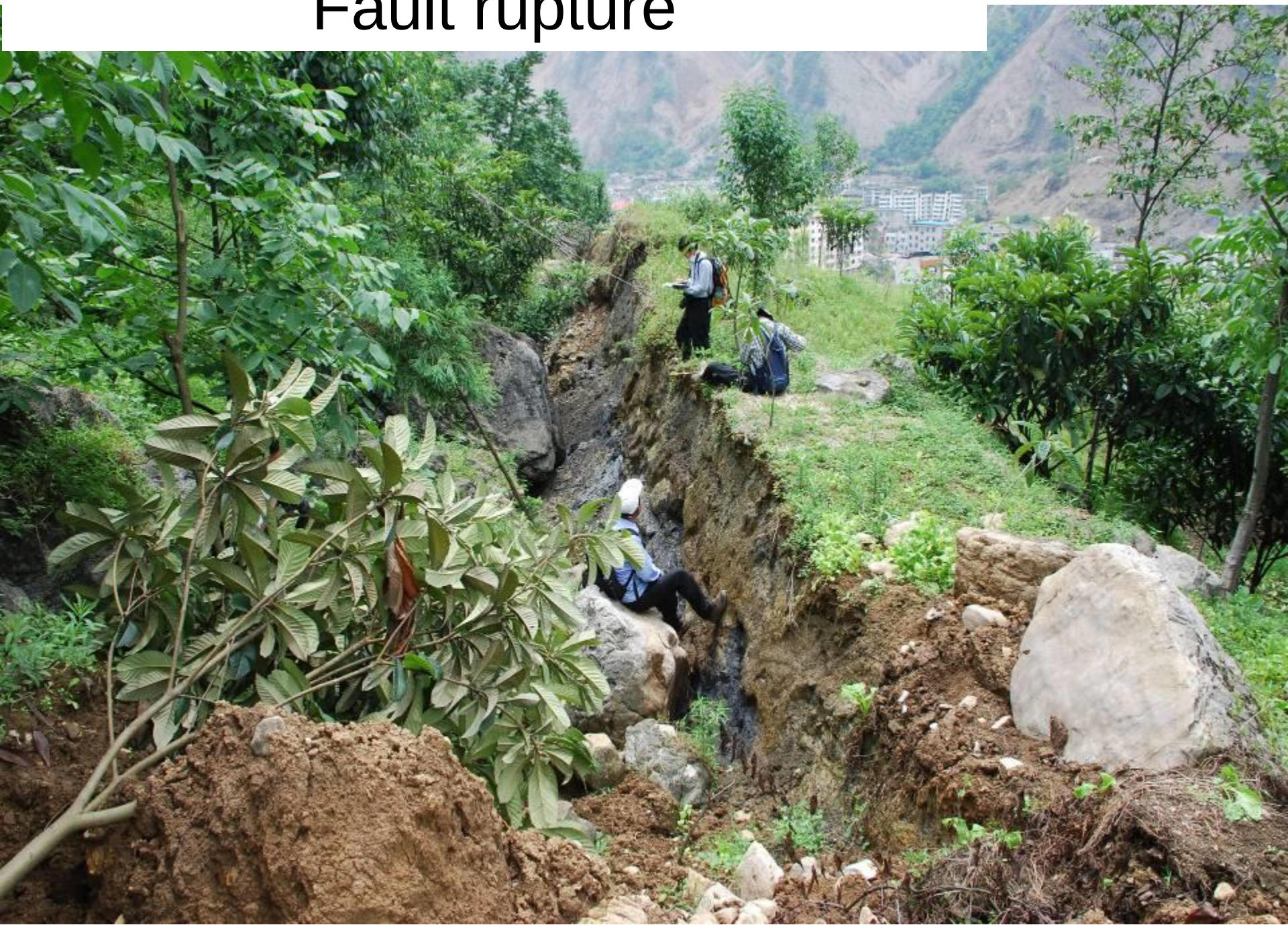
Search and rescue in very heavy rain

The saved child saluted to soldiers


Land slide

Land slide

Fault rupture



Fault rupture


深溪沟地震在断层面上形成的擦痕
Fault Scratch


前山断裂错断白鹿镇中学校园，距断层数米处的教学楼没有遭到严重破坏
Fault rupture

Fault scarp

Fault scarp: 9.5m

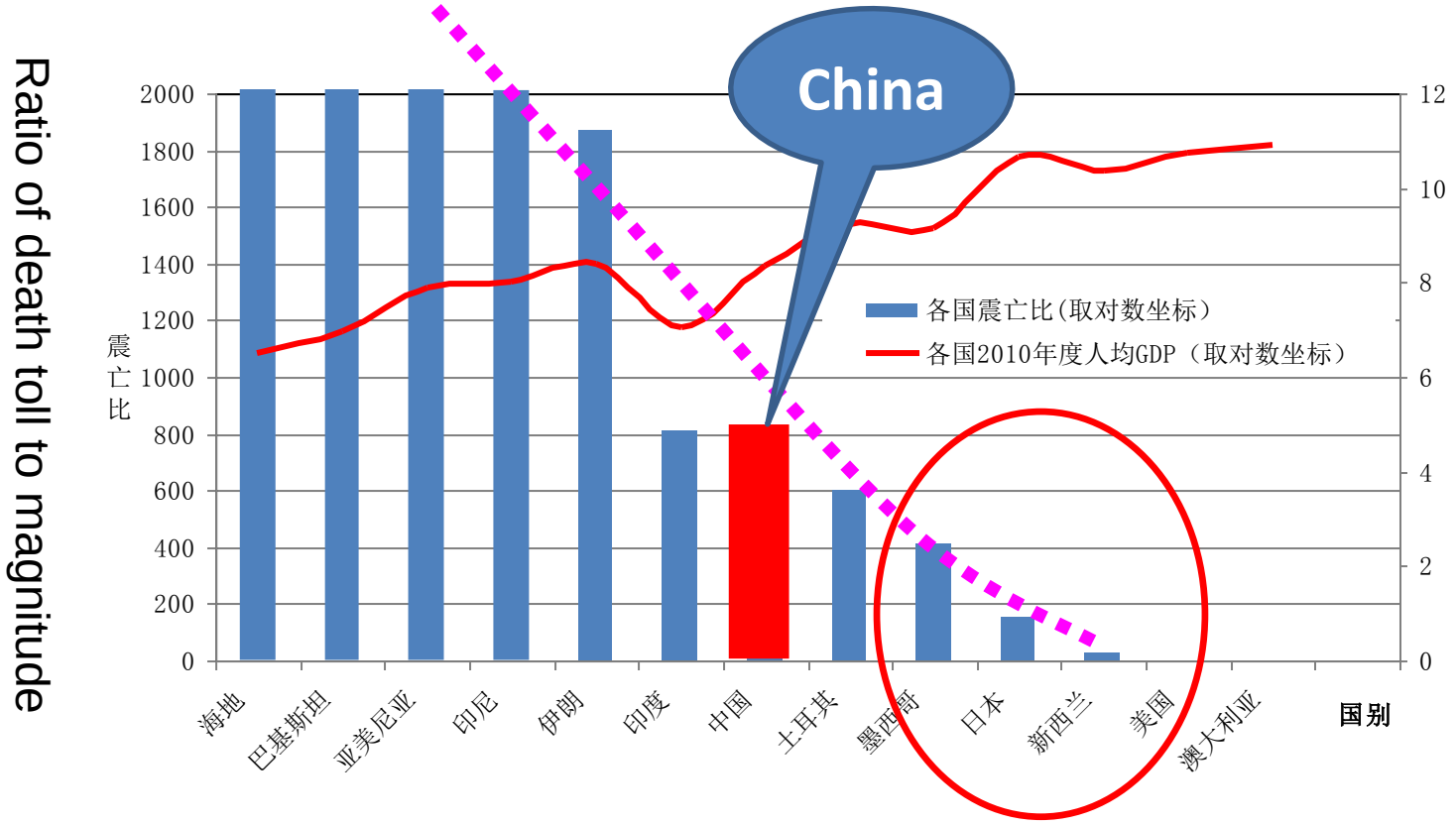
Damages of rural houses

Damages of rural houses

Damage of school building

Damage of school building

Death toll ratio comparision



Technical support for reconstruction

Defects of structure in resisting earthquake

散 Lack of **Integrity**, loosening

脆 Lack of **Ductility**, Brittle

偏 Lack of **Balance**, Eccentric

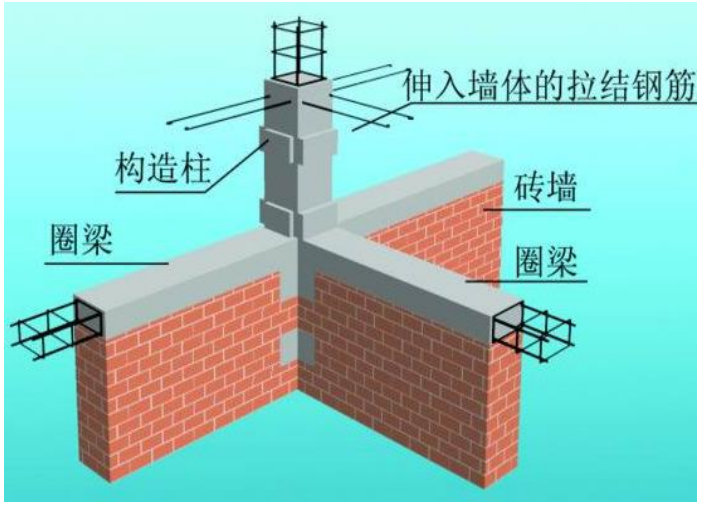
単 Lack of **Redundancy**, Single

Performance of those lack of Integrity

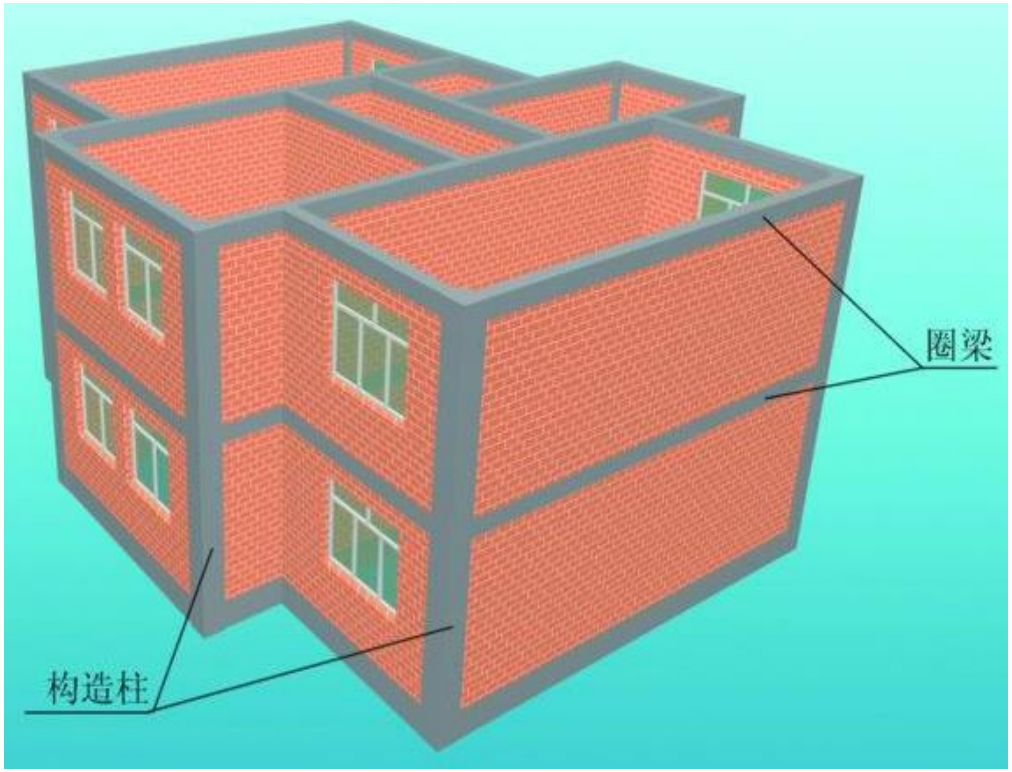
Integrity and Redundancy

Integrity and Redundancy

Integrity and Redundancy



圈梁、构造柱的轮廓及其与墙的关系



圈梁、构造柱的平面和立面分布

Model buildings which survived the M 8.0 EQ

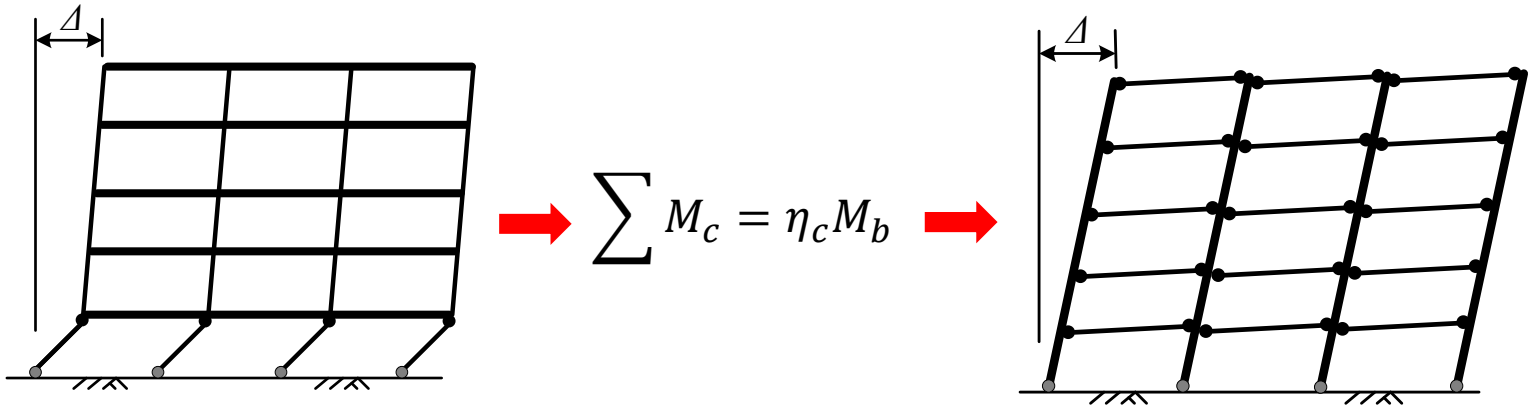
Most of the RC frame teaching building collapsed, Why?

问题引入：漩口中学教学楼倒塌而其他不倒，为什么？

Gap between theory and practice

From weak column strong beam

to strong column weak beam



弱柱强梁

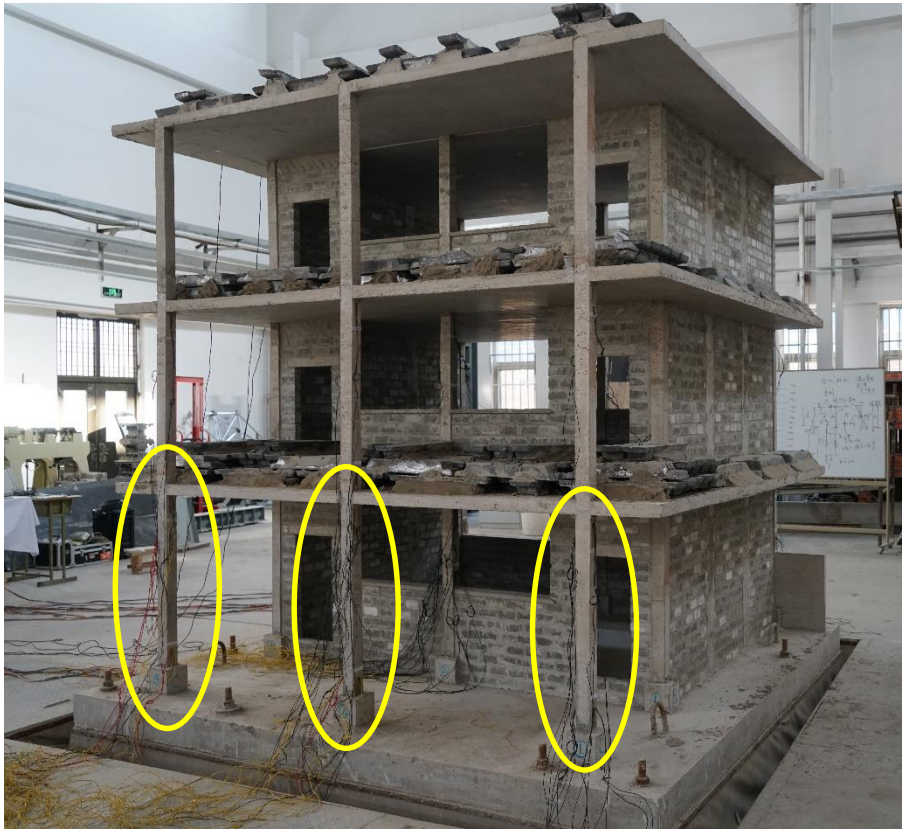
强柱弱梁

Weak columns
after earthquake

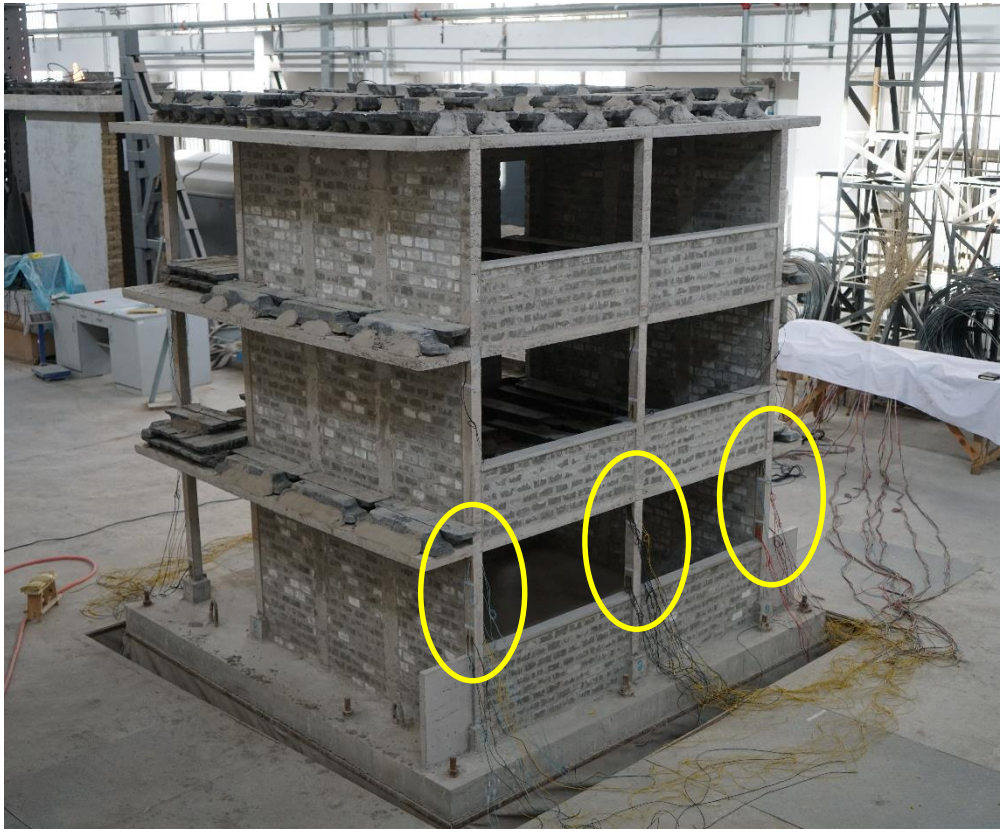
Unbalanced constrain in longitudinal

Unbalanced constrain in longitudinal

Columns: unbalanced constrain

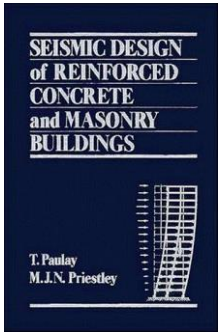


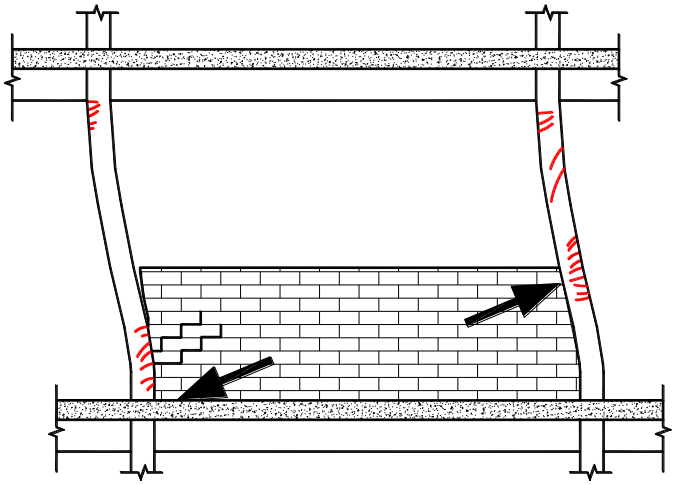
Corridor: without constrain, lower stiffness, lower shear



Window: with constrain of half-height continuous walls, much higher stiffness, much higher shear

One span vs multi span



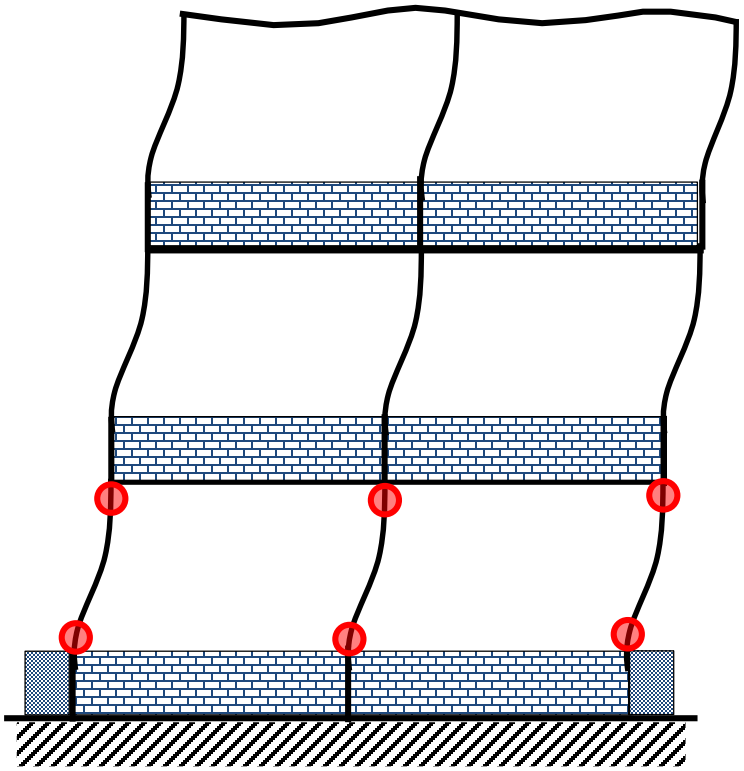


Paulay T, 1992.

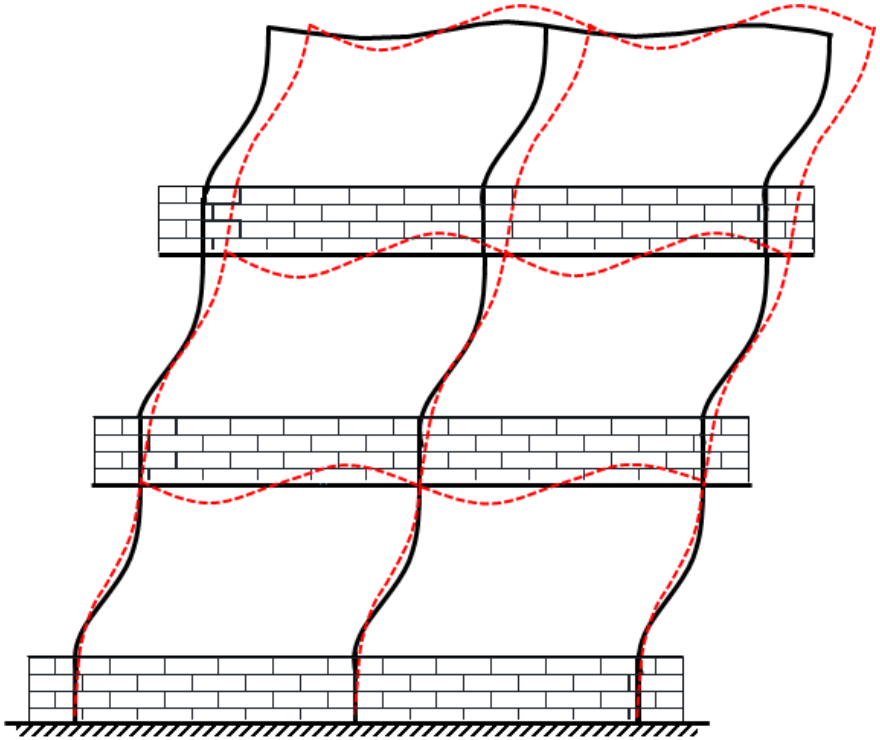
Dowel—very high stiffness

其他学者只考虑填充墙的单侧挤压，没有考虑连续约束作用

Beam can not bending with walls above

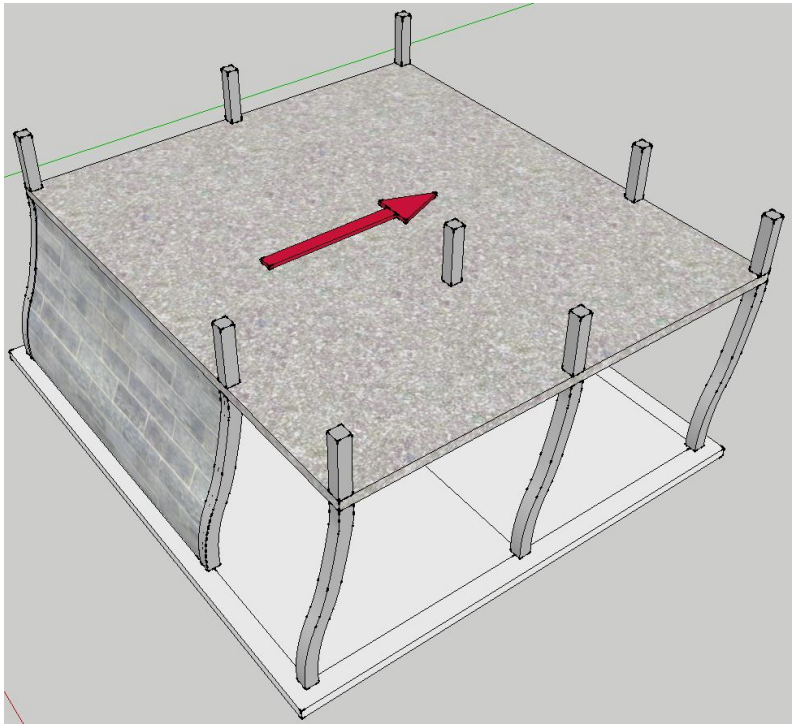


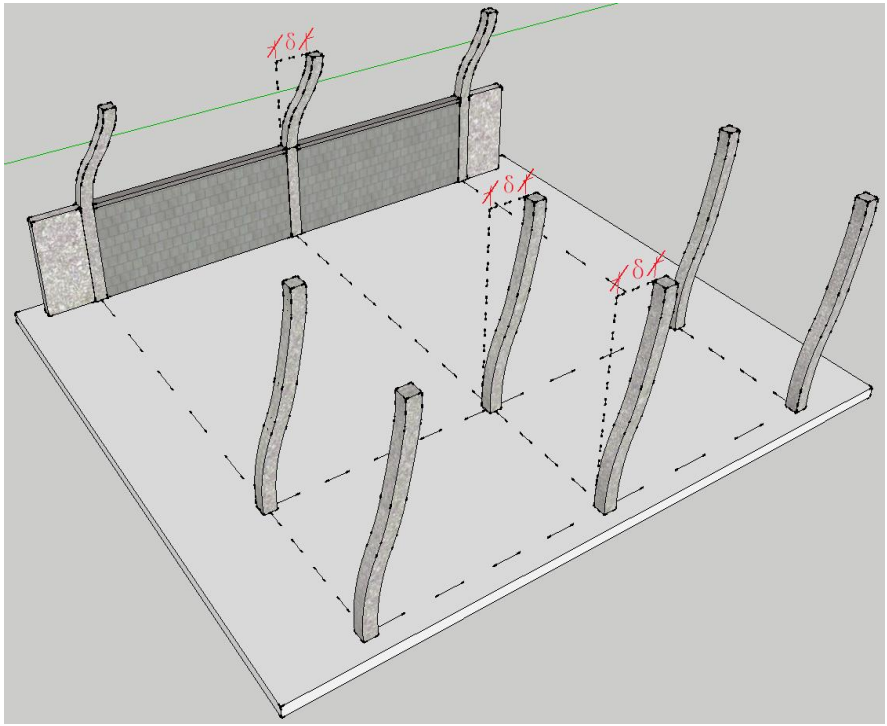
Actual

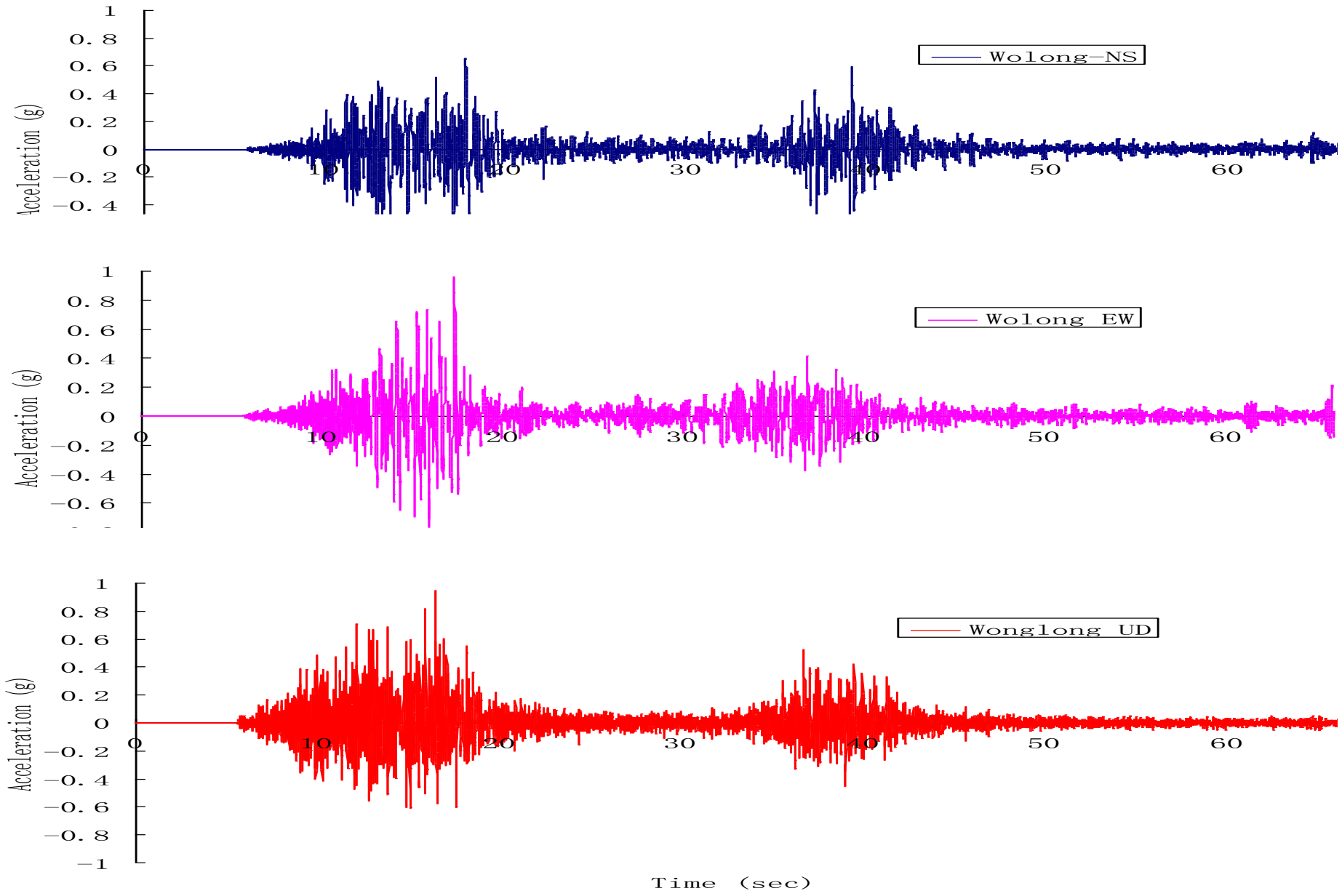


Expected

Comparison of deformation

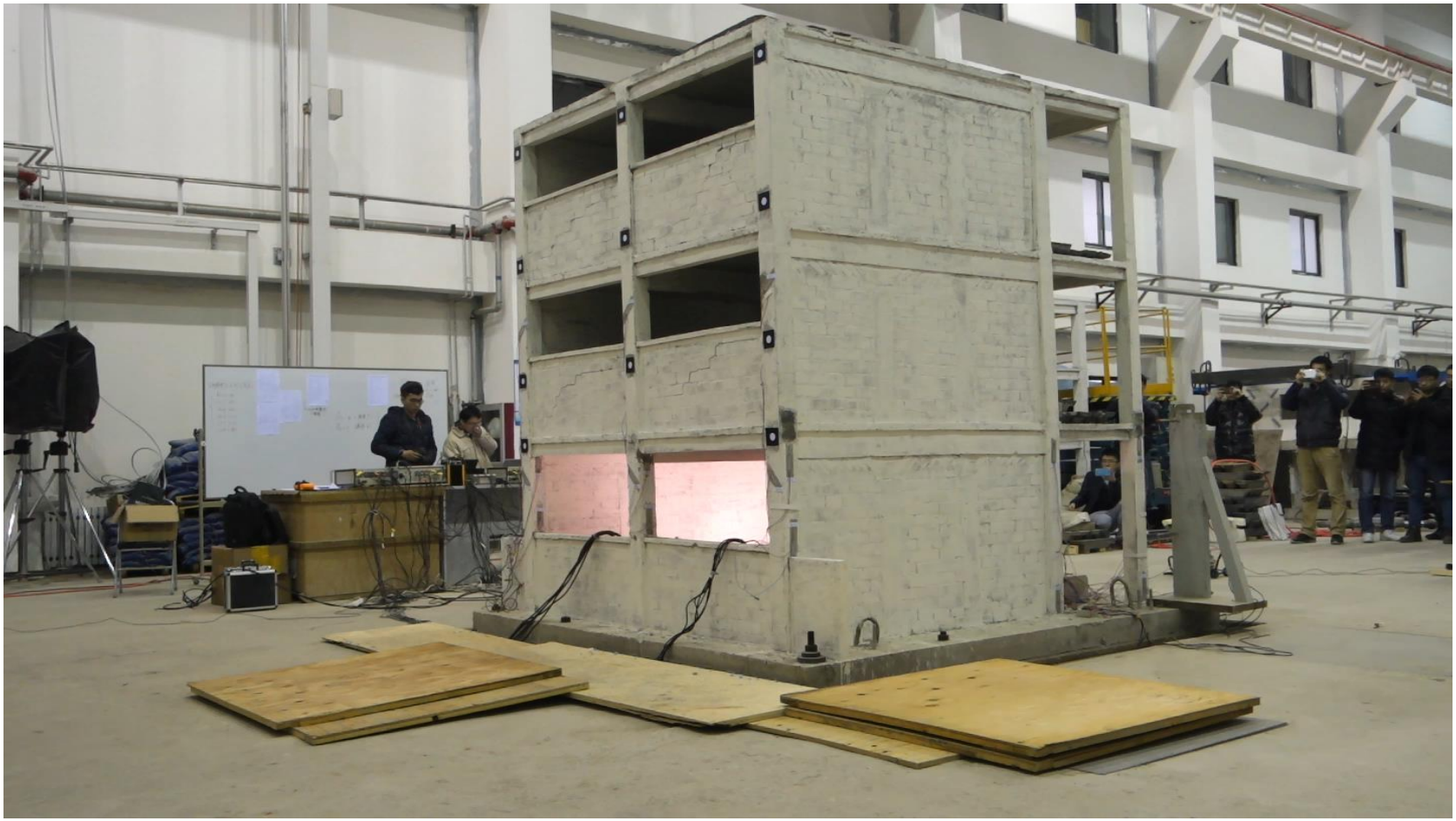




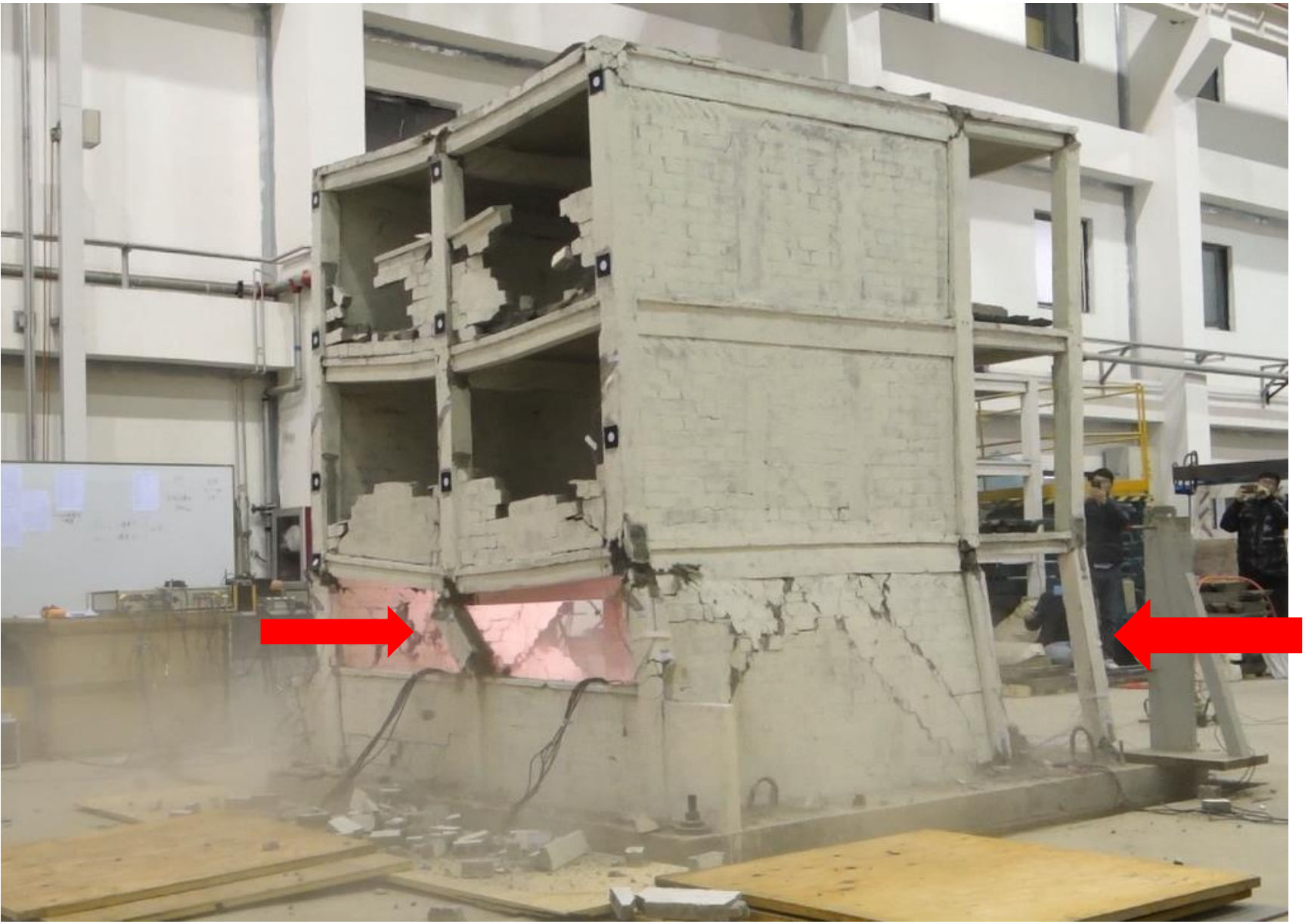


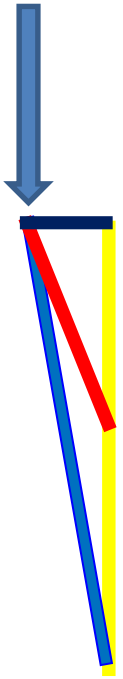
Shaking table test using input records with PGA=0.96g

Collapse process of RC frame

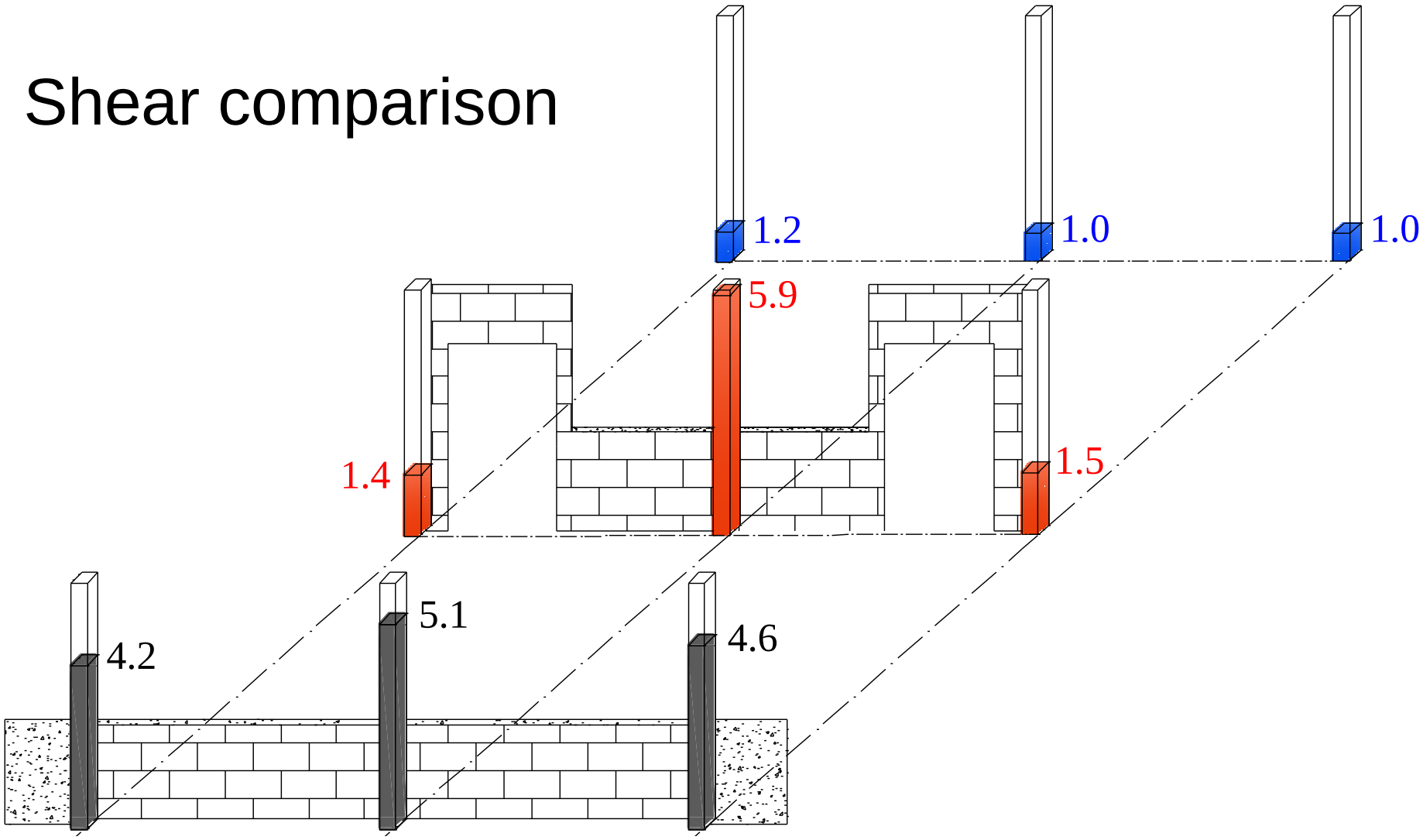


Just before collapsed

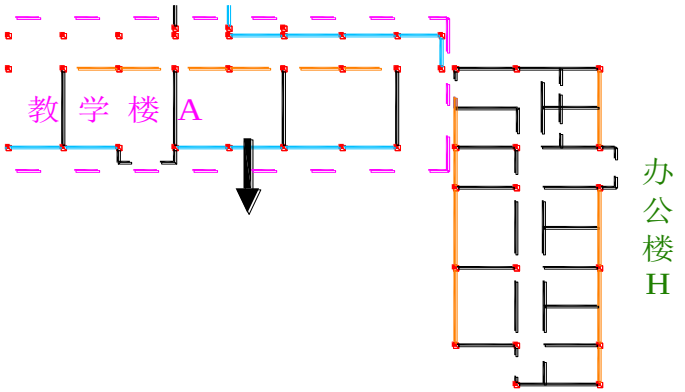


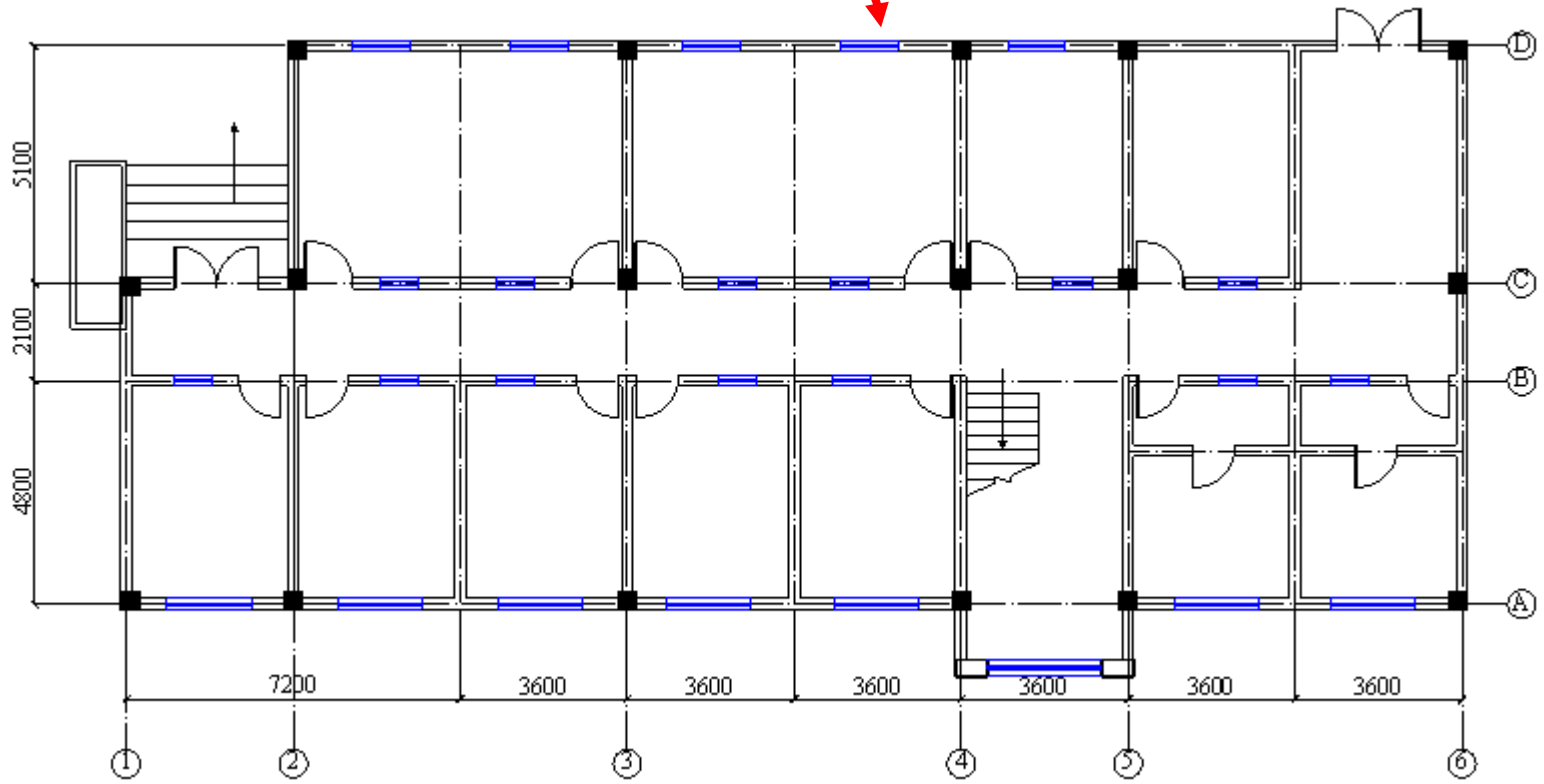


Shear comparison



No collapsed with balanced constrains





Soft first story

Front

Back

Collapsed structure with first soft story

Collapsed structure with first soft story

Collapsed structure with first soft story

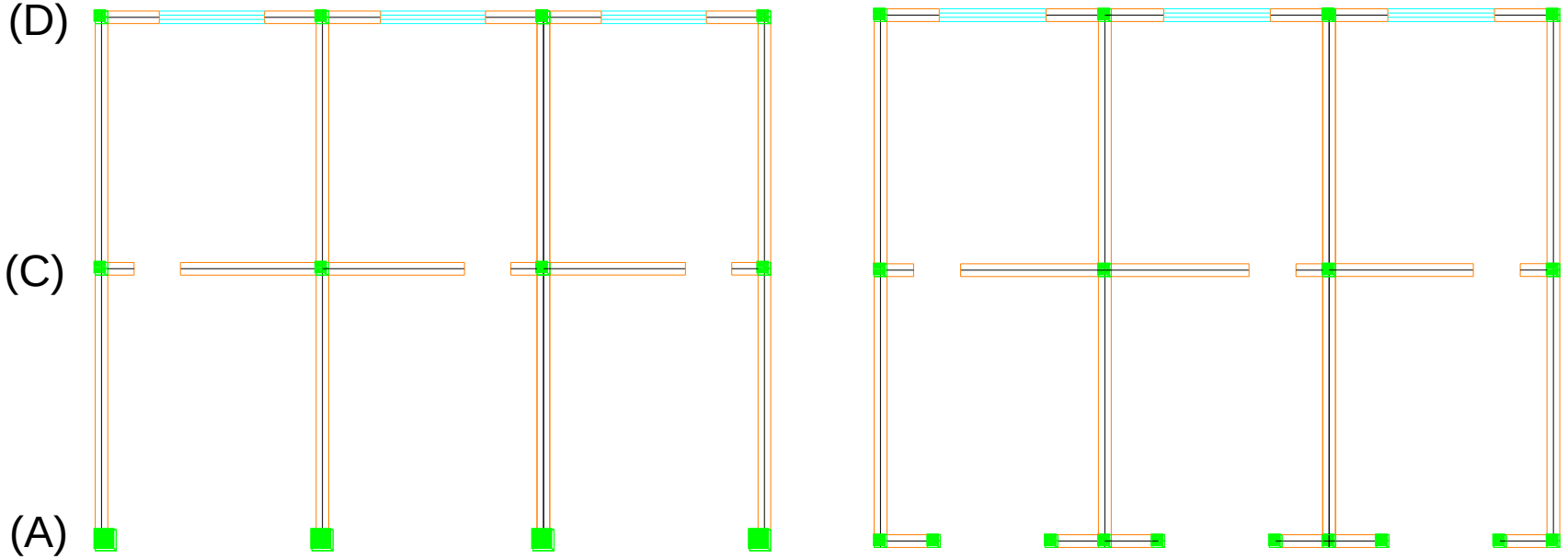
The Strong Model Building-front

The Strong Model Building-front

北川电信底层前脸“翼柱”构造

Comparison of seismic performance

底商多层砌体立面和平面对比



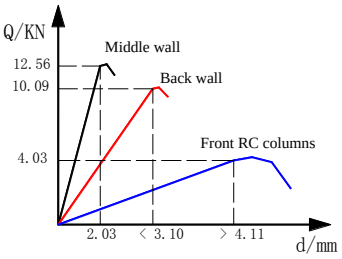
Shear force concentrating to stiffer walls

典型的底商多层砌体房屋

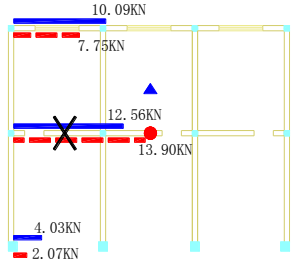
强震下底层沿纵向倒塌

PGA0.8g输入后，模型内伤严重，成为“站立废墟”

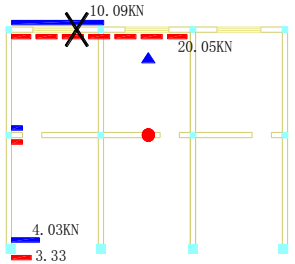
PGA1.0g输入后，模型沿其纵向倒塌



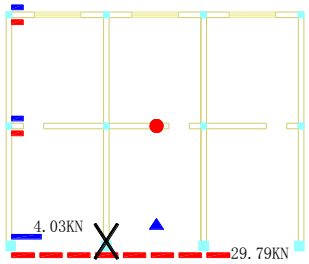
各纵墙地震剪力-位移曲线



纵墙按刚度比例分担地震剪力，第二道纵墙刚度最大，地震剪力最高，但其延性差，率先失效。



第二道纵墙失效后，地震剪力在第一、第三道纵墙间重新分配，同理，第三道纵墙很快失效，三道纵墙被先后“各个击破”。



第二、第三道纵墙失效后，横墙缺少了出平面约束，几何刚度降低，竖向承载能力也大大降低，结构自重将残余的底层构件（包括前脸和横墙）压垮而倒塌。

倒塌机理研究模型制作过程

Criteria for new buildings design

- Integrity vs looseness
  整而不散
- Ductility vs brittleness
  延而不脆
- Uniform vs eccentricity
  匀而不偏
- Redundancy vs singularity
  冗而不单

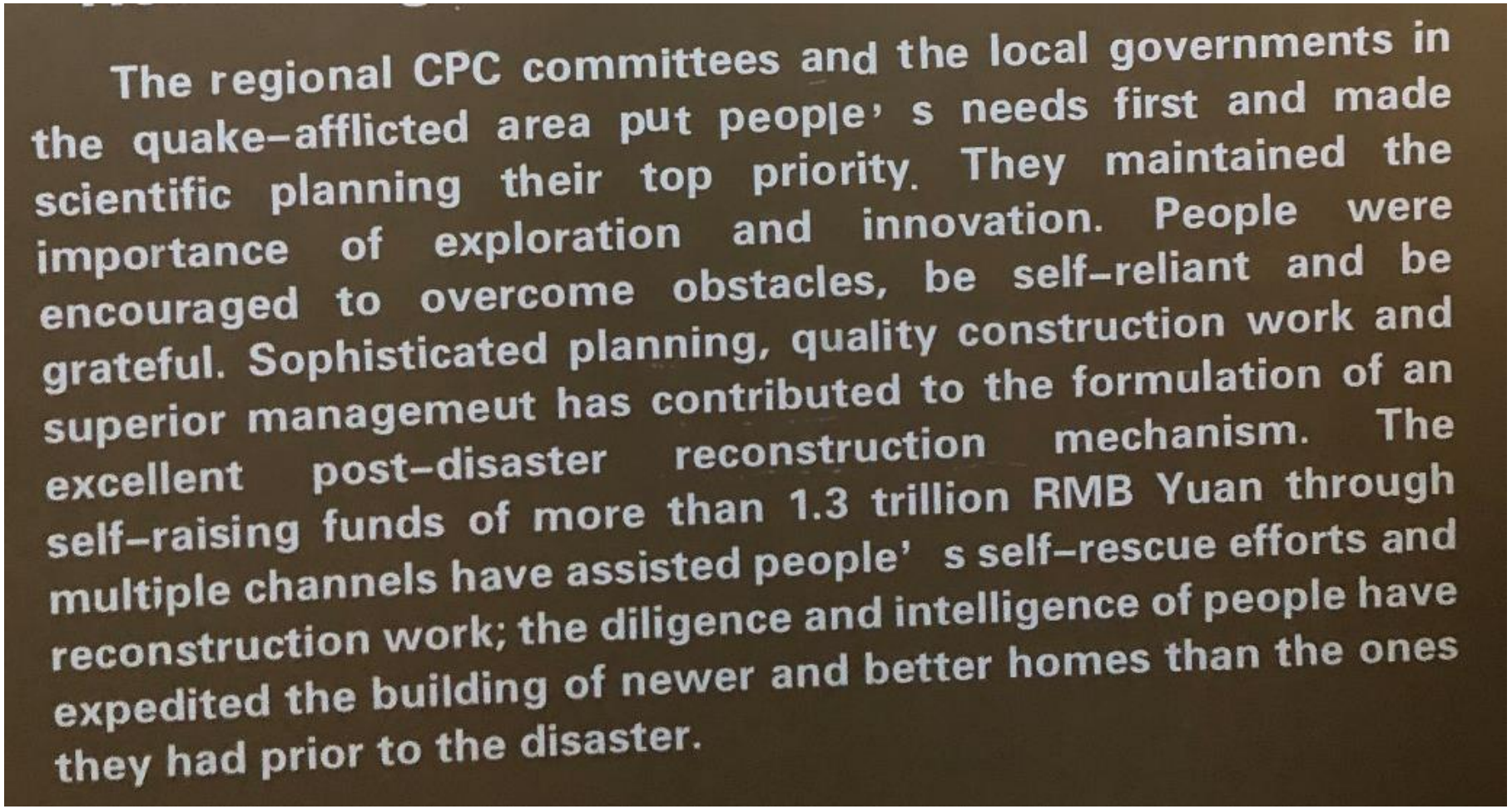
Reasonable Planing


国家汶川地震灾后重建规划 — 城镇体系规划
空间结构规划图
N
甘肃省
陕西省
青海省
若尔盖
九寨沟
阿坝
红原
松潘
平武
青川
广元
剑阁
旺苍
高山高原区
（扶贫与生态涵养地区）
中山深谷区
（人口与产业疏散优化地区）
平坝丘陵区
（人口与产业重点集聚地区）
马尔康
黑水
茂县
新北川
江油
梓潼
苍溪
阆中
南部
汶川
理县
安县
绵阳
罗江
盐亭
什邡
德阳
中江
射洪
南充
遂宁
简阳
安岳
都江堰
彭州
崇州
金堂
大邑
邛崃
金兴
小金
雅安
乐山
内江
自贡
汉源
重庆市
成德绵广西翼发展轴
成德绵广主要发展轴
成德绵广东翼发展轴
旅游发展生命线通道
人口产业向东拓展
图例
区域中心城市
区域次中心城市
市域中心城市
县域中心城市
成德绵城镇群
成德绵广城镇密集带

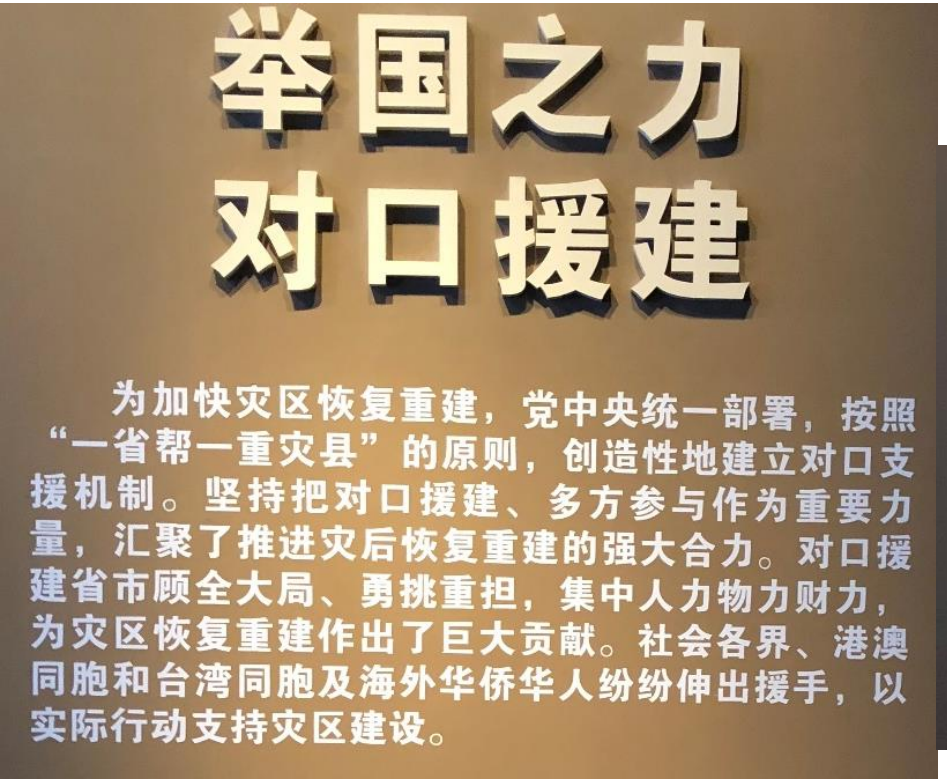
Temporary houses

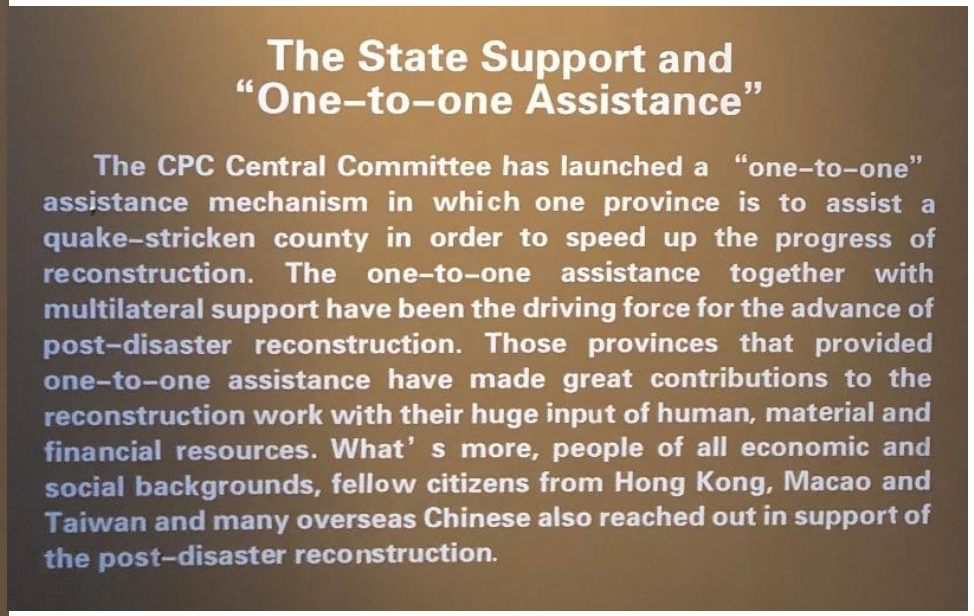
Disaster relief distribution

Rebuilding homes through Self-reliance

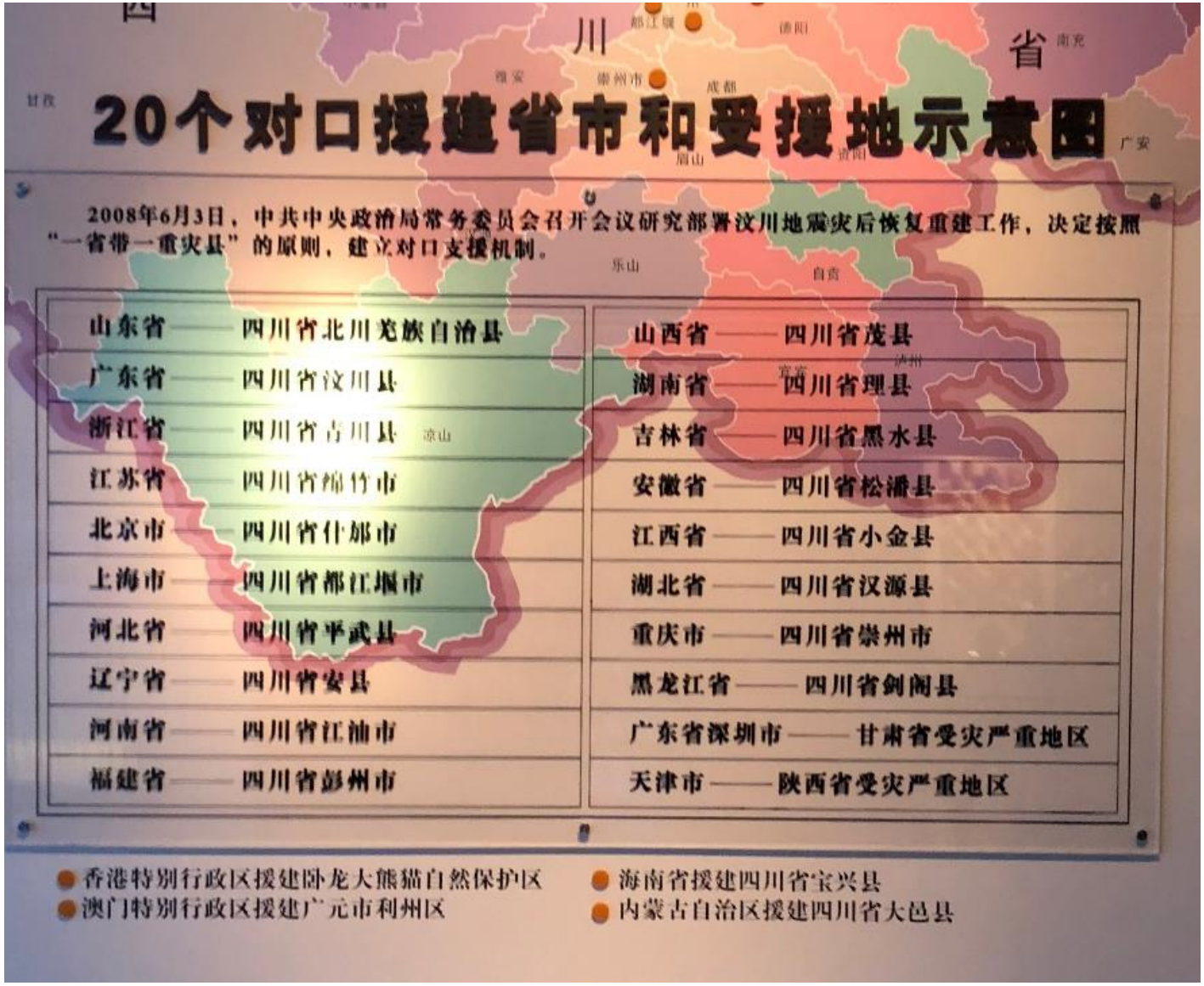


One-to-one Assistance





One province assist one county



Field inspection of provincial heads

Field inspection of provincial heads

Plaques of field commanding office

Plaques of field commanding office

Victims expressing their thanks

Field work

Donation from oversea Chinese

Donation of party membership dues

Reconstruction results

Reconstruction results

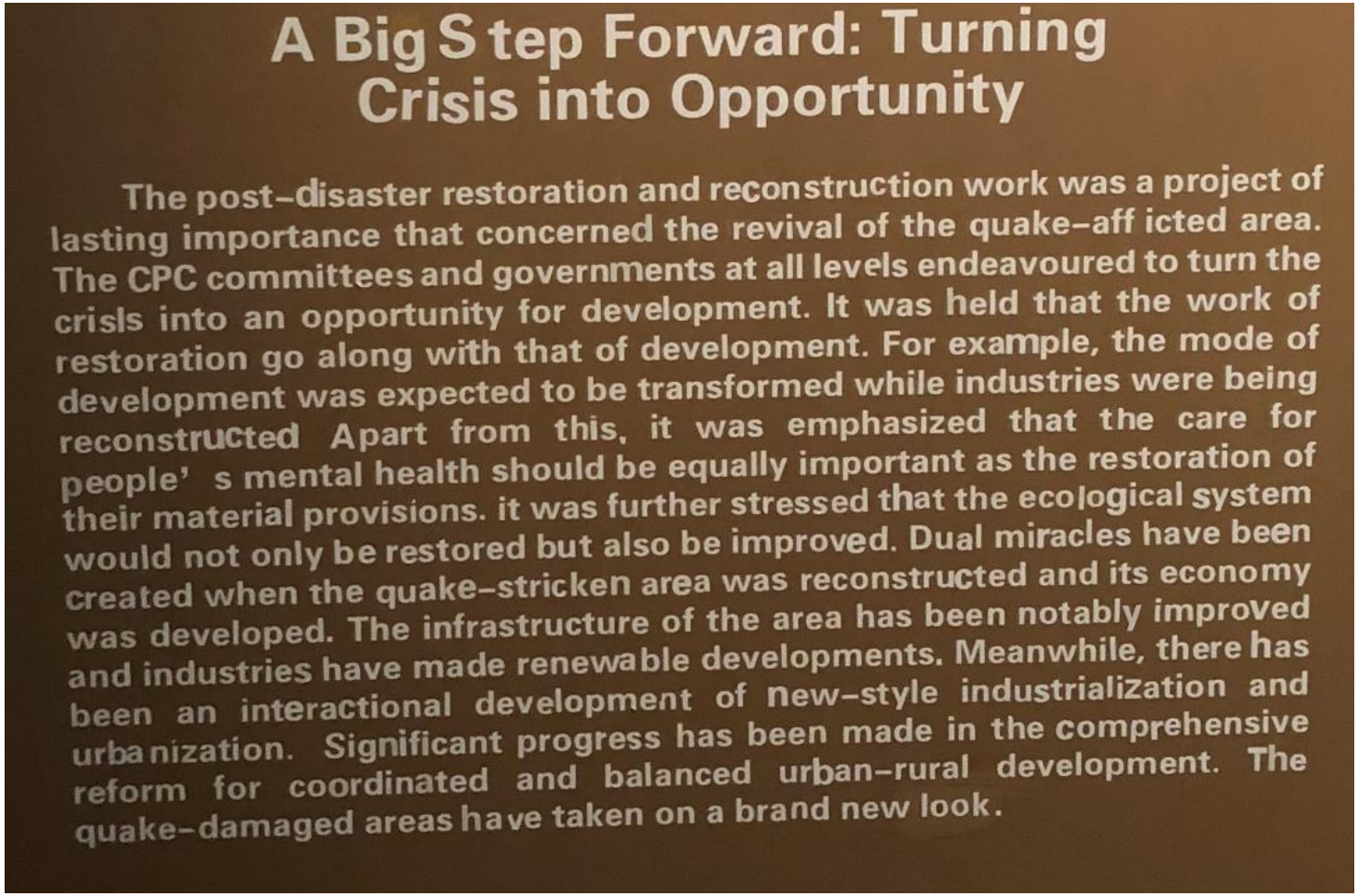
四川省汶川县映秀镇群众入住新居与援建者共同举办百家宴

Reconstruction results

Reconstruction results

Reconstruction results

A big step forward after the disaster

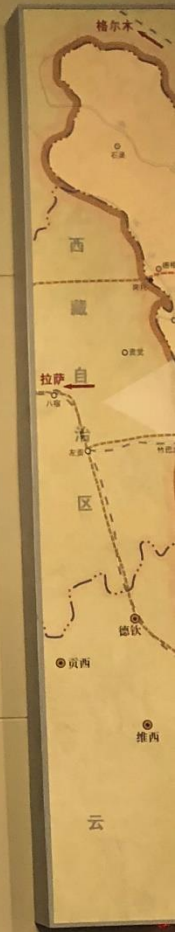


A Big S tep Forward: Turning Crisis into Opportunity

The post-disaster restoration and reconstruction work was a project of lasting importance that concerned the revival of the quake-aff icted area. The CPC committees and governments at all levels endeavoured to turn the crisis into an opportunity for development. It was held that the work of restoration go along with that of development. For example, the mode of development was expected to be transformed while industries were being reconstructed Apart from this, it was emphasized that the care for people' s mental health should be equally important as the restoration of their material provisions. it was further stressed that the ecological system would not only be restored but also be improved. Dual miracles have been created when the quake-stricken area was reconstructed and its economy was developed. The infrastructure of the area has been notably improved and industries have made renewable developments. Meanwhile, there has been an interactional development of new-style industrialization and urbanization. Significant progress has been made in the comprehensive reform for coordinated and balanced urban-rural development. The quake-damaged areas have taken on a brand new look.

基础设施大提升

基础设施建设取得重大突破。截止2011底高速公路和铁路的通车、在建里程已双双突破6000公里，居全国前列；溪洛渡、瀑布沟、锦屏等大型水电站相继开工建设，全省在建规模超过3000万千瓦，总装机容量达到3500万千瓦；农村用电状况得到较大改善，全省农网入户率已超过85%，受益面达98%。

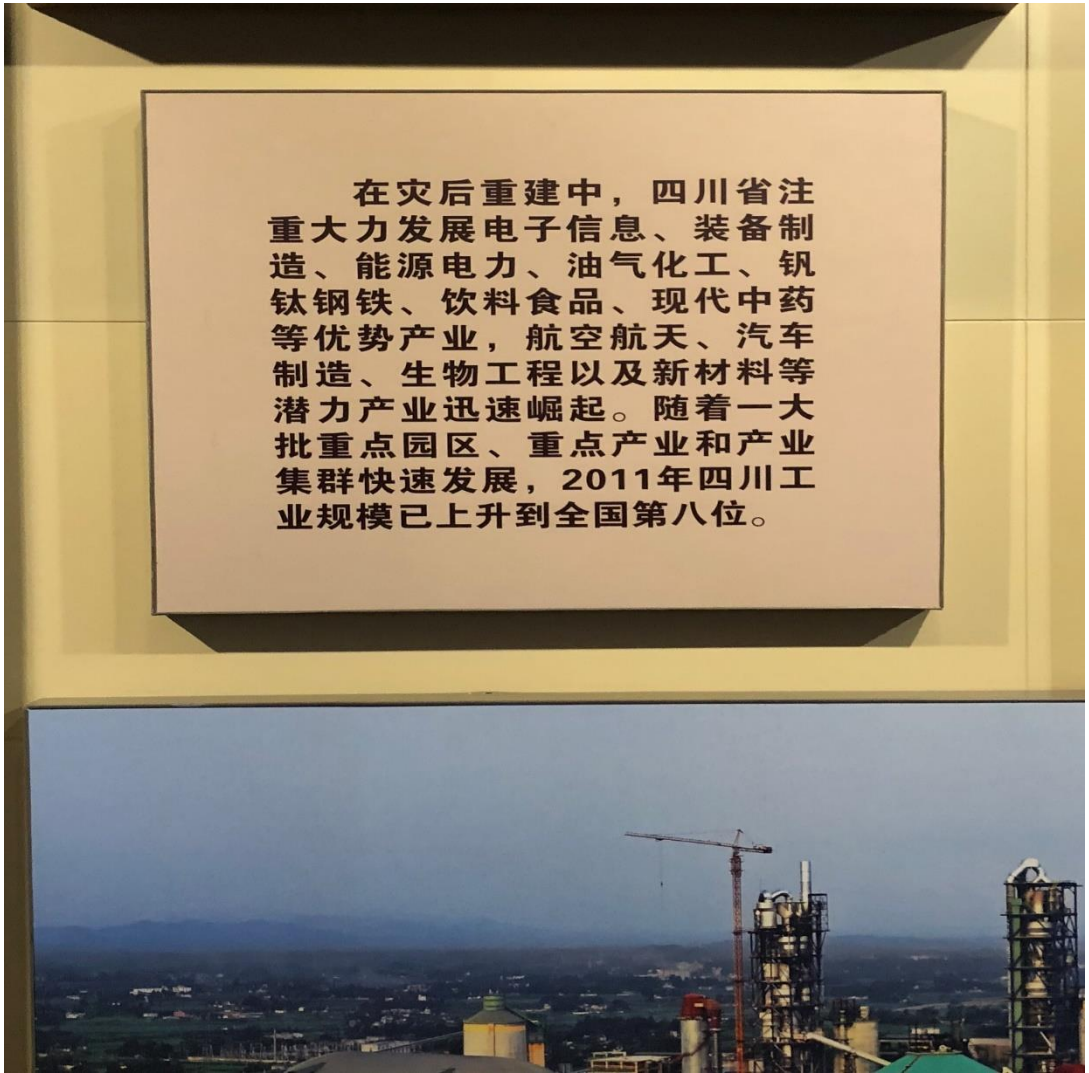


Power supply

灾后重建的新电力枢纽工程

四川省达州市普光气田

Multi-disciplinary industries

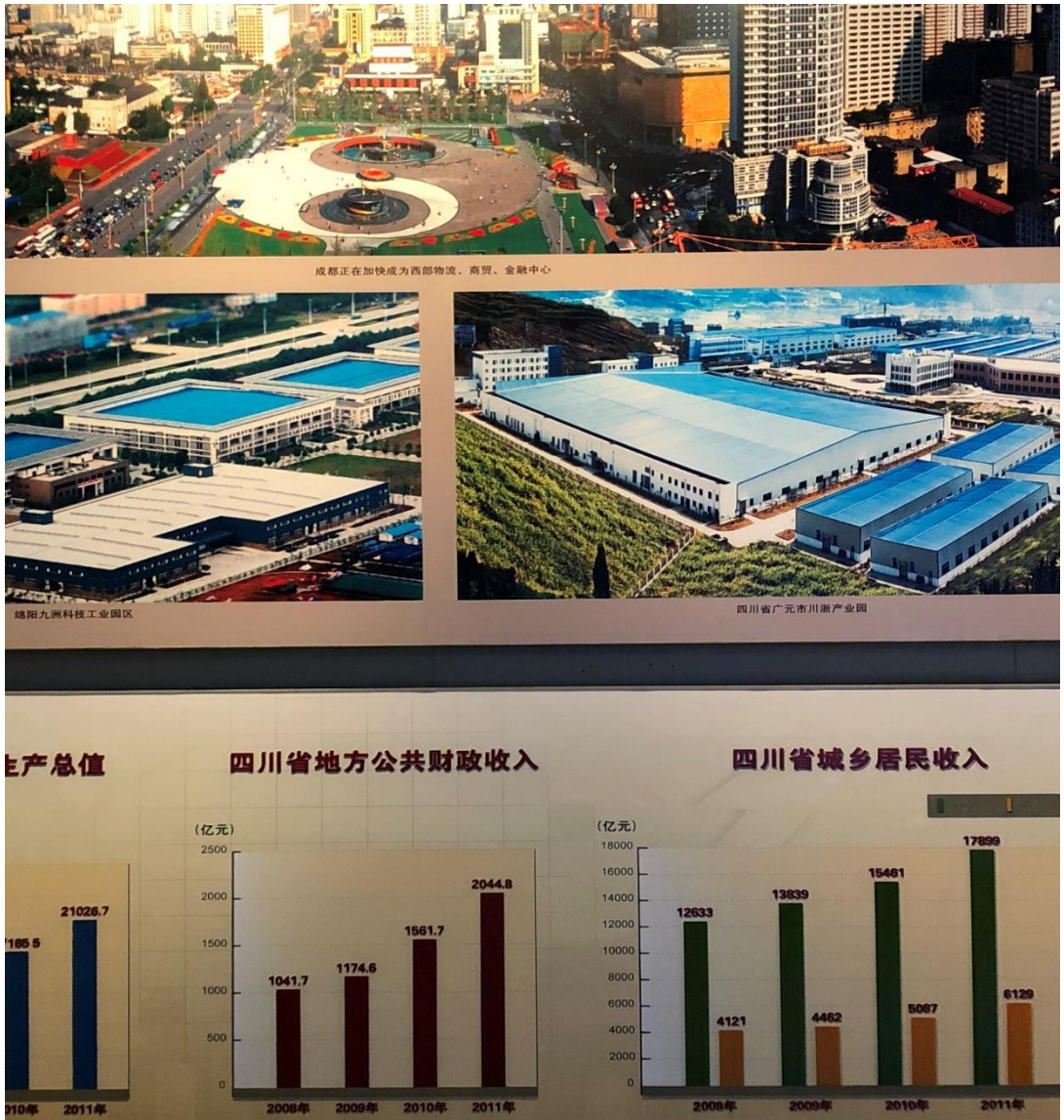


Mechanical industry

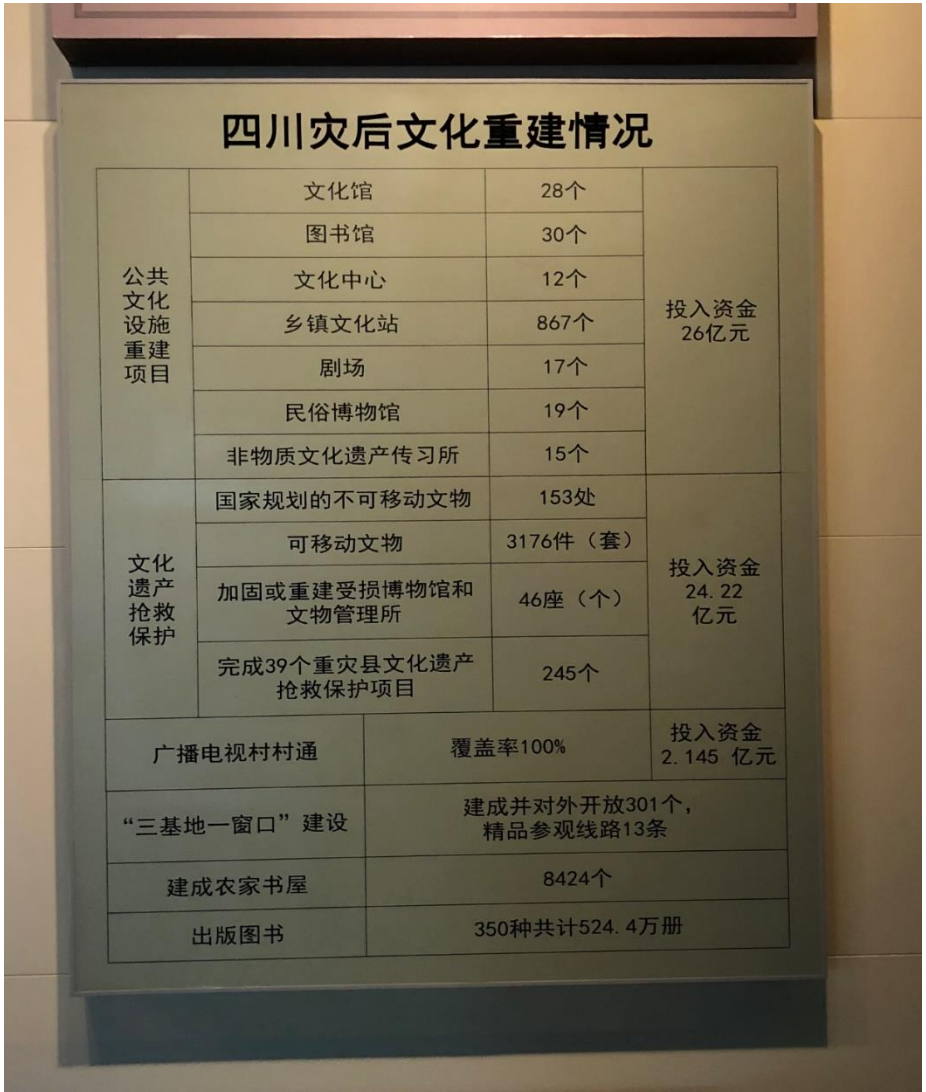
High tech

四川省成都市天府软件园

Great progress than before EQ



Culture reconstruction

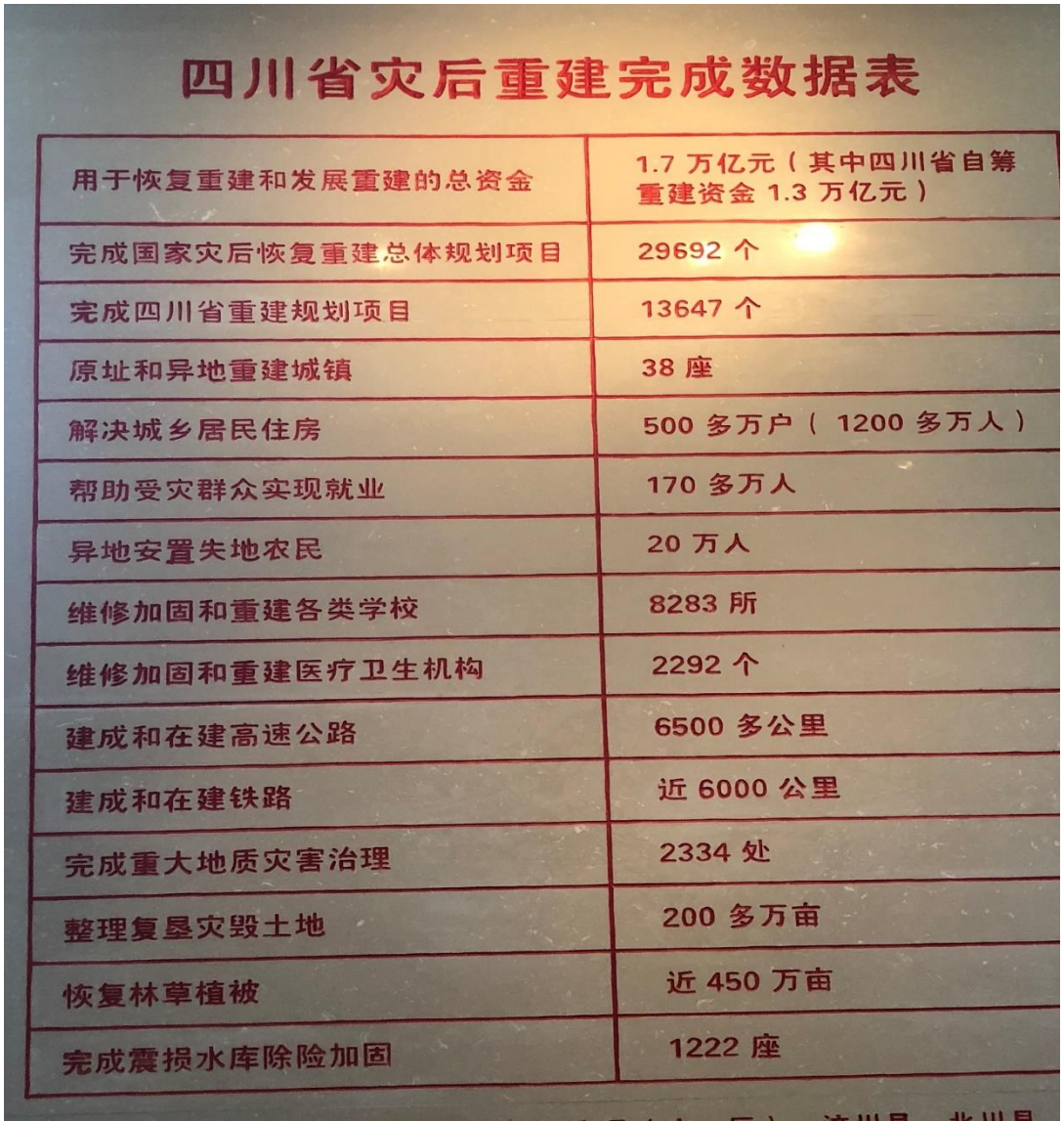


四川灾后文化重建情况

公共文化设施重建项目	文化馆	28个	投入资金26亿元
	图书馆	30个	
	文化中心	12个	
	乡镇文化站	867个	
	剧场	17个	
	民俗博物馆	19个	
	非物质文化遗产传习所	15个	
文化遗产抢救保护	国家规划的不可移动文物	153处	投入资金24.22亿元
	可移动文物	3176件（套）	
	加固或重建受损博物馆和文物管理所	46座（个）	
	完成39个重灾县文化遗产抢救保护项目	245个	
广播电视村村通		覆盖率100%	投入资金2.145 亿元
“三基地一窗口”建设		建成并对外开放301个，精品参观线路13条	
建成农家书屋		8424个	
出版图书		350种共计524.4万册	

Environmental repair

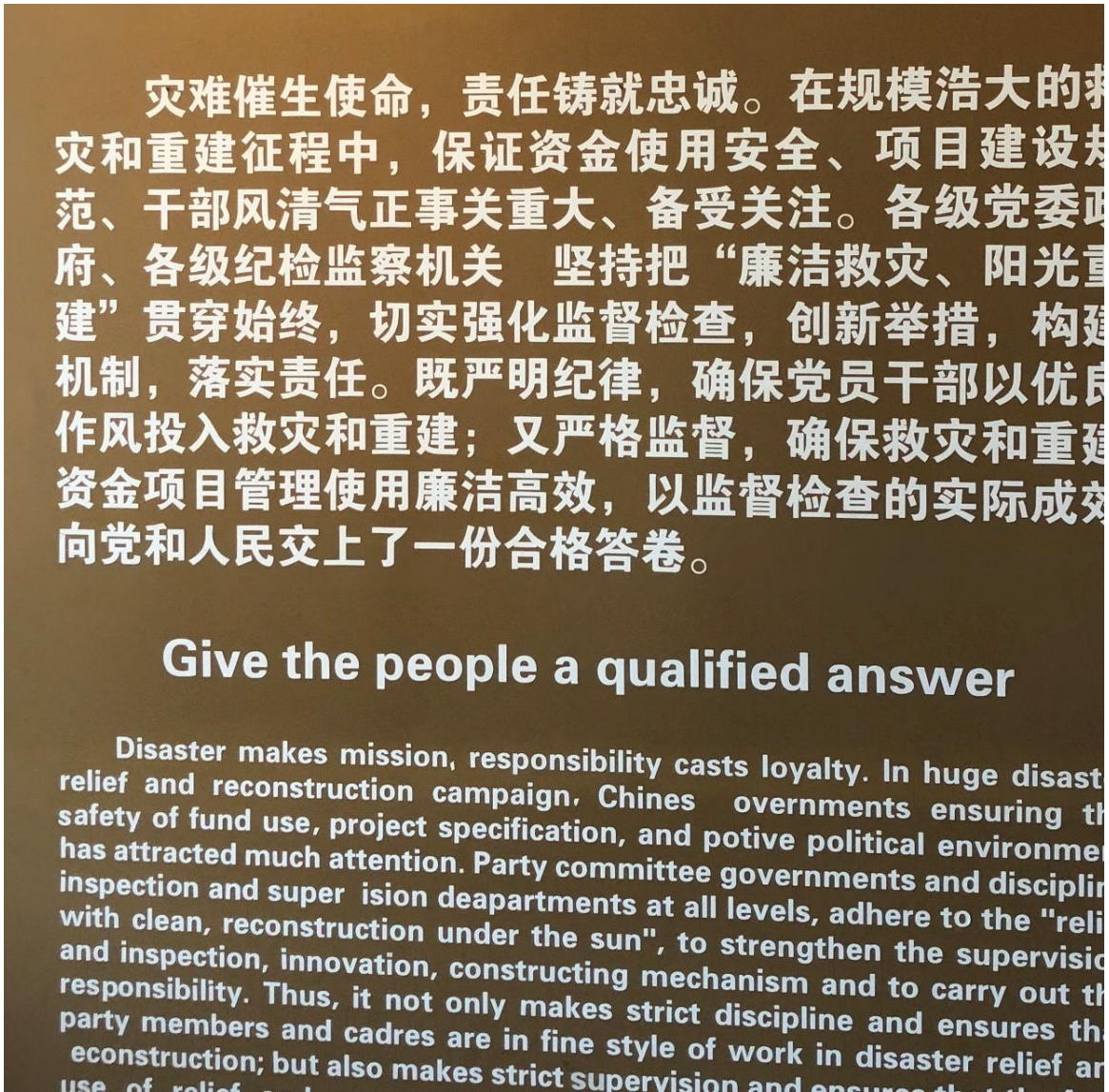
Statistics of reconstruction



四川省灾后重建完成数据表

用于恢复重建和发展重建的总资金	1.7 万亿元（其中四川省自筹重建资金 1.3 万亿元）
完成国家灾后恢复重建总体规划项目	29692 个
完成四川省重建规划项目	13647 个
原址和异地重建城镇	38 座
解决城乡居民住房	500 多万户（ 1200 多万人）
帮助受灾群众实现就业	170 多万人
异地安置失地农民	20 万人
维修加固和重建各类学校	8283 所
维修加固和重建医疗卫生机构	2292 个
建成和在建高速公路	6500 多公里
建成和在建铁路	近 6000 公里
完成重大地质灾害治理	2334 处
整理复垦灾毁土地	200 多万亩
恢复林草植被	近 450 万亩
完成震损水库除险加固	1222 座

Prevention of corruption



Two year later

Two years later

Xun GUO