

Reconstruction Experience after May 12, 2008 Wenchuan Earthquake

Xun GUO

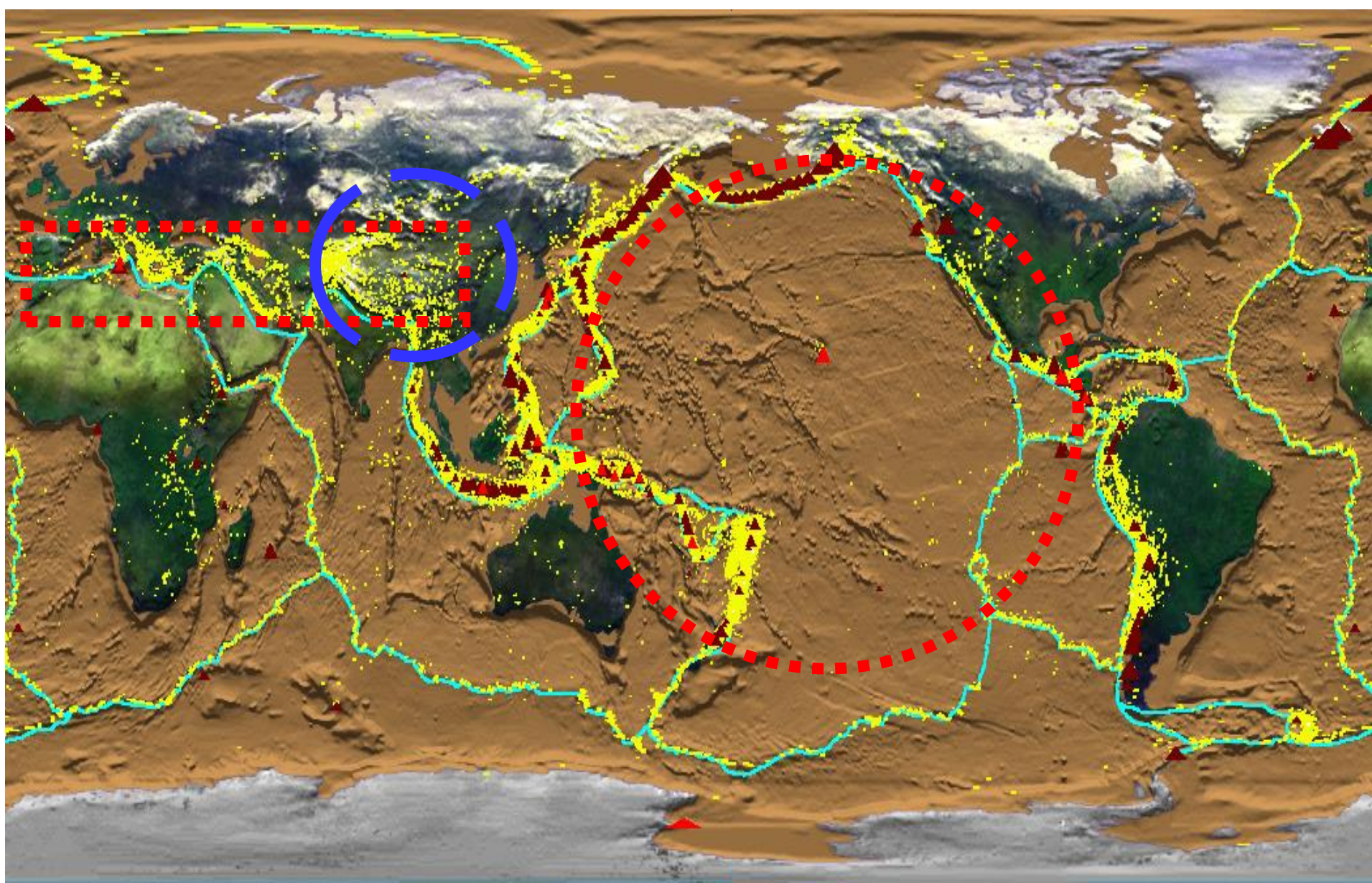


Professor, Head of Civil Engr. Department
Institute of Disaster Prevention of China

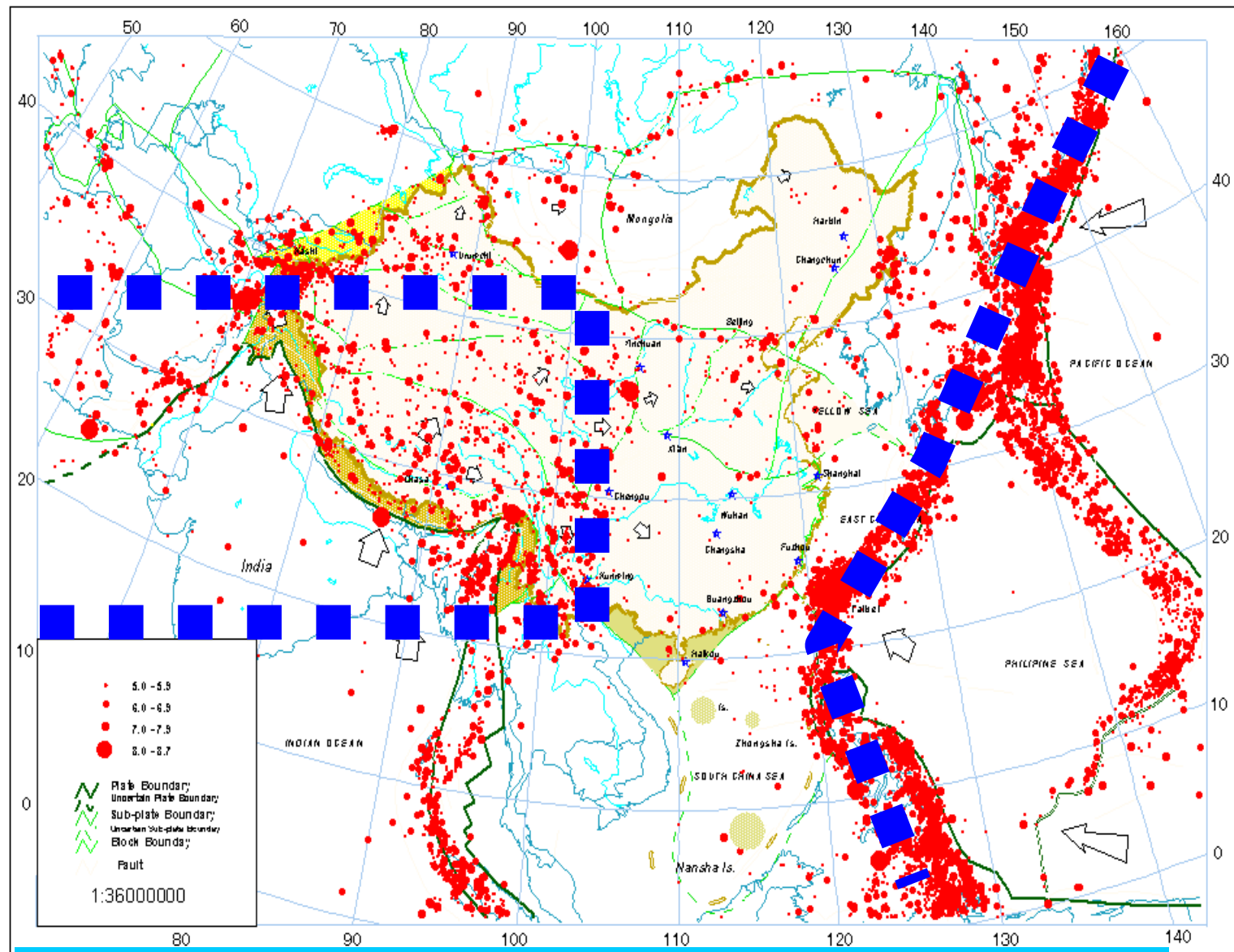
Contents

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

Glance of the disaster of Wenchuan earthquake



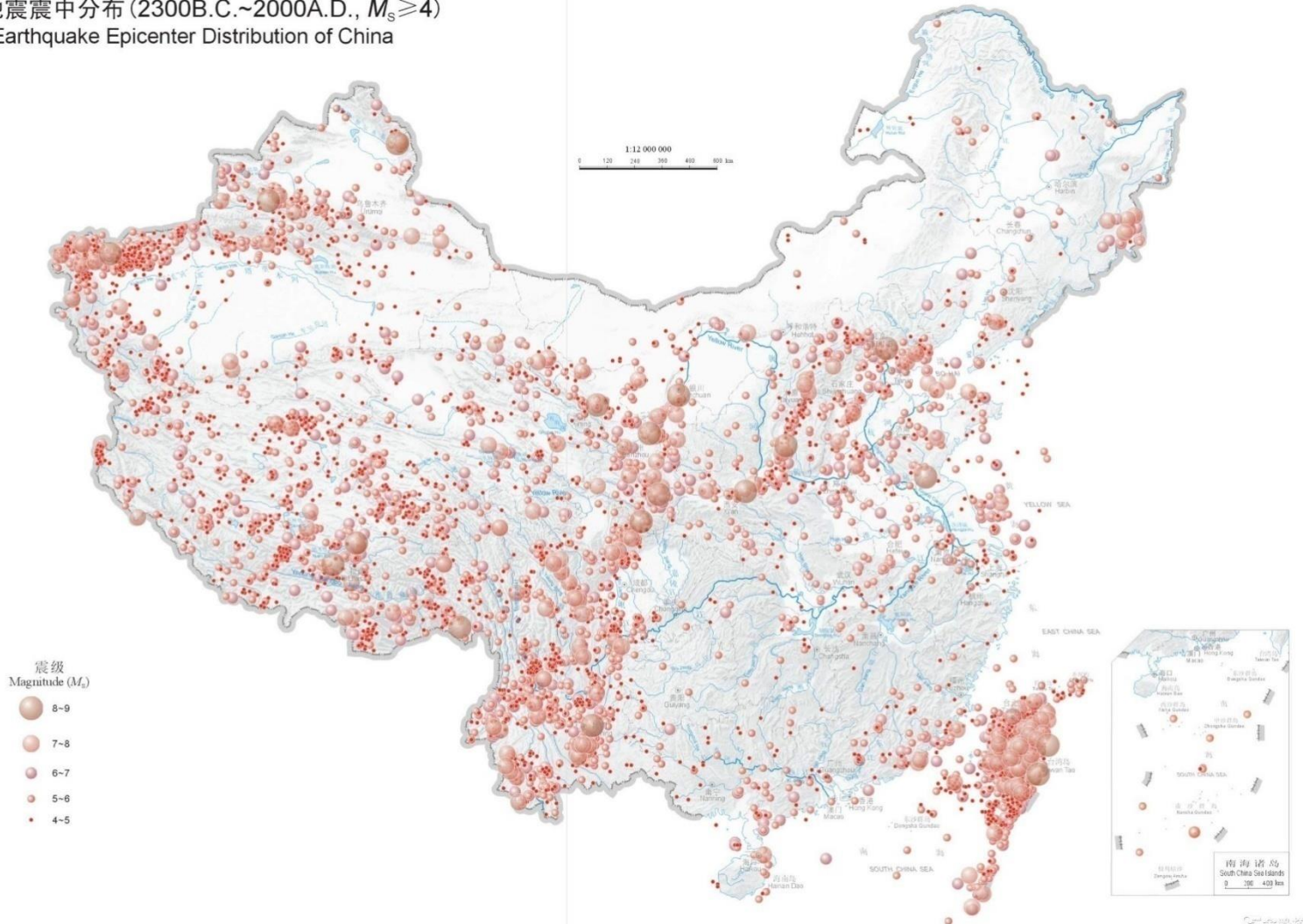
Two seismic belts in the world



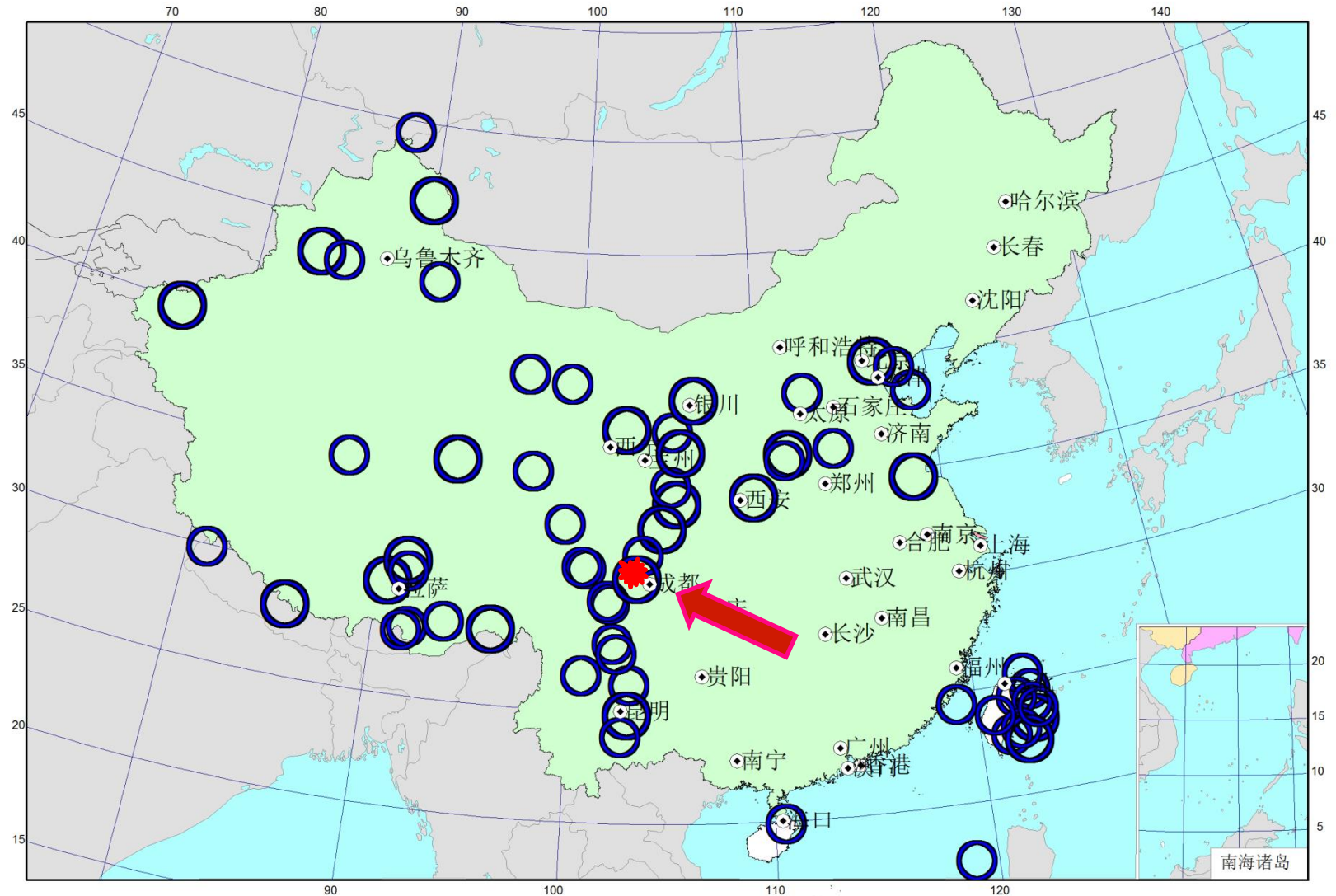
China suffers from both seismic belts

Distribution of historical earthquakes

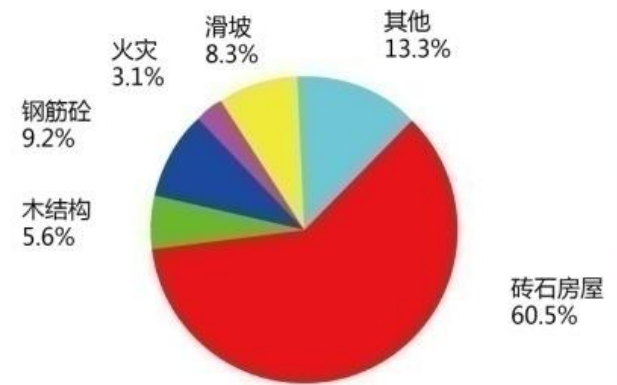
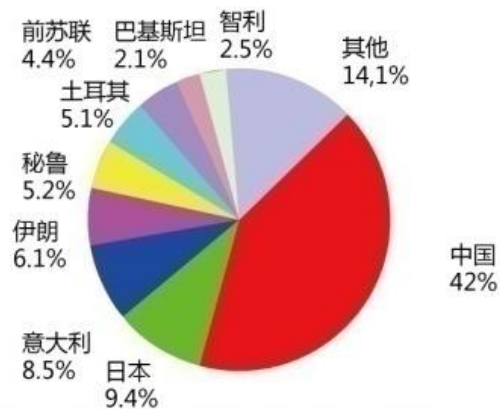
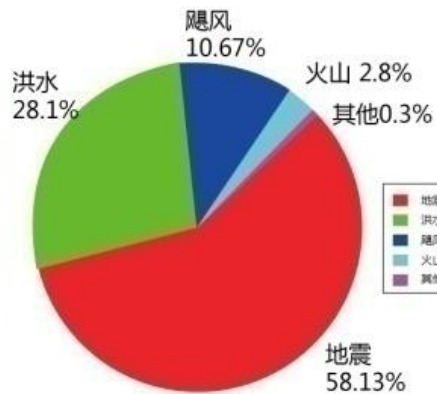
中国地震震中分布 (2300B.C.~2000A.D., $M_s \geq 4$)
Earthquake Epicenter Distribution of China



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

中国地震动峰值加速度区划图



Earthquake parameters

四川汶川县发生**7.8**级地震

5月12日

据国家地震台网重新核定



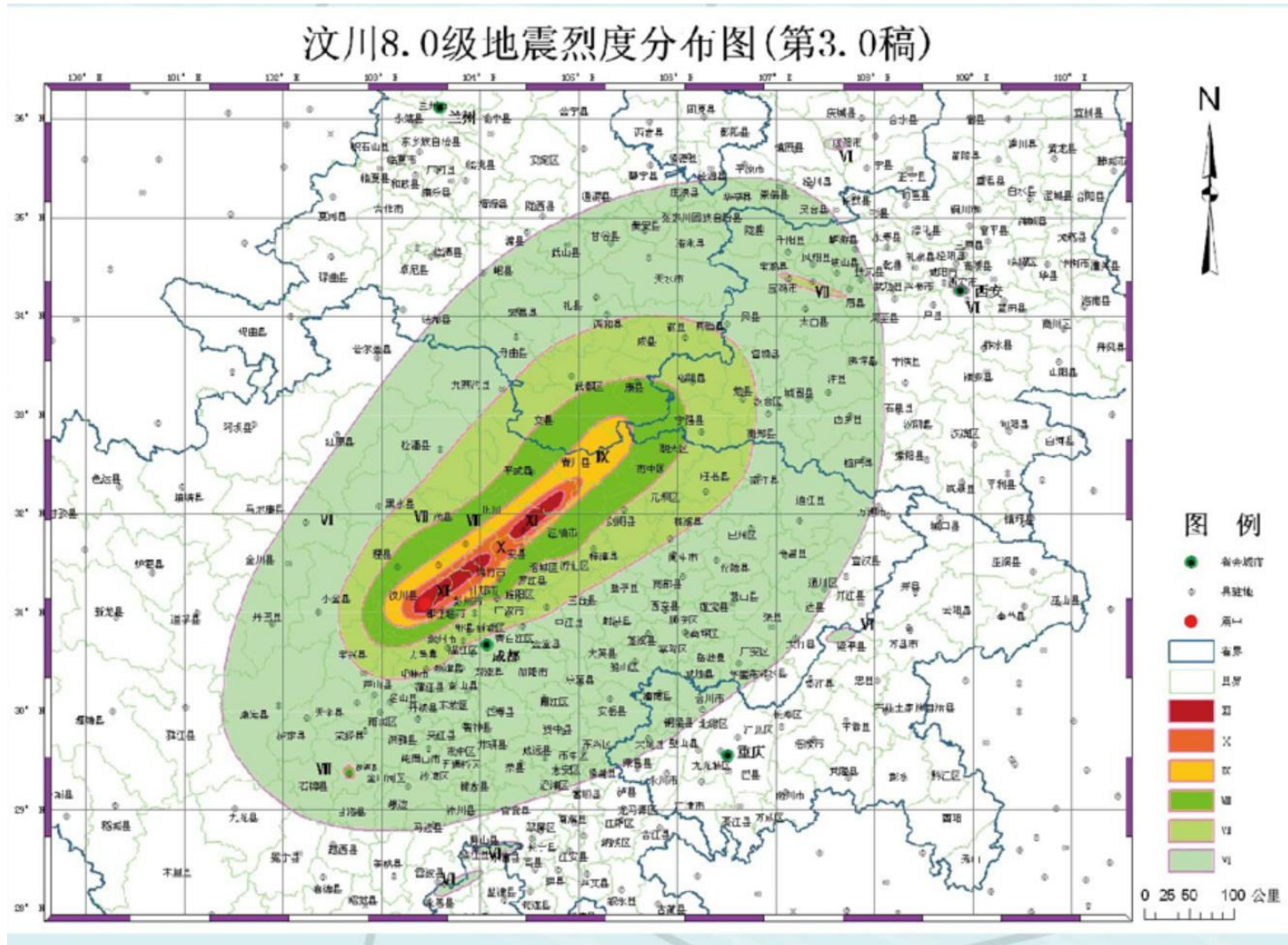
May 12, 2:28pm

M8.0

N 031.00

E 103.40

Intensity map of Wenchuan EQ



Total loss



Casualties: 87,000

Properties: \$110 Billion

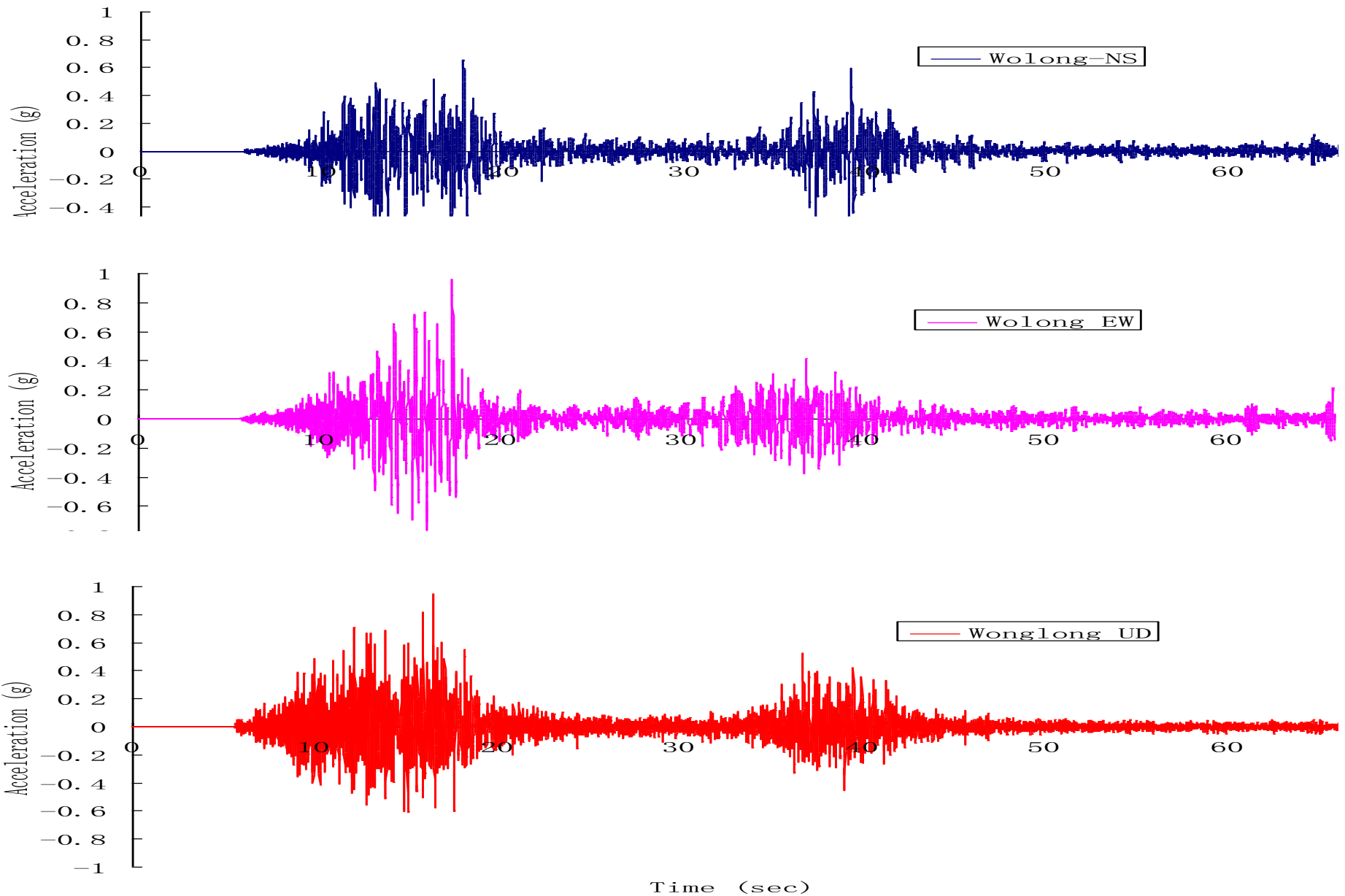
About 80% of the buildings
collapsed around epicenter

PGA is estimated as 1.5g



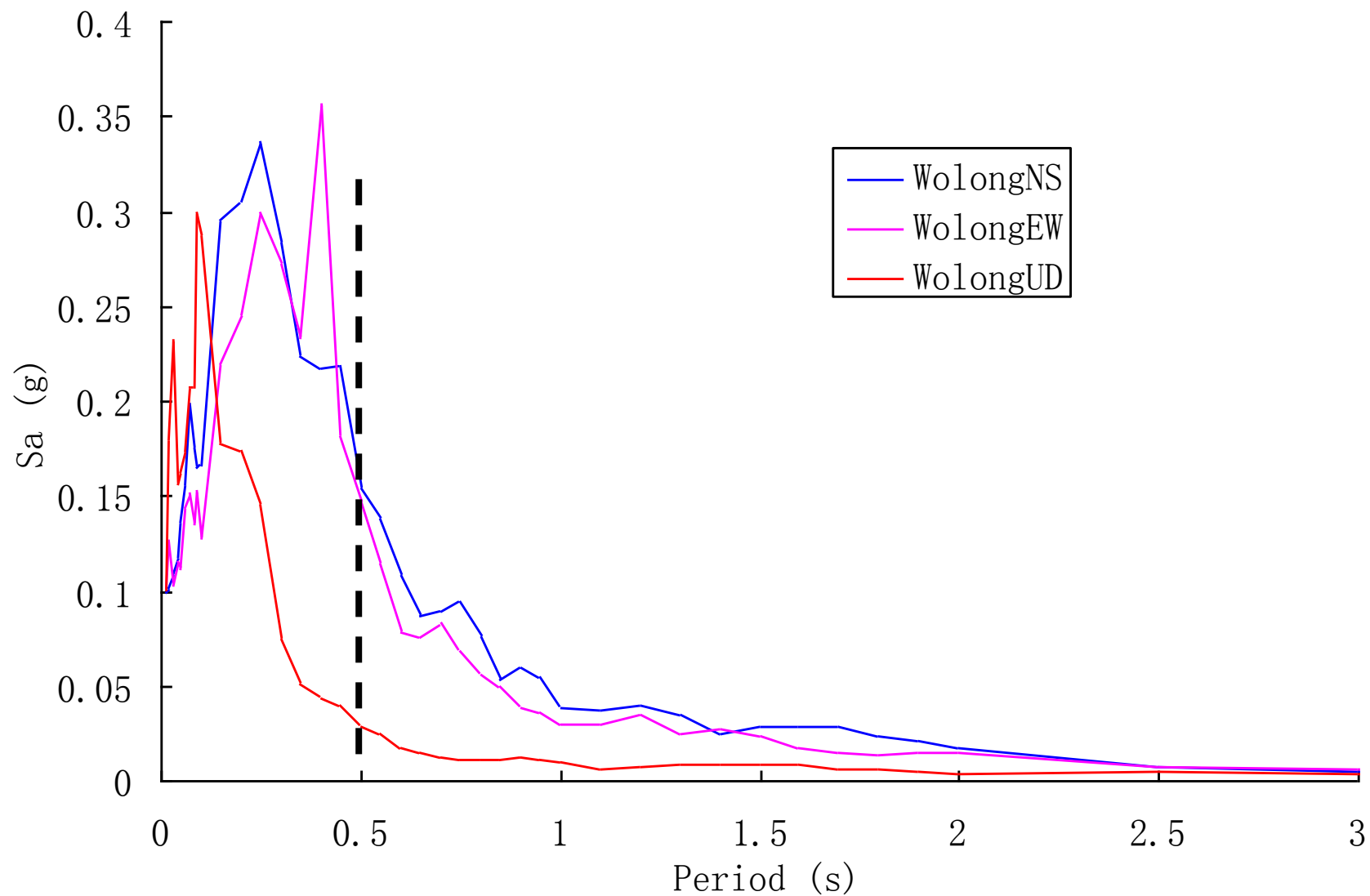
PGA is estimated as 1.5g





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



四川北川中學生李陽為压在废墟下的同學廖波當線汲水



5月12日，四川汶川大轉移途中，老師和學生手拉著手，走在崎嶇陡峭的山路上。



5月13日，四川汶川縣映秀小學幸存的同學在震後被埋废墟下的同學。

PLA soldiers acted as a bridge





Search and rescue in
very heavy rain



The saved child saluted to soldiers

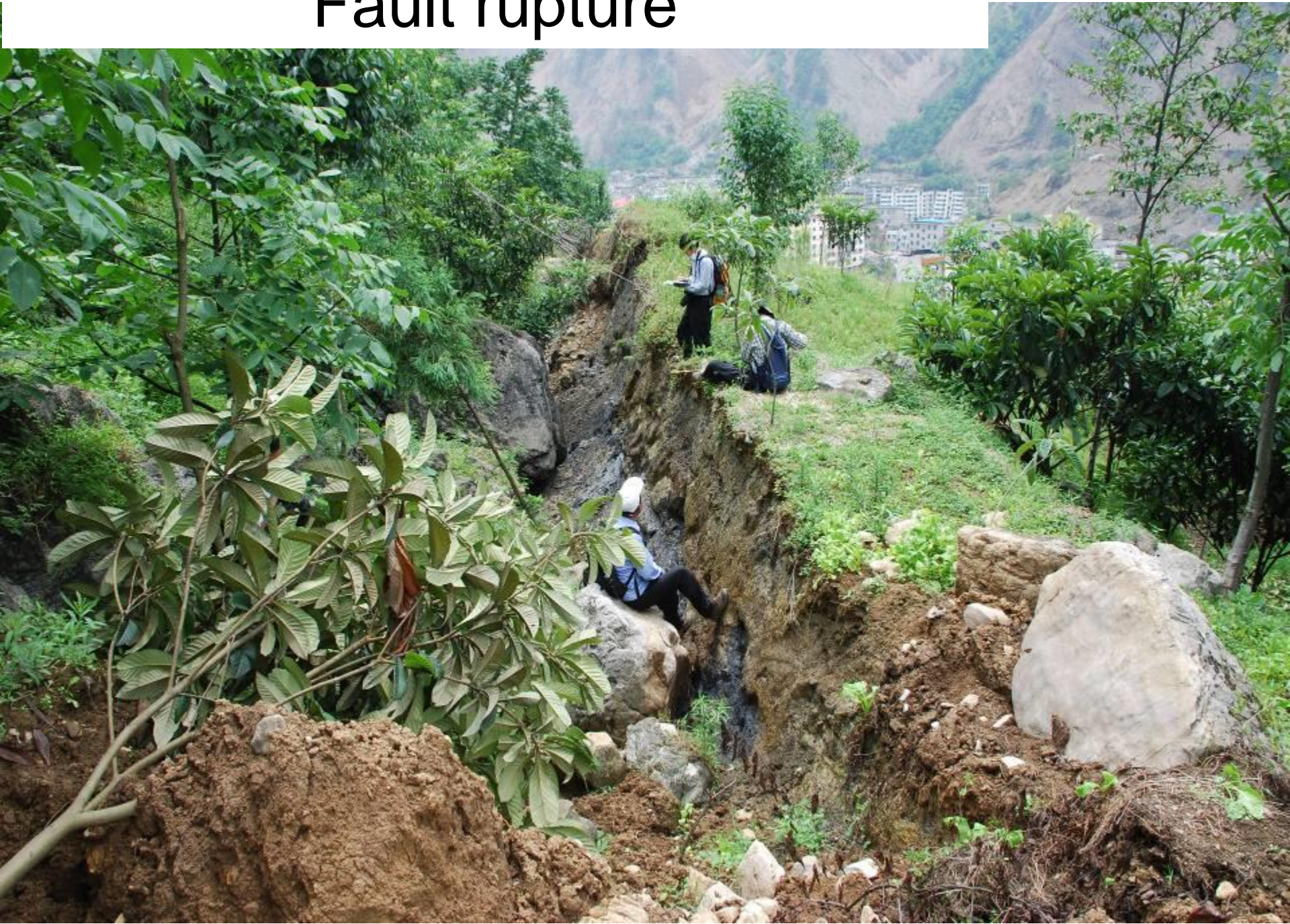
Land slide



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

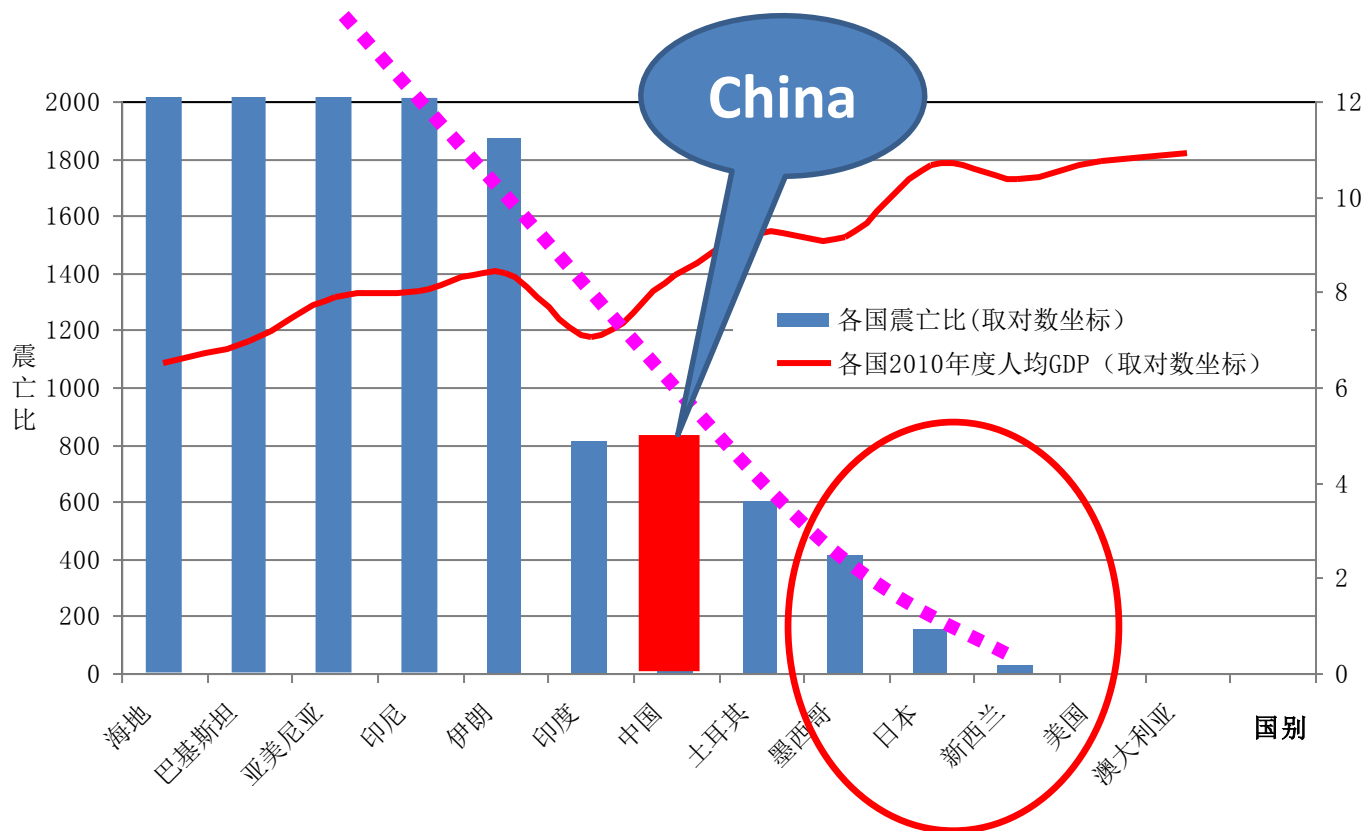


Damage of school building



Death toll ratio comparision

Ratio of death toll to magnitude



Technical support for reconstruction

Defects of structure in resisting earthquake

散
脆
偏
单

Lack of **Integrity**, loosening

Lack of **Ductility**, Brittle

Lack of **Balance**, Eccentric

Lack of **Redundancy**, Single

Performance of those lack of Integrity



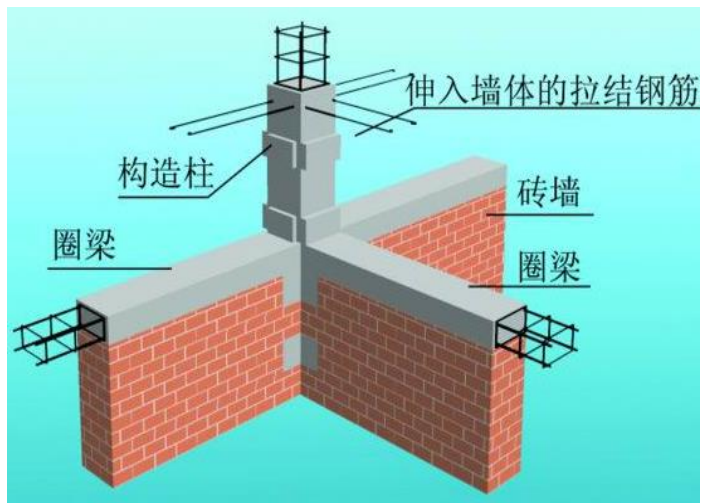
Integrity and Redundancy



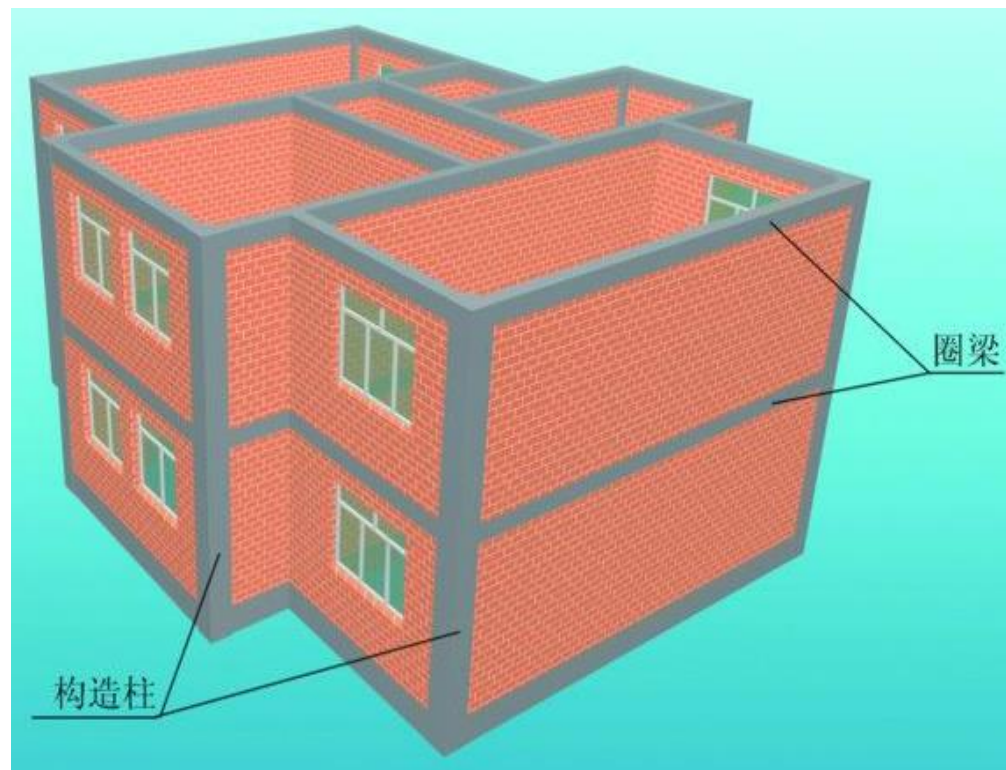
Integrity and Redundancy



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



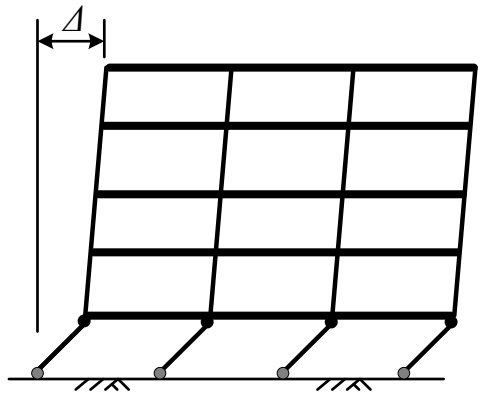
Most of the RC frame teaching building collapsed, Why?

问题引入：漩口中学教学楼倒塌而其他不倒，为什么？



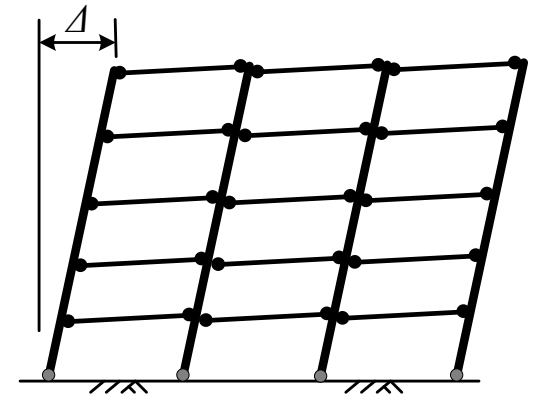
Gap between theory and practice

From weak column strong beam
to strong column weak beam



弱柱强梁

$$\rightarrow \sum M_c = \eta_c M_b \rightarrow$$



强柱弱梁



Weak columns
after earthquake



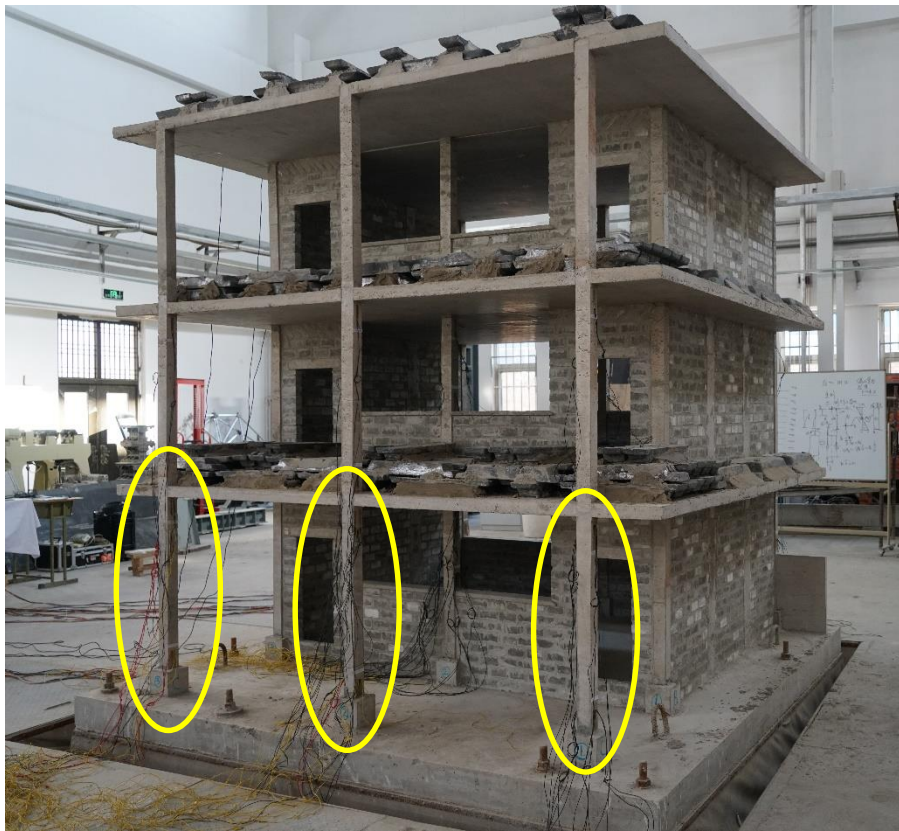
Unbalanced constrain in longitudinal



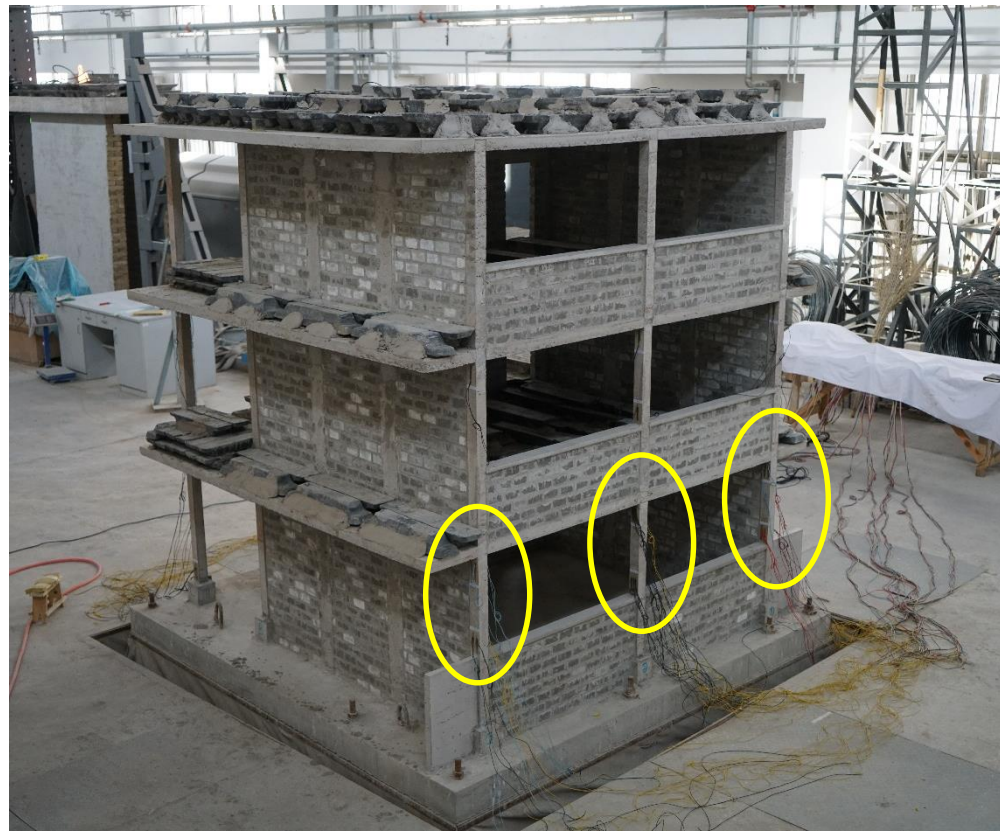
Unbalanced constrain in longitudinal



Columns: unbalanced constrain

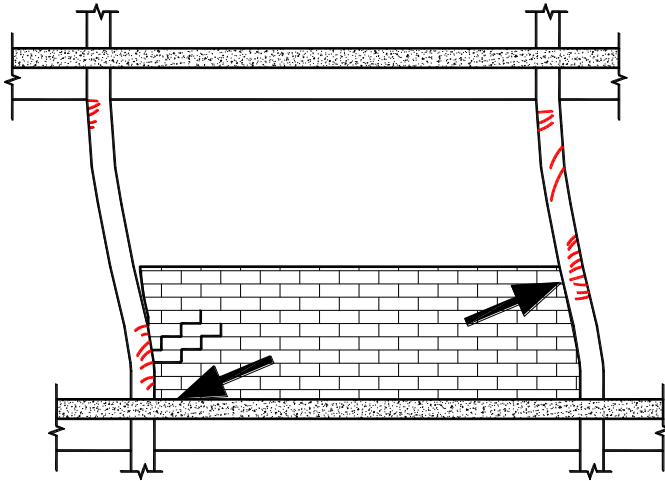
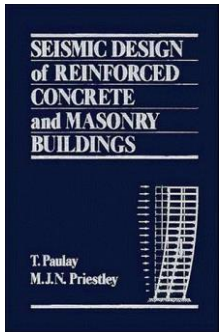


Corridor: without constrain,
lower stiffness, lower shear



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

One span vs multi span



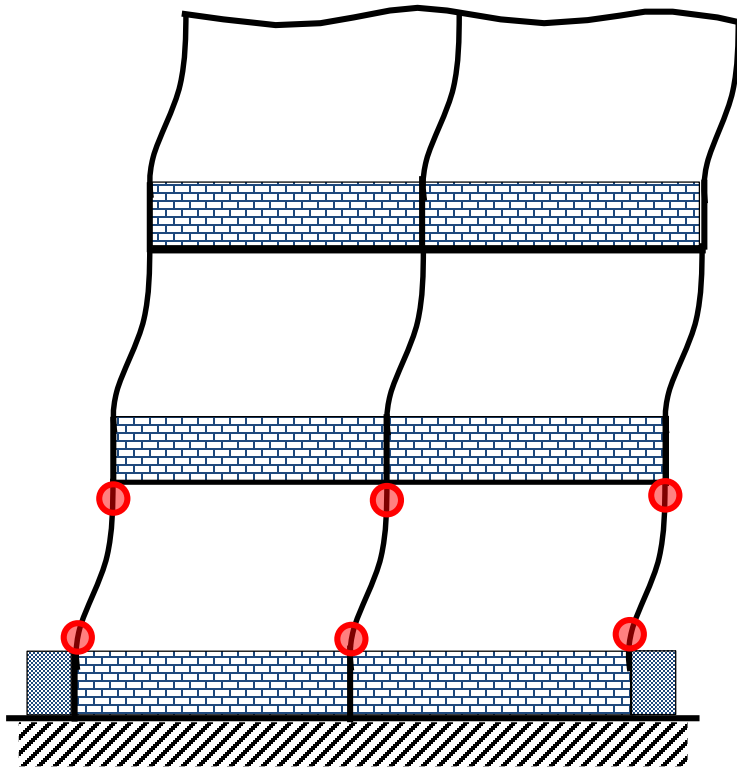
Paulay T, 1992.



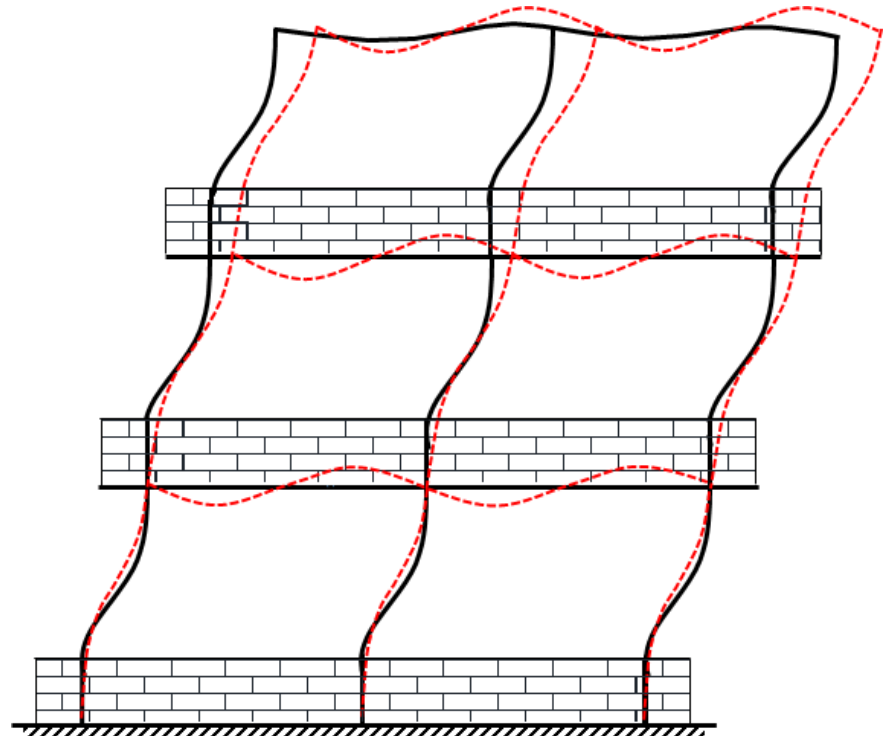
Dowel—very high stiffness

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

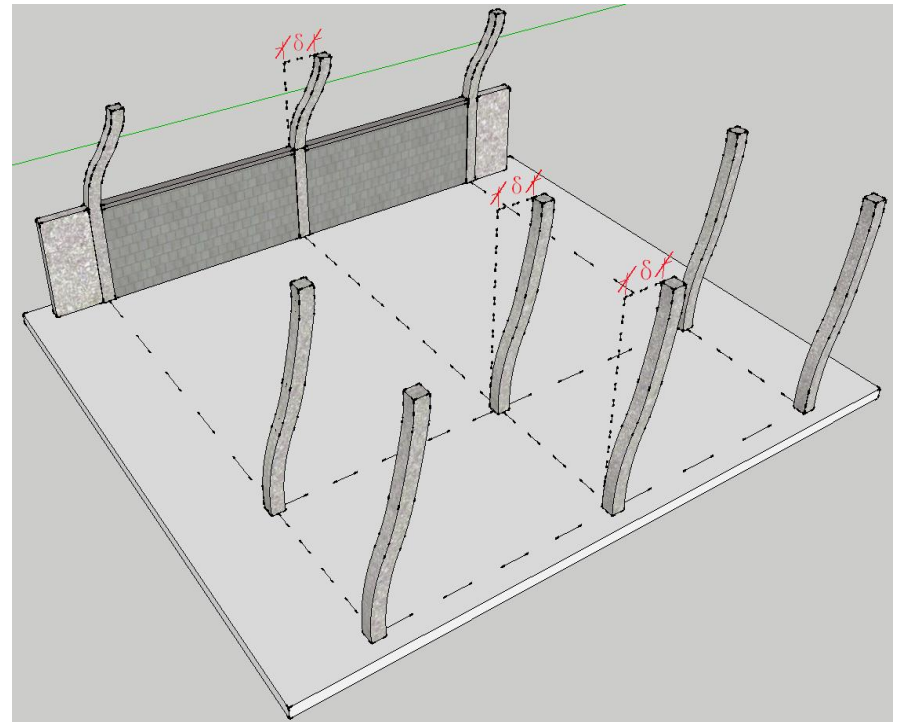
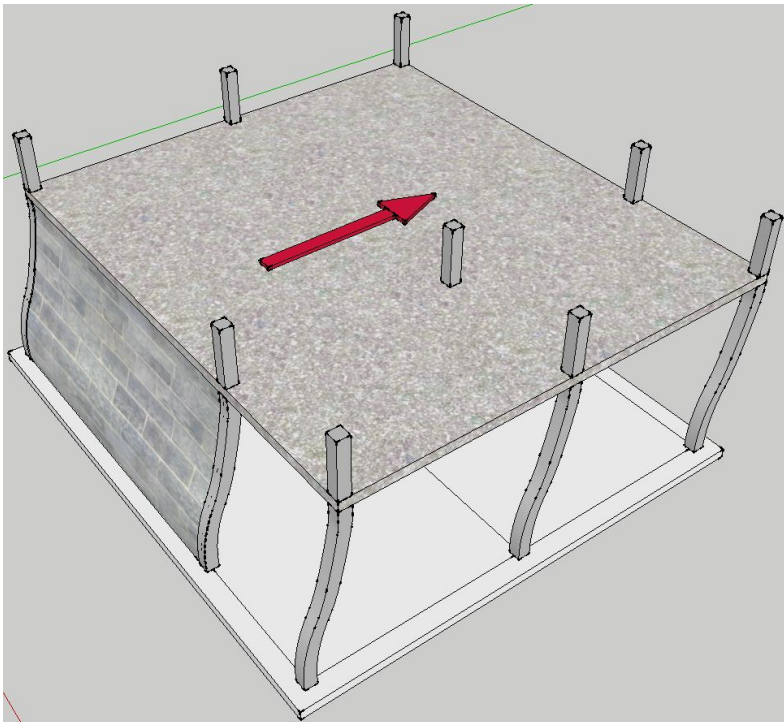


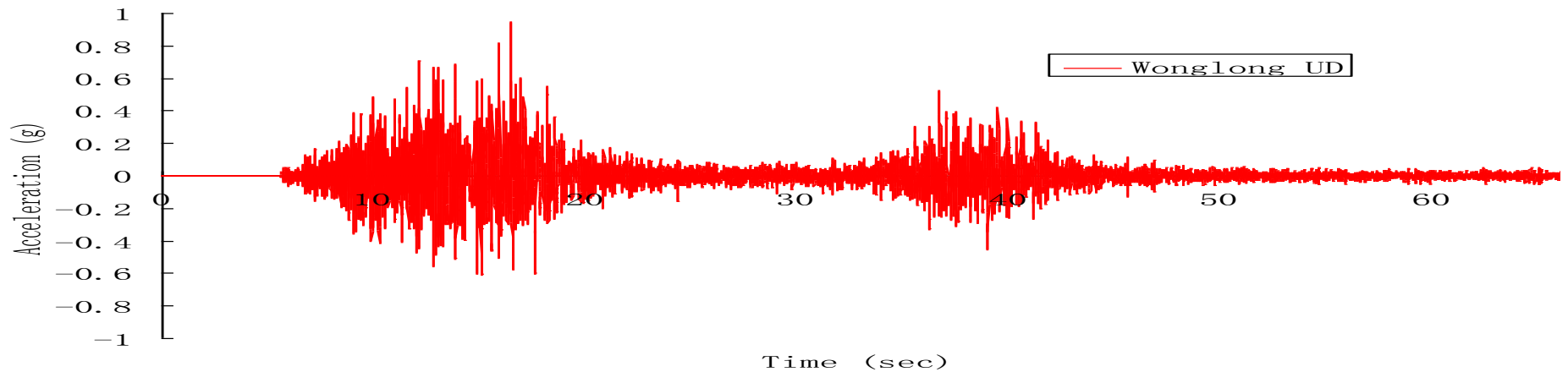
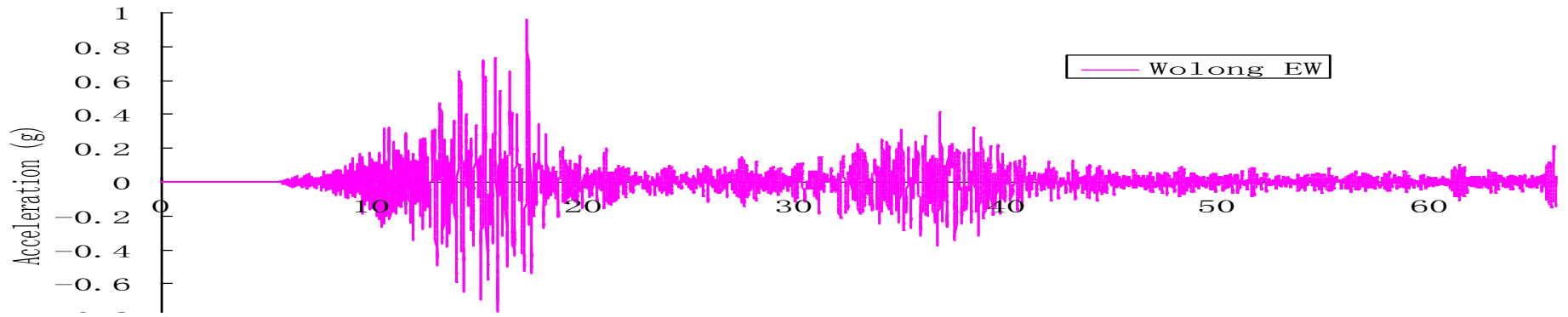
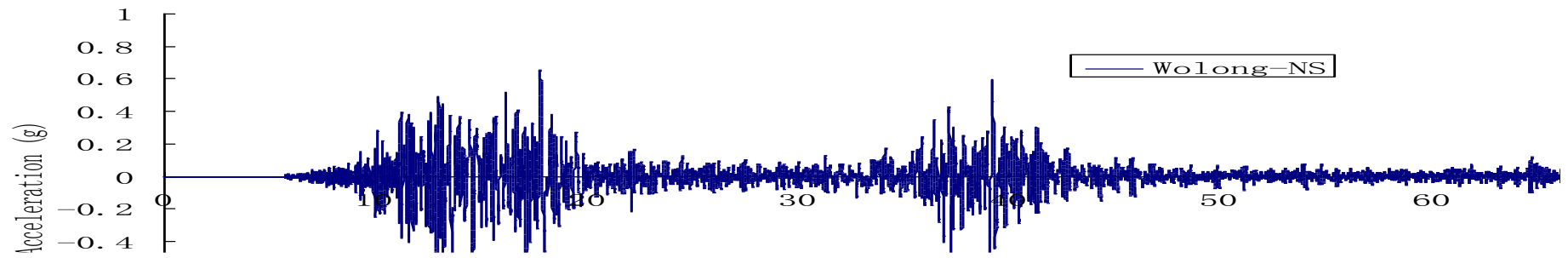
Actual



Expected

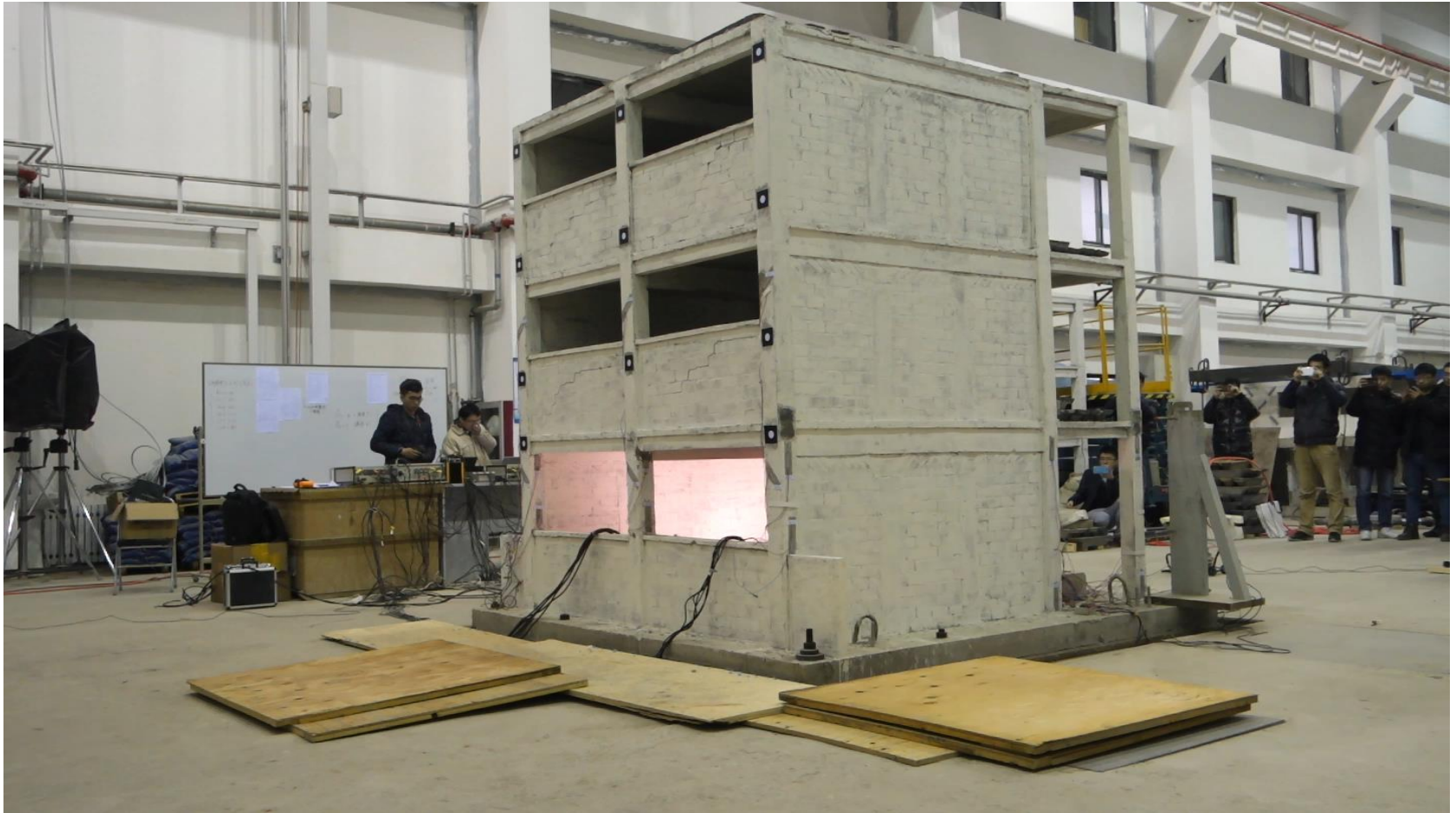
Comparison of deformation



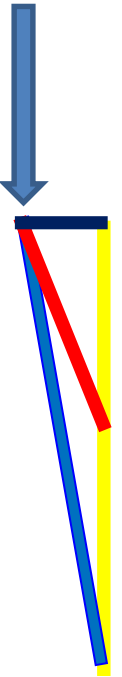
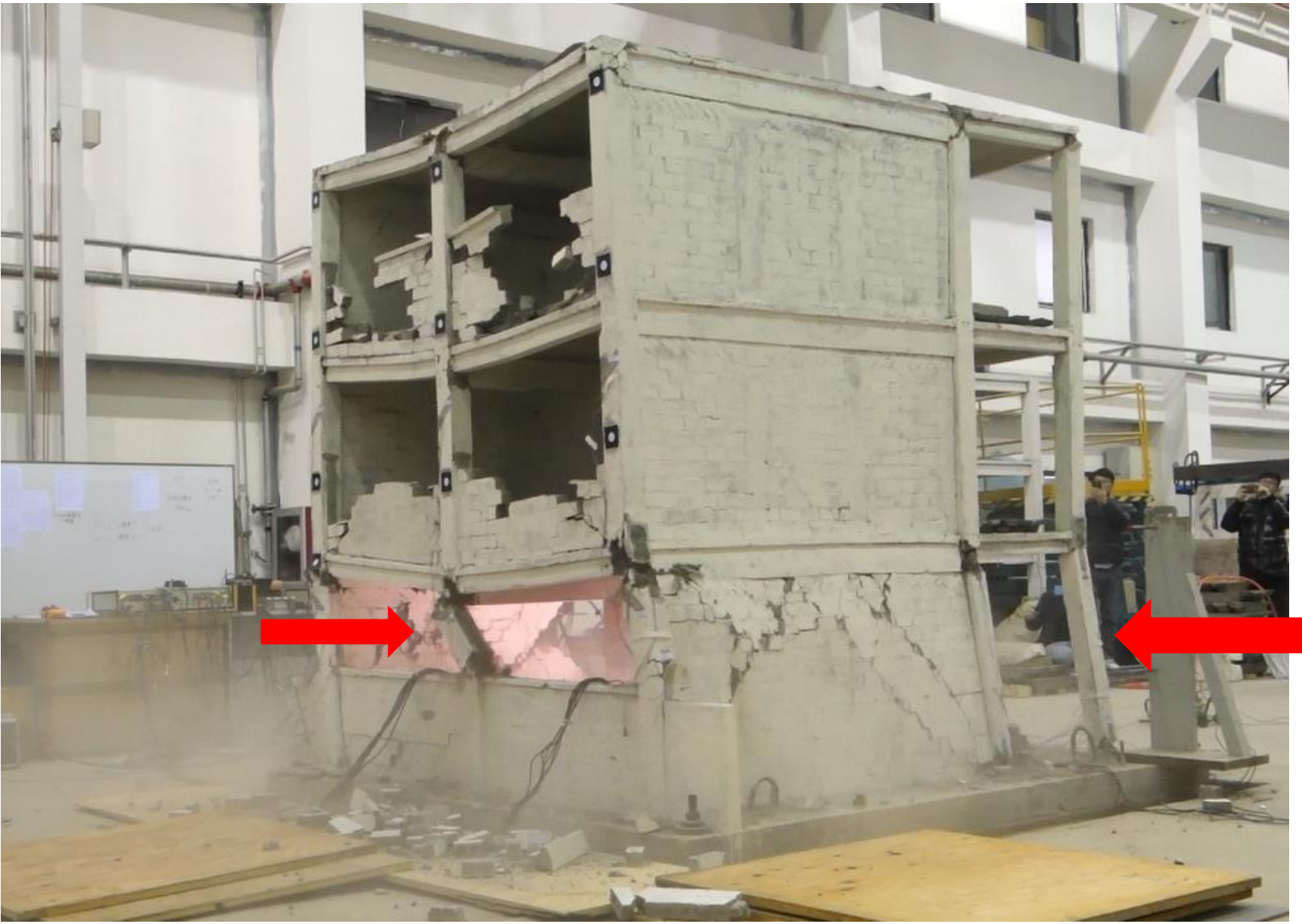


Shaking table test using input records with PGA=0.96g

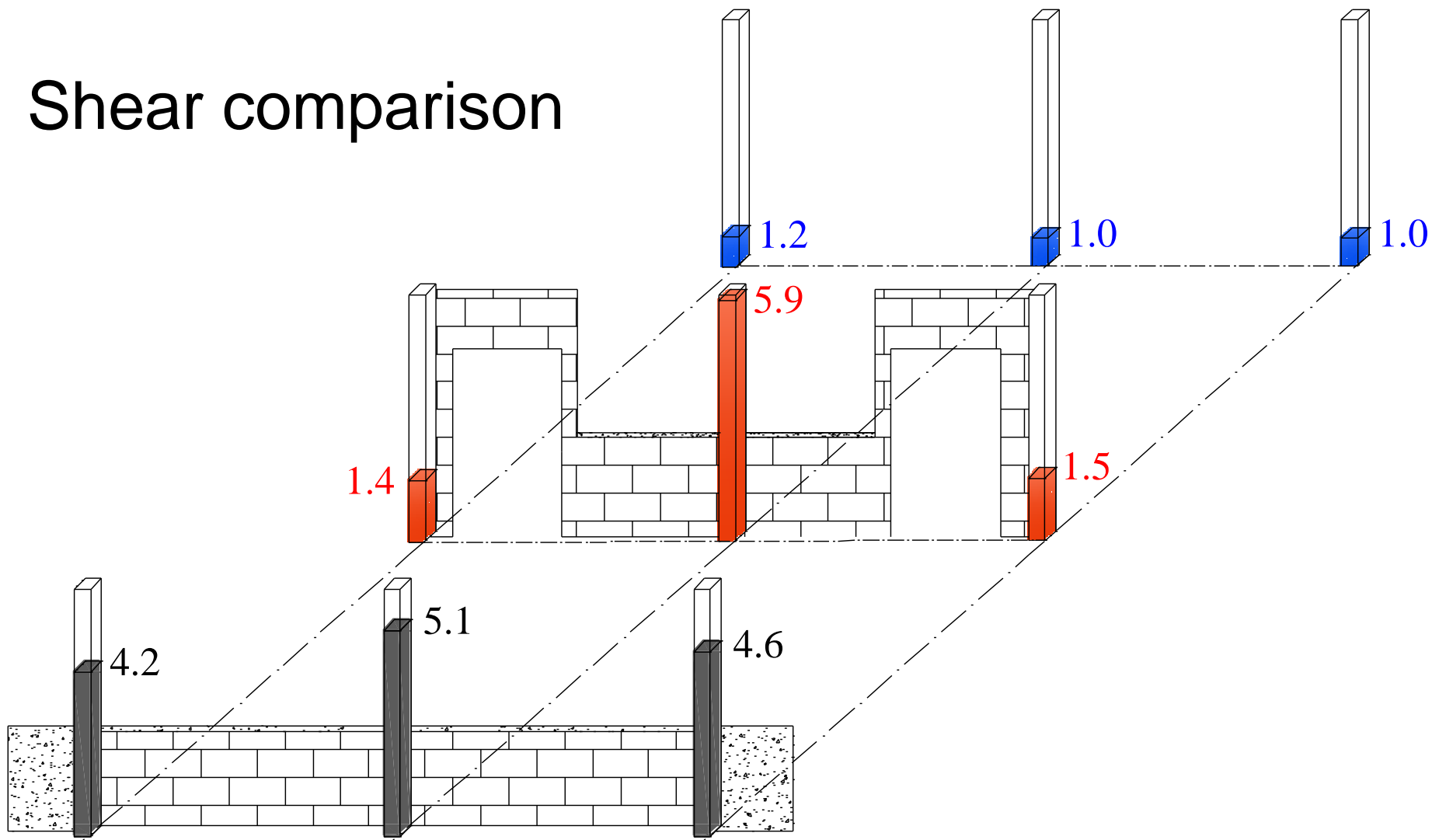
Collapse process of RC frame



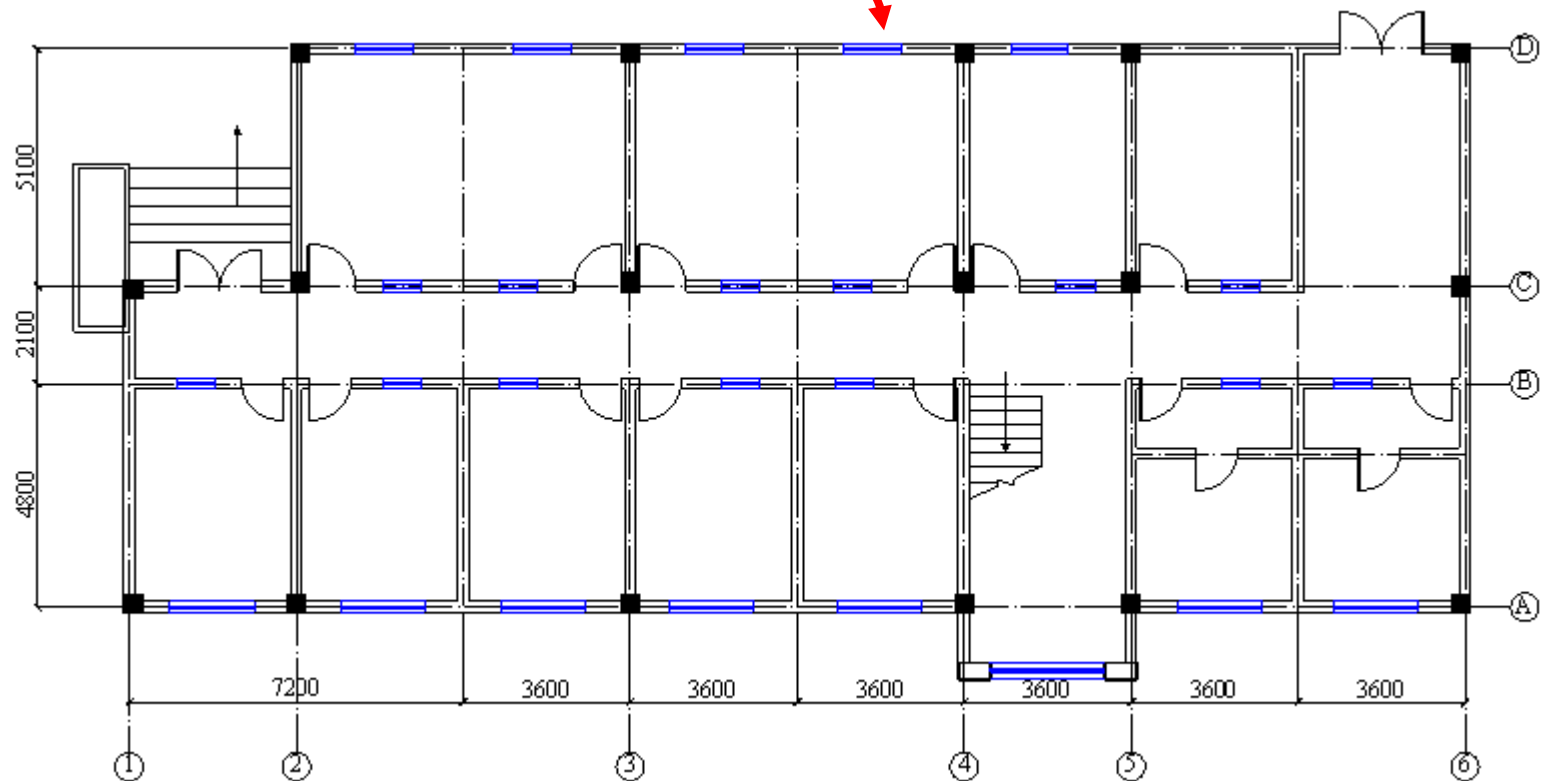
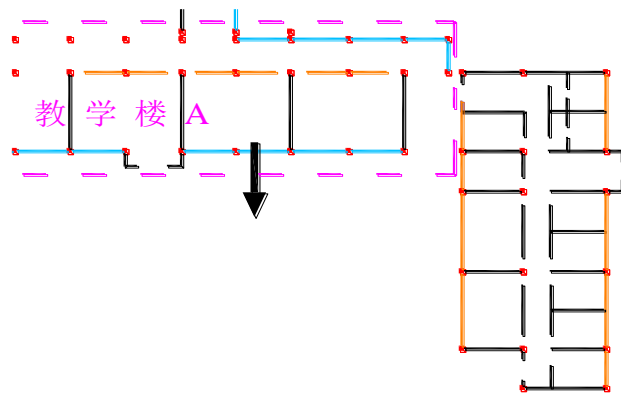
Just before collapsed



Shear comparison



No collapsed with balanced constraints





Front

Soft first story

Back



Collapsed structure with first soft story



Collapsed structure with first soft story



Collapsed structure with first soft story



The Strong Model Building-front





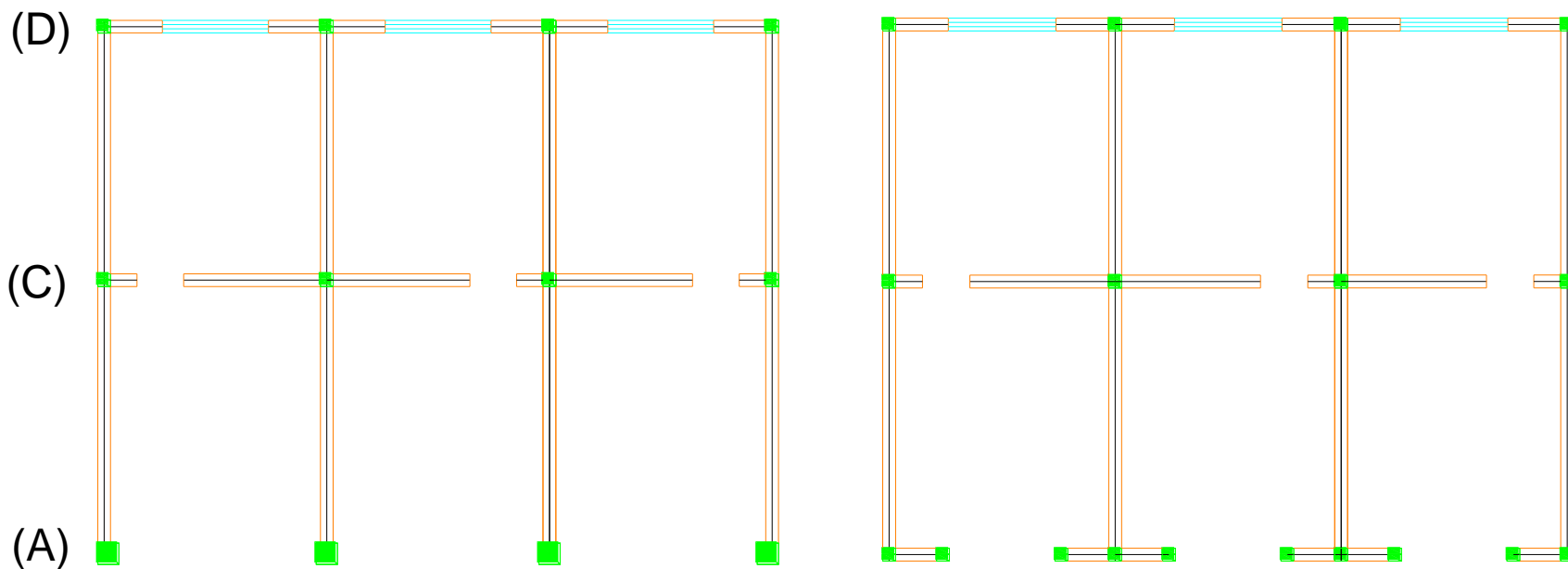
The Strong Model Building-front

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



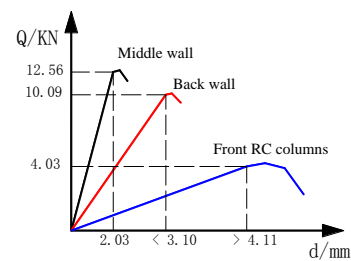
强震下底层沿纵向倒塌



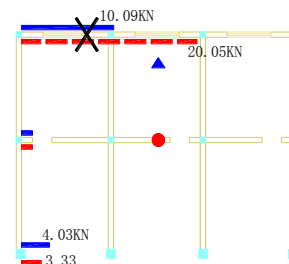
PGA0.8g输入后, 模型内伤严重, 成为“站立废墟”



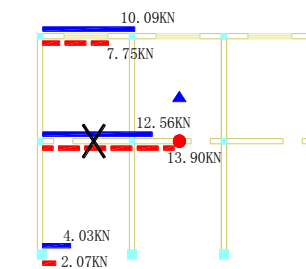
PGA1.0g输入后, 模型沿其纵向倒塌



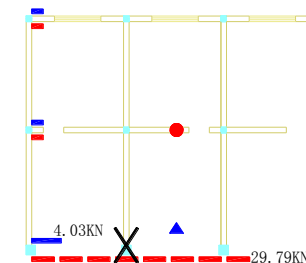
各纵墙地震剪力-位移曲线



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”。



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、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 (包括前墙和横墙) 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



Temporary houses



Disaster relief distribution



Rebuilding homes through Self-reliance

The regional CPC committees and the local governments in the quake-afflicted area put people's needs first and made scientific planning their top priority. They maintained the importance of exploration and innovation. People were encouraged to overcome obstacles, be self-reliant and be grateful. Sophisticated planning, quality construction work and superior management has contributed to the formulation of an excellent post-disaster reconstruction mechanism. The self-raising funds of more than 1.3 trillion RMB Yuan through multiple channels have assisted people's self-rescue efforts and reconstruction work; the diligence and intelligence of people have expedited the building of newer and better homes than the ones they had prior to the disaster.

One-to-one Assistance

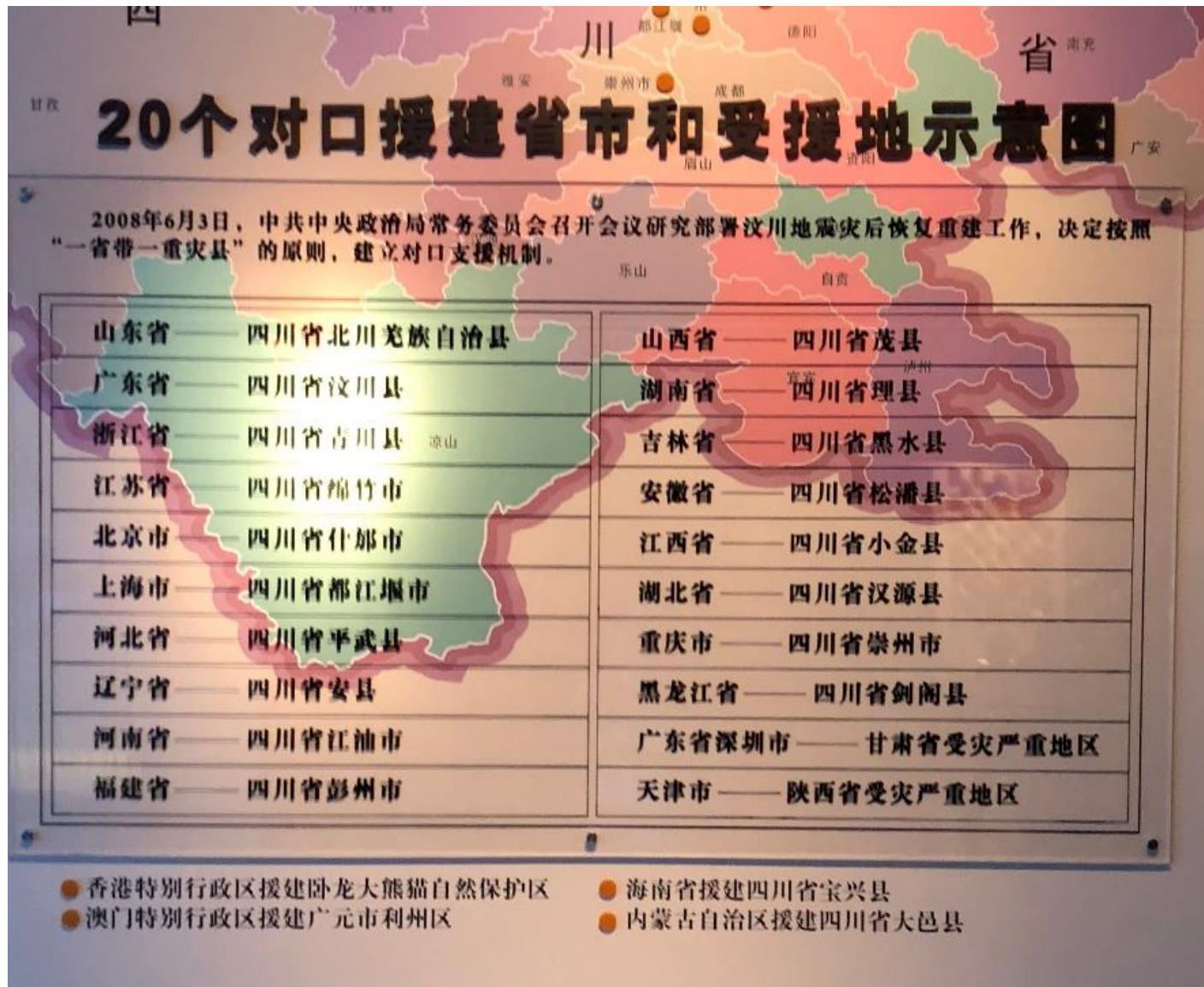
举国之力 对口援建

为加快灾区恢复重建，党中央统一部署，按照“一省帮一重灾县”的原则，创造性地建立对口支援机制。坚持把对口援建、多方参与作为重要力量，汇聚了推进灾后恢复重建的强大合力。对口援建省市顾全大局、勇挑重担，集中人力物力财力，为灾区恢复重建作出了巨大贡献。社会各界、港澳同胞和台湾同胞及海外华侨华人纷纷伸出援手，以实际行动支持灾区建设。

The State Support and “One-to-one Assistance”

The CPC Central Committee has launched a “one-to-one” assistance mechanism in which one province is to assist a quake-stricken county in order to speed up the progress of reconstruction. The one-to-one assistance together with multilateral support have been the driving force for the advance of post-disaster reconstruction. Those provinces that provided one-to-one assistance have made great contributions to the reconstruction work with their huge input of human, material and financial resources. What's more, people of all economic and social backgrounds, fellow citizens from Hong Kong, Macao and Taiwan and many overseas Chinese also reached out in support of the post-disaster reconstruction.

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



解放军援建的四川省八一康复中心



现代化的医疗



四川省都江堰市4对再生育双胞胎家庭欢乐在一起



据统计，四川共5425户，其中符合力和意愿的家庭41月底，已有3981名儿健康出生。图为2川县43岁的刘洪英羌族的首个试管婴儿



Reconstruction results



四川省绵阳市新北川中学建成后的第一次



四川省青川县木鱼中小学校



俯瞰都江堰市七一聚源中学，与之相邻的是八一聚源高级中学和都江堰市职业高中校园。



四川省都江堰市医疗中心



四川省绵竹市孝德镇

城乡新面貌查询

Reconstruction results



四川省绵阳市新北川中学建成后的第一次



四川省青川县木鱼中小学校



俯瞰都江堰市七一聚源中学，与之相邻的是八一聚源高级中学和都江堰市职业高中校园。



四川省都江堰市医疗中心



四川省绵竹市孝德镇

城乡新面貌查询

A big step forward after the disaster

A Big Step 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-afflicted 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

在灾后重建中，四川省注重大力发展电子信息、装备制造、能源电力、油气化工、钒钛钢铁、饮料食品、现代中药等优势产业，航空航天、汽车制造、生物工程以及新材料等潜力产业迅速崛起。随着一大批重点园区、重点产业和产业集群快速发展，2011年四川工业规模已上升到全国第八位。



Mechanical industry



High tech



四川省成都市天府软件园



Great progress than before EQ



成都正在加快成为西部物流、商贸、金融中心

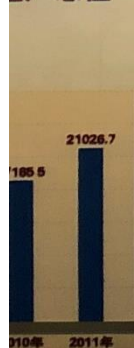


绵阳九洲科技工业园区

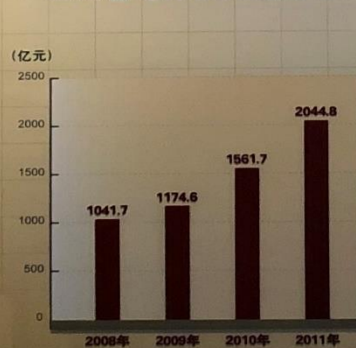


四川省广元市川南产业园

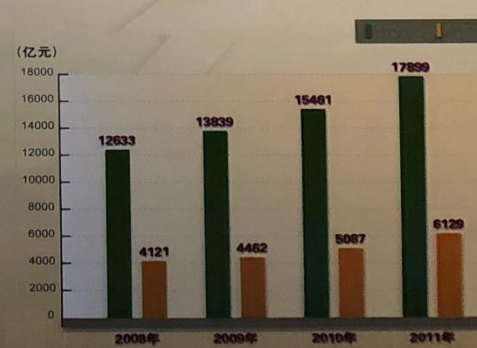
生产总值



四川省地方公共财政收入



四川省城乡居民收入



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

灾难催生使命，责任铸就忠诚。在规模浩大的救灾和重建征程中，保证资金使用安全、项目建设规范、干部风清气正事关重大、备受关注。各级党委政府、各级纪检监察机关坚持把“廉洁救灾、阳光重建”贯穿始终，切实强化监督检查，创新举措，构建机制，落实责任。既严明纪律，确保党员干部以优良作风投入救灾和重建；又严格监督，确保救灾和重建资金项目管理使用廉洁高效，以监督检查的实际成效向党和人民交上了一份合格答卷。

Give the people a qualified answer

Disaster makes mission, responsibility casts loyalty. In huge disaster relief and reconstruction campaign, Chinese governments ensuring the safety of fund use, project specification, and positive political environment has attracted much attention. Party committee governments and discipline inspection and supervision departments at all levels, adhere to the "relief with clean, reconstruction under the sun", to strengthen the supervision and inspection, innovation, constructing mechanism and to carry out the responsibility. Thus, it not only makes strict discipline and ensures that party members and cadres are in fine style of work in disaster relief and reconstruction; but also makes strict supervision and ensures that the use of relief

Two year later



Two years later



Thank you for your attention

Xun GUO