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Geohazard Prevention After Wenchuan Earthquake in China

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Geohazard Prevention after Wenchuan Earthquake in China

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- What we have done before Wenchuan earthquake
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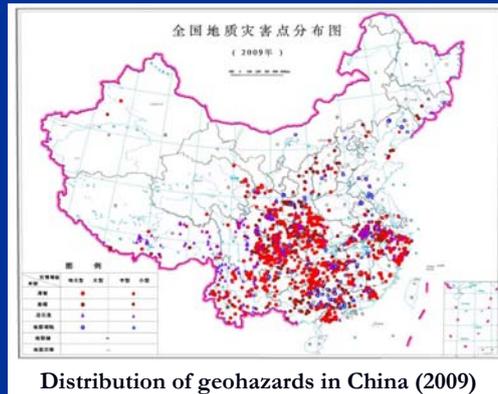




1 Introduction

♣ China is a economy has been suffering frequent geohazards and consequent severe damages. **WHY?** There are $\frac{3}{4}$ mountainous areas in total land scope.

♣ There are more than 1 million geohazards in China, most of which occurred in the south-southwest of China.



♣ China government has done best to geo-hazard prevention and control. A geo-hazard prevention system has been created, mainly including three types:

- (1) **Monitoring and early warning** (public inspection & prevention 群测群防, professional monitoring 专业监测);
- (2) **Evacuation plans** 避让搬迁;
- (3) **Mitigation measures** 工程治理.

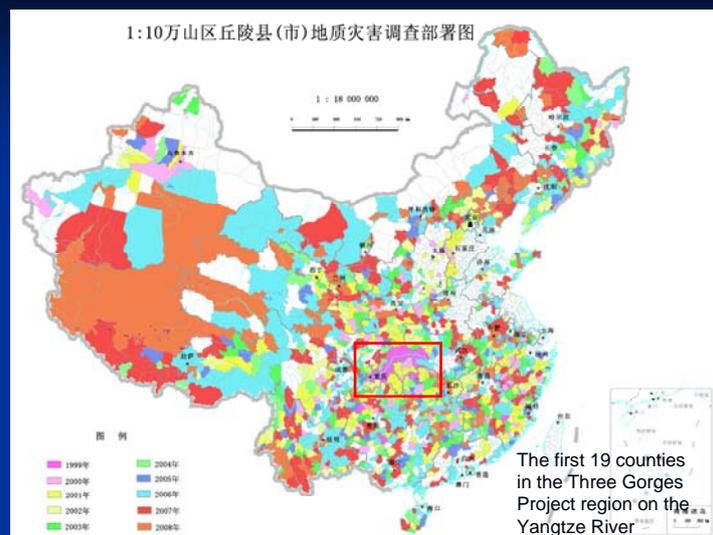
The above system plays an important role after Wenchuan earthquake.



2. What we have done before Wenchuan earthquake

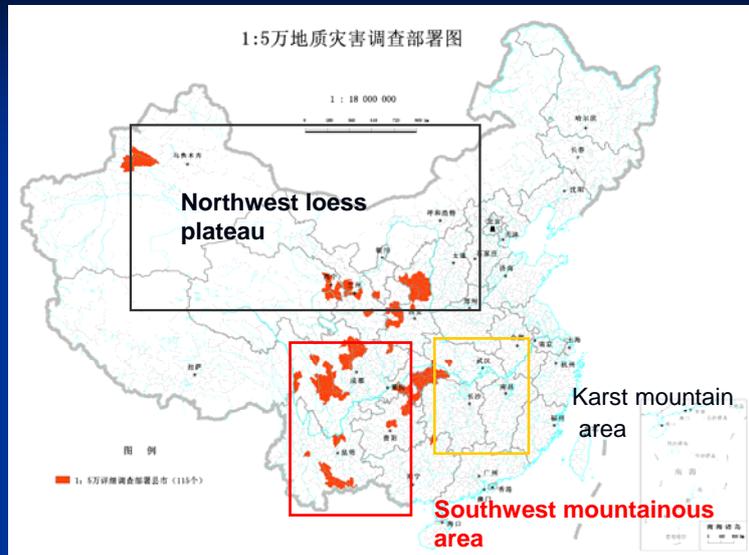
- 1640 counties geohazards investigation (1:100,000)
- 115 counties geohazards survey and mapping (1:50,000)
- Geohazard investigation in the National Important Project region (e.g. the three gorges)
- Geohazards assessment for new planning construction (Dam, road, railway, buildings, etc.)

(1) Mountainous county geohazards investigation (1:100,000)



Map showing the yearly investigation from 1999 to 2008
1640 counties, 200 organizations involved, Total invest: 370 M Yuan
Coverage: 6.5M km², Geohazards:176 T, Population:790 M

(2) Geohazards survey and mapping (1:50,000)



115 counties geohazards survey carried out by 2010

中国地质调查局地质调查技术标准

DD xxxx—xxxx

滑坡崩塌泥石流灾害详细调查规范

(1:50000)

(审定稿)

**Regulation for geohazard survey
(1:50000)**

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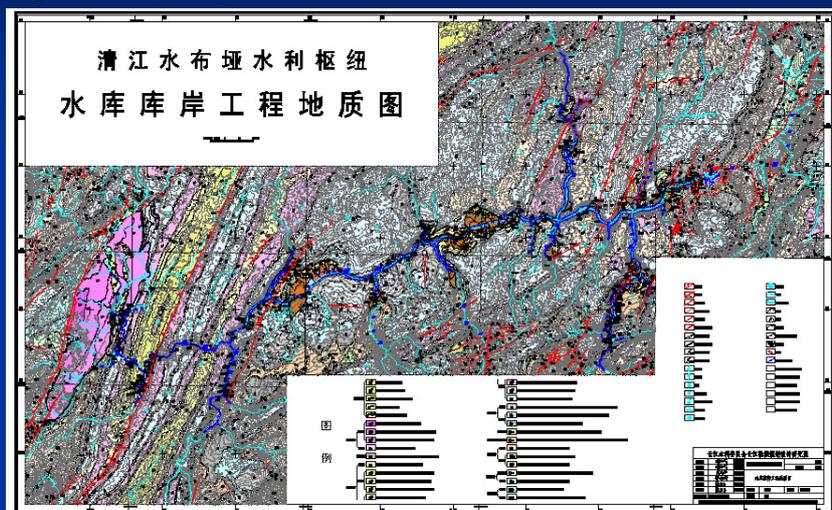
During the process, Technical guidelines or regulations were created, including landslide inventory sheet, framework, quality control and inspection measures and etc.

(3) Geohazard investigation in the National important Project regions



Large scale landslide survey and monitoring in TGP area (Aerial photos)
40000 km² Aerial photos and 3D virtual environment of the TGP area.

(4) Geohazards assessment is demanded for new planning construction site (Engineering geological mapping, landslide exploration, etc.)



Engineering geological map for Shuibuya Reservoir region on Qingjiang River

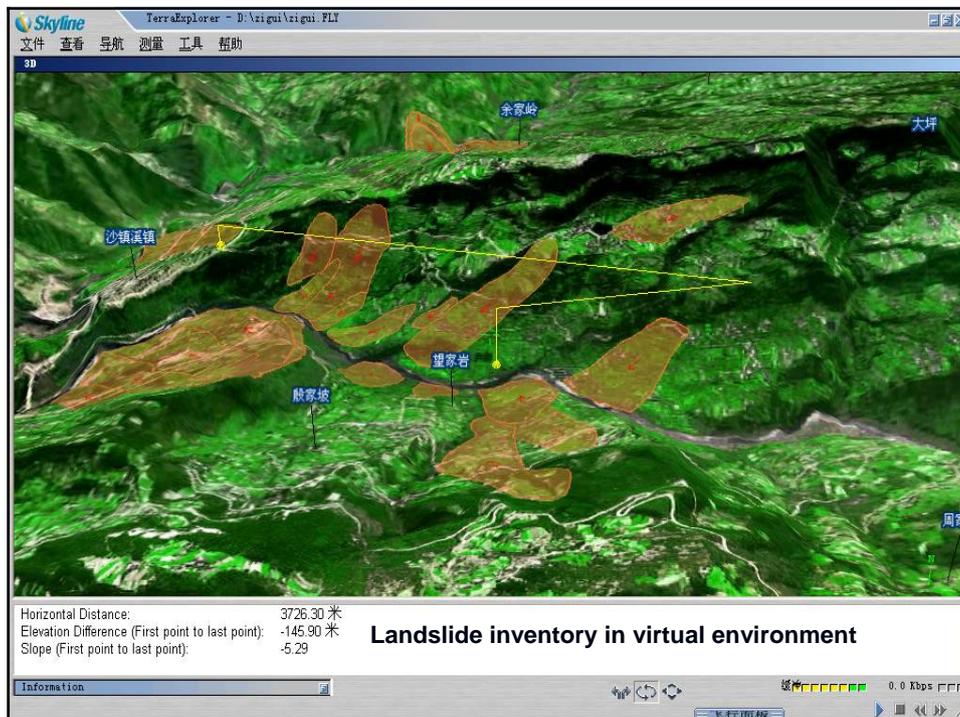
(5) County GH inventory and information system

- 1640 counties
- Number of geological hazards Recorded: 176,452
- The first National wide Geohazards Inventory Database

县市地质灾害调查总灾害点数

灾害类型	总灾点数	滑坡	崩塌	泥石流	地面塌陷	地裂缝	斜坡	地面沉降
个数	176452	75821	31384	20305	9269	2542	37104	27

Slide Fall Debris flow Collapse Ground fissure **Unstable slope** Subsidence

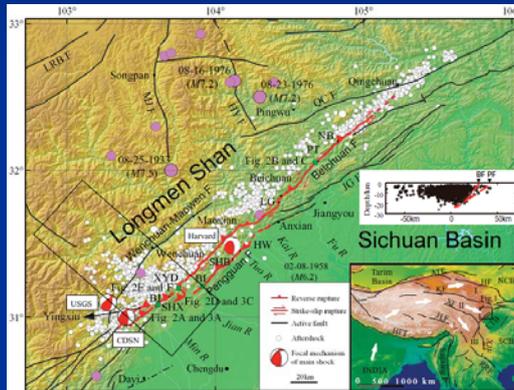


Landslide inventory form (Slide) in English

Field Slide Survey Sheet									
Project name		Map name			Map No.				
Name	Province	County (City)	Town	Village	Team				
Field No.	Latitude	Longitude	Elevation (m)	Dip					
Grid No.	City No.								
Type	Structure	Material	Block	Flow block					
Geological features	Structural lithology character		Geologic structure		Mineralogy		Groundwater type		
	Lithology	Era	Dip/Angle	Position	Failure mode	Impregnation	Flow water	Underwater	
Topographic features	Progression (m)		Hydrographic		Location relative to river				
	Annual	Monthly	Maximum	Flow bed level	Left bank	Right bank	Cracks	Beak	Curve
Original slope	Slope degree		Slope structural type		Control structural plane				
	Bed plane	Stratigraphic	Structural	Other					
Geometry features	Length (m)		Width (m)		Area (m ²)		Slope		
	Length	Width	Area	Volume	Slope	Angle	Altitude		
Structure features	Structure		Structure		Structure		Structure		
	Structure	Structure	Structure	Structure	Structure	Structure	Structure	Structure	Structure
Ground condition	Ground		Ground		Ground		Ground		
	Ground	Ground	Ground	Ground	Ground	Ground	Ground	Ground	Ground

3 Earthquake rupture avoidance during site selection after Wenchuan earthquake

After Ms8.0 Wenchuan earthquake on May 12 2008, ruptures with lengths of 270m and 70m mainly occurred along the Central Fault and the Front Fault, respectively. Most of the ridges, water systems and buildings along the ruptures are destroyed.



Distribution map of Wenchuan earthquake surface rupture (after Xu, 2009)

How do we deal with the Earthquake rupture during reconstruction?



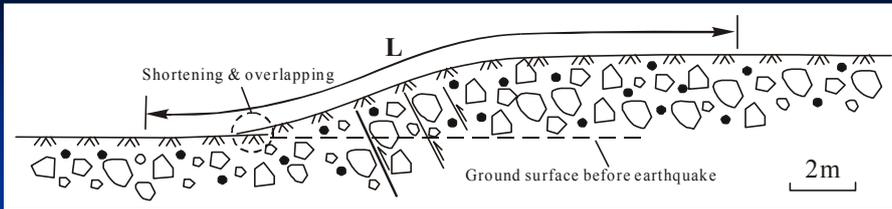
How do we deal with the Earthquake rupture during reconstruction?

China's Code for Seismic Design of Buildings (2008 revision) provides that, the minimum **safe distance** for Class C buildings (general industrial, civil) in the case of VIII earthquake intensity is **200m**; when the earthquake intensity reaches IX, the minimum distance is **300m**.

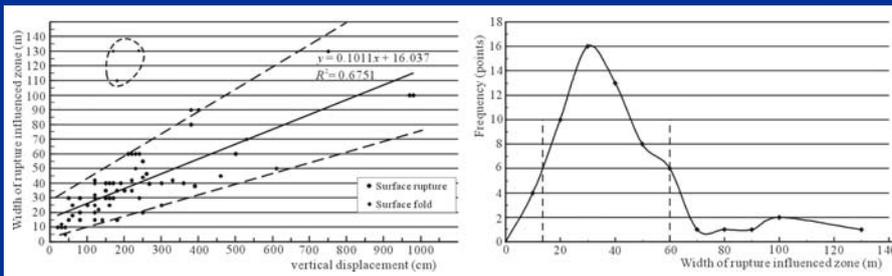
Obviously, the code is just suitable for plain areas with rich land resources. it is not suitable for mountainous areas (lack of plane land).

In our opinion, the width for active fault or rupture should be confirmed according to the rupture's feature.

Data from Wenchuan earthquake stroked area

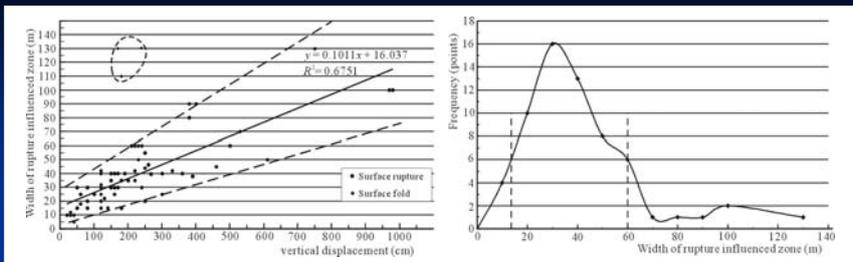


Sketch map of the rupture influenced zone



Relationship between influenced width and vertical displacement

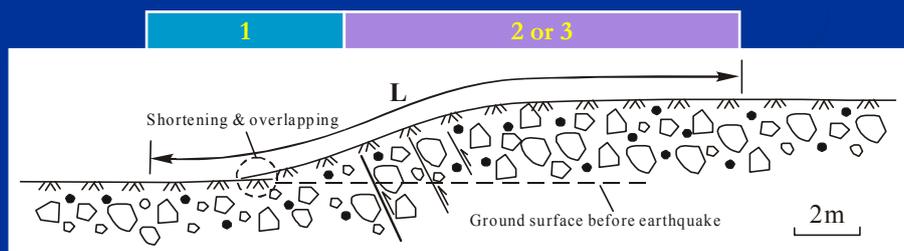
Frequency distribution map of width of influenced zone



It is indicated that the influenced widths of the earthquake ruptures mainly range from 16m to 60m, and the relationship between the influenced width (D) and the vertical displacement (H) is obvious linearity, which can be expressed as:

$$D = 10.11H + 16.0$$

Due to the Longmenshan fault being a mainly thrusting fault, the influenced zone ratio between the hanging side and the down side is generally from 3:1 to 2:1, which can help to determinate the safe distance for building site.



Sketch map of the rupture influenced zone

4. Slope geohazard assessment and site selection



Wenchuan earthquake caused a plenty of landslides, rock falls, etc. How can we reduce or prevent from geohazard risks during reconstruction?



We have put forward the “3 one” experience during site selection after the 5.12 earthquake:

- ◆ **One map:** distribution map of geohazards
- ◆ **One table:** investigation table of geohazards
- ◆ **One report:** investigation and assessment report of geohazards



One Map

During site selection, based on investigation, we draw a geological map for a certain slope or site, showing the engineering geological setting of the planning site, the characteristic of the slope at the back of the planning buildings, etc.

By this map, we can indicate the suitability and qualitative geohazard risk of the site.

Landslide interpretation using Aerial photos and field investigation



Landslide distribution map in ArcGIS



Landslide field investigation



Image map with topographic

One Table

In the process, we finish a investigation table including main parameters and characteristics of the slope at the back of planning construction, scale of a landslide and its stability, etc.





One Report

Finally, we finish a geohazard risk assessment report, giving the total geology of the site, characteristics of geohazards, and their developing trend, etc. drawing an conclusion about the site **suitable or not** for a certain construction.



5. Monitoring and Early warning for Geohazards

We can not ensure that a building is of security under extreme condition, especially in a rain season. So CGS create System of Monitoring and Early Warning for Geohazards.

By this system, we have prevented from more than 500 times geohazards per year in recent 20 yrs.

5.1 Public Inspection & Prevention

(1) The public inspection and prevention network has three-levels: county, town, village

Purpose: making the local people pay more attention to and inspect the potential hazards around them, in order to improve their adaptation abilities.

Methods:

- ♣ Design the preparedness plan for every geo-hazard and delineate the dangerous zone;
- ♣ Appoint a certain person in charge of the monitoring of a certain geo-hazard site and dispense the geo-hazard awareness card to the people threatened by geo-hazards.
- ♣ Public education and training with basic geo-hazard knowledge. (know-how, learn and share).



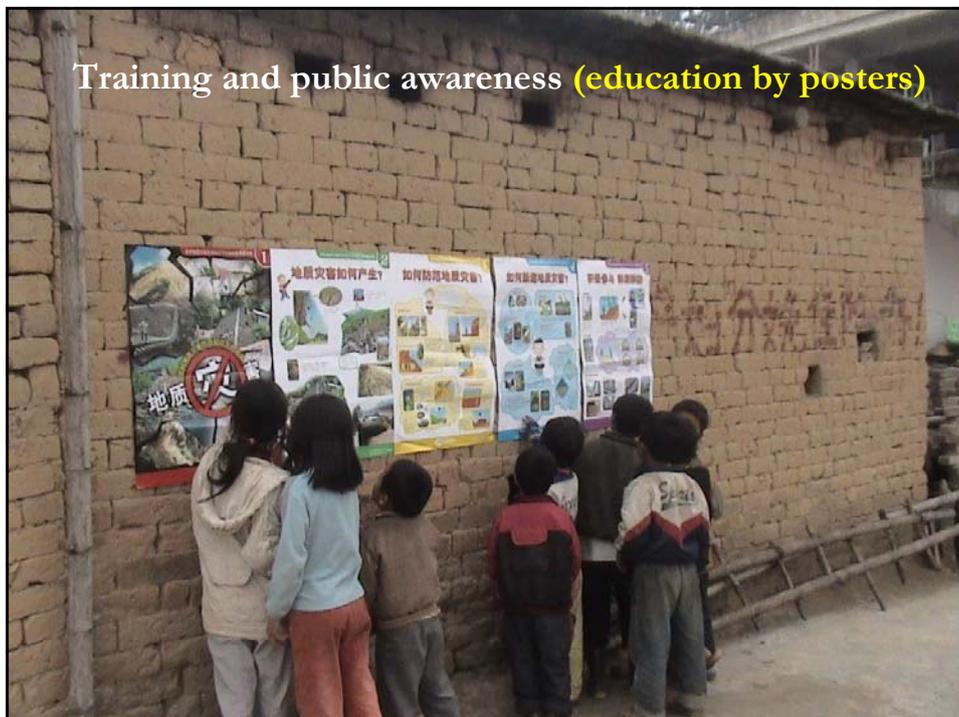
Local people inspect landslide deformation by simple monitoring methods. If they found the landslide might happen, they will evacuate by themselves.

(2) Geohazard knowledge training and education

The “Bring geo-hazard knowledge into tens of thousands villages program” was carried out in China since 2005. Through training courses by professional experts, TV, newspapers and posters etc, local people got more knowledge and information.



Training and public awareness (training by professional experts)



Training and public awareness (education by posters)



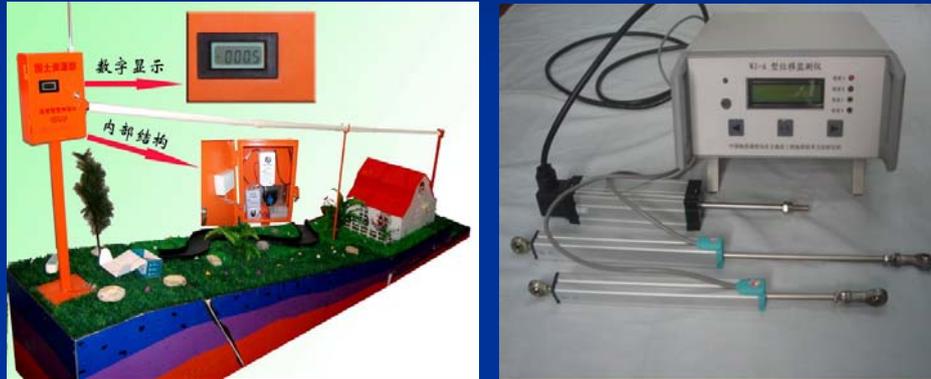
(3) The public inspection and prevention network attained obvious effects

Since 2001, the public inspection and prevention network has predicted more than **5000 hazards** successfully, avoiding **220,000 fatalities** and injuries, as well as about **4 billion RMB** economic lost.

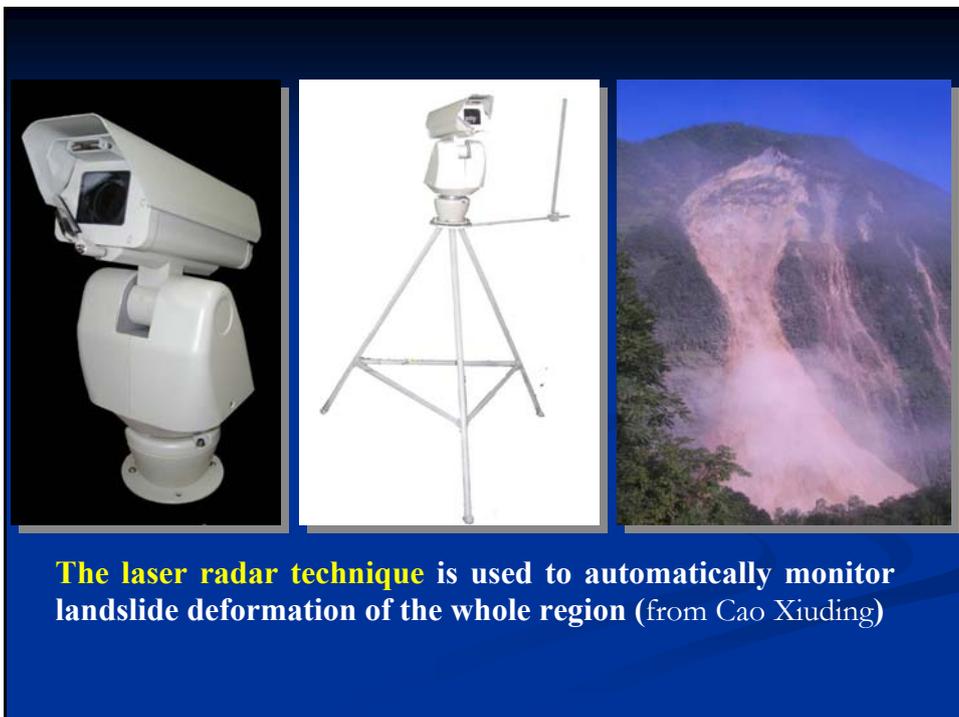
Year	Number	Avoiding fatalities	Avoiding economic loss (unit: 10, 000 RMB)
2001	231	4200	88600
2002	703	19120	24000
2003	697	29664	40000
2004	965	65561	86100
2005	500	11376	34100
2006	478	20566	23900
2007	920	37926	55000
2008	478	20709	32156
2009	209	14330	16353
Total	5181	223452	400209

5.2 Professional Monitoring

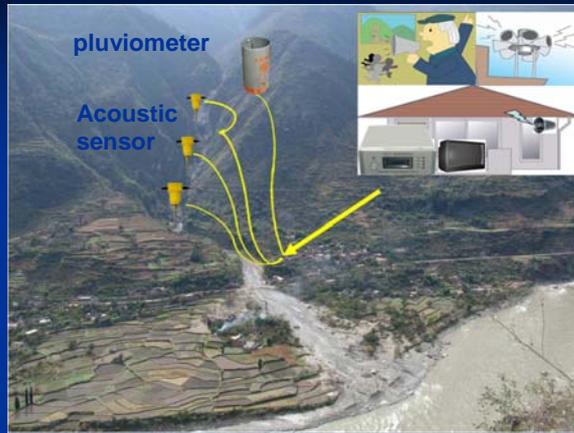
(1) Develop various professional monitoring instruments



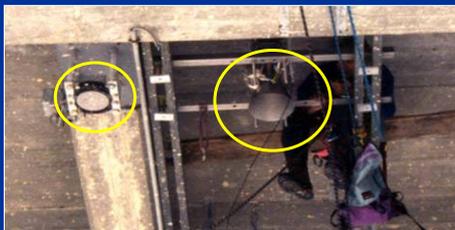
Landslide deformation monitoring instrument (from Cao Xiuding)



The laser radar technique is used to automatically monitor landslide deformation of the whole region (from Cao Xiuding)



Acoustic monitoring (**the debris flow ground sound monitoring device**): through this method to achieve debris flow monitoring and early warning (from Cao X.D.)



Laser and ultrasonic debris flow monitoring device: monitoring debris flow through detecting the thickness changes of debris by laser and ultrasonic wave.

5.2 Professional Monitoring

(2) CGS has arranged >10 professional monitoring and early warning demonstration regions in China. There will be >30 regions till 2015.



6 Conclusion and Discussion

- **Since** 1980s, based on the nationwide geohazards survey, Chinese government has created a geohazard prevention system with the Chinese characteristics. This system mainly consists of three methods: monitoring and early warning; evacuation plans; mitigation measures. **This** system already attained obvious effects.
- **After** 5.12 earthquake, CGS did effective work to reduce geohazard, such as rupture avoidance and geohazard risk assessment during reconstruction site selection.

- According to the actual situations in China, the regional geohazard early warning system was developed, and played an important role in geohazard mitigation.
- We should acutely aware that we are facing more and more geohazard risks under extreme conditions, which need all engineering geologists' contribution to deal with in the future.

Zhouqu debris flow in China (August 8, 2010)



One of the deadliest debris flow in the world, 1720 fatalities, about 20,000 people homeless.

Thank You for your attention

谢谢