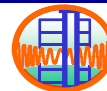


MC/MD
2010.05.06 (Thu)

Seismic Upgrading of School Buildings

Chung, LL (鍾立來), and Hwang, SJ

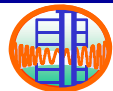


Chi-Chi Earthquake

01:47 a.m., September 21, 1999



**If earthquake happened at school time,
death toll would have been doubled, tripled, ...**



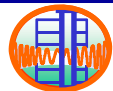
Compete with time: retrofit is the best solution!

**It takes 2 months for retrofit of a school building
and 2 years for reconstruction.**

**It costs NT\$2,000/m² of floor area for retrofit of a
school building and NT\$20,000/m² reconstruction.**

**Time and money for retrofit is
1/10 that for reconstruction.**

**Taiwan is seismicity active.
To compete with time, retrofit is the best solution.**

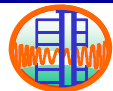


Magnitude of Problems

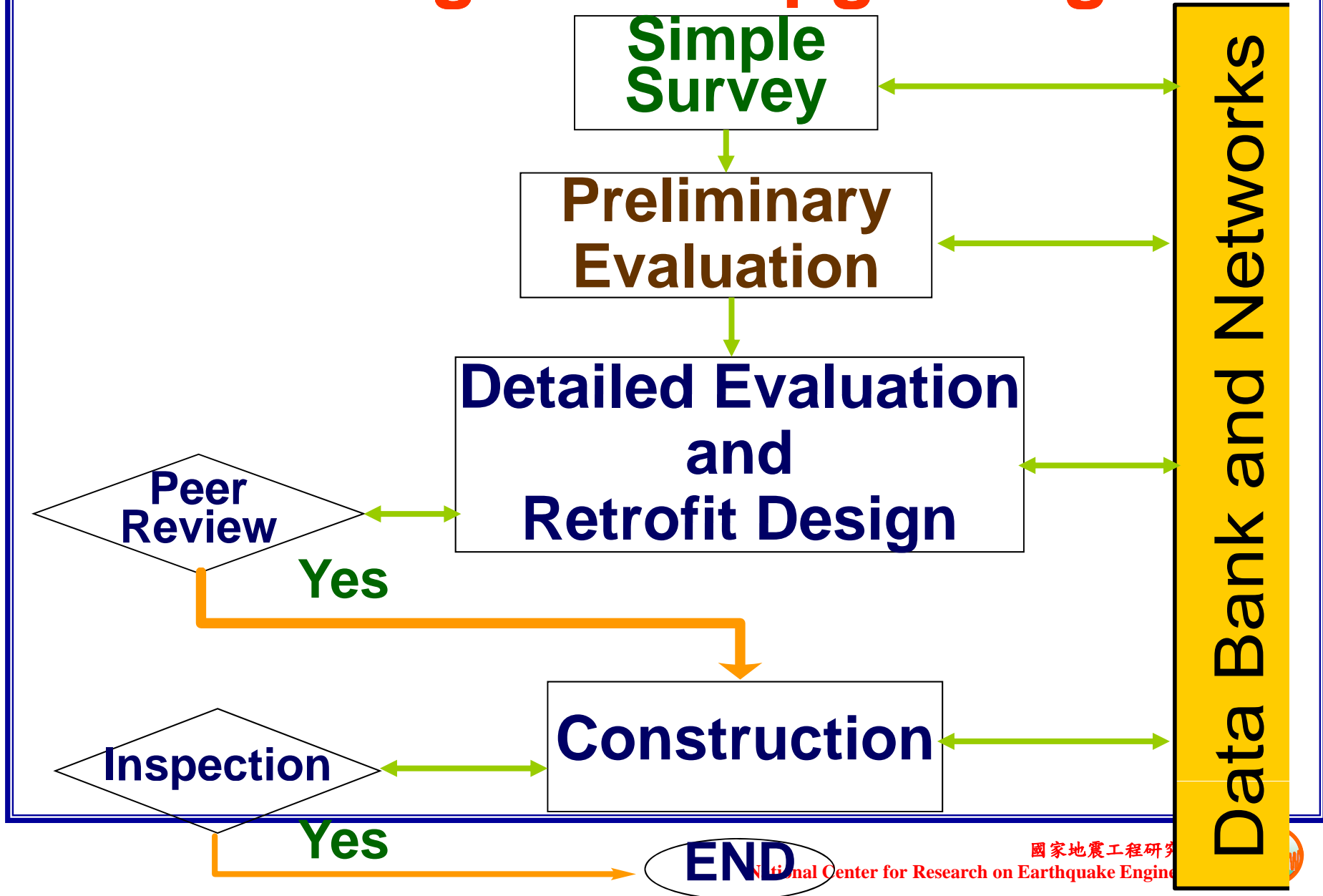
Seismic deficiency is common for school buildings in Taiwan.

Seismic upgrading of school buildings is a stringent issue.

More than 20,000 buildings in elementary and secondary schools (grades 1-12).

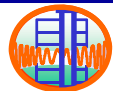


Strategies for Upgrading



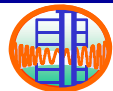
Simple Survey

- **By school administrators**
- **Almost free**
- **School and building data submitted through internet to NCREE**
- **Performance index I_s**



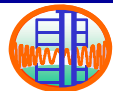
Preliminary Evaluation

- Priority according to I_s from simple survey
- By professional engineers
- Half a day for a building
- NT\$6,000 for a building
- Performance index I_s
- Results submitted through internet to NCREE



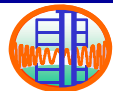
Detailed Evaluation

- Priority according to I_s from preliminary evaluation
- By professional engineers
- 45-60 days for a building
- NT\$150 per m² of floor area
- Capacity and demand ratio (CDR)
- Peer review
- Results submitted through internet to NCREE



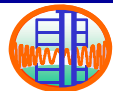
Retrofit Design

- Priority according to capacity and demand ratio (CDR) from detailed evaluation
- By professional engineers
- 45-60 days for a building
- NT\$150 per m² of floor area
- Documents for design implementation
- Peer review
- Results submitted through internet to NCREE



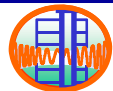
Retrofit implementation

- NT\$4,000 per m² of floor area
- Inspection
- Results submitted through internet to NCREE



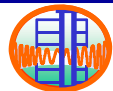
Peer Review

- Reviewer bank with 40% university professors and 60% professional engineers
- Review committee with 3 members, at least one professor and at least one professional engineer
- NT\$6,500 a meeting



Response to Financial Tsunami

- NT\$558.3 billion for strengthening local infrastructure to expand domestic demand and economy stimulus to expand investment in public works
- NT\$18.3 billion for seismic upgrading of buildings in elementary and secondary schools
- Thousands of school buildings go through the process of preliminary evaluation, detailed evaluation, retrofit design and implementation
- 1,500 school buildings will be retrofitted.



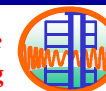
Project for Seismic Upgrading (Budgets in million NT\$)

Year	2009	2010	2011	2012
Preliminary evaluation	36	---	---	---
Detailed evaluation	589	306	135	99
Retrofit design	171	242	98	59
Retrofit implementation	5,800	6,120	2,480	2,140



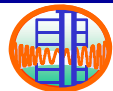
Project for Seismic Upgrading (Number of Buildings)

Year	2009	2010	2011	2012
Preliminary evaluation	6,000	---	---	---
Detailed evaluation	1,560	850	375	276
Retrofit design	450	650	261	152
Retrofit implementation	423	620	253	217



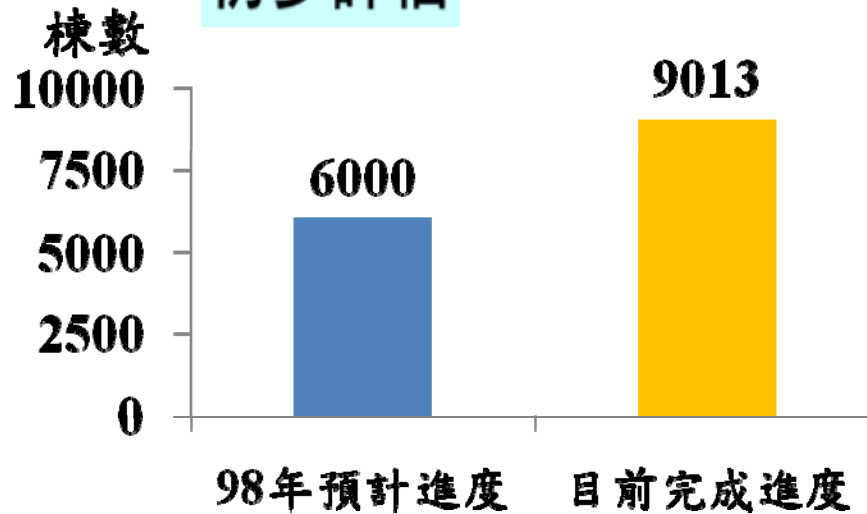
Role of NCREE

- **Establish and maintain data base for decision making**
- **Draft operation specification for detailed evaluation, retrofit design and inspection**
- **Assign peer review**
- **Hold workshops for engineers, school administrators, education officials**



2009 Progress

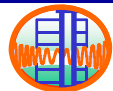
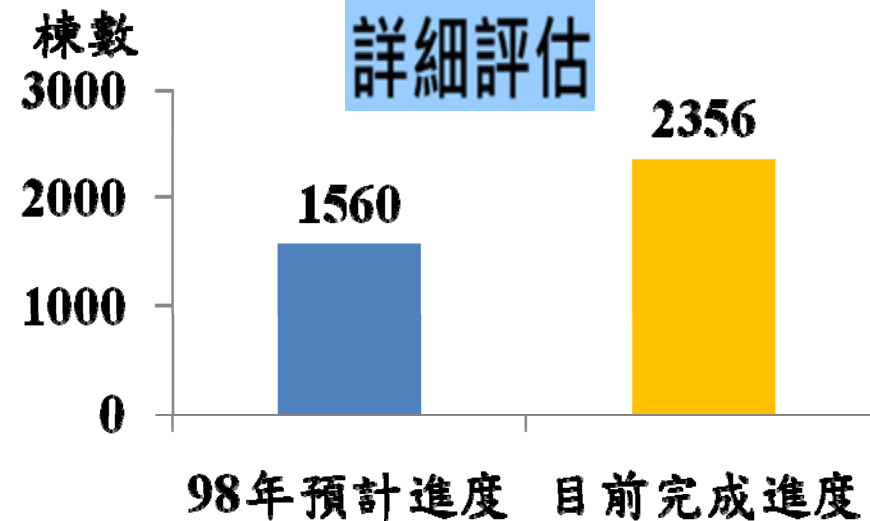
初步評估



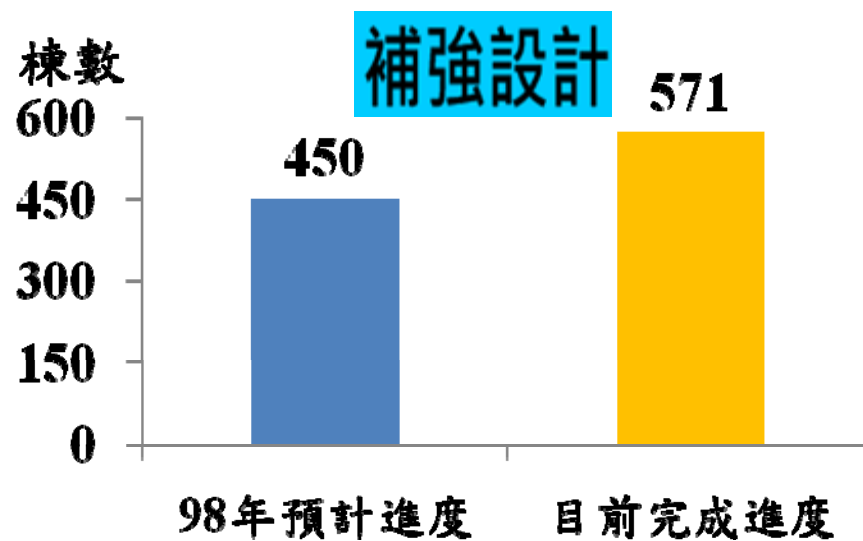
Preliminary evaluation
150%

Detailed evaluation
151%

詳細評估

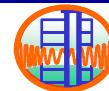
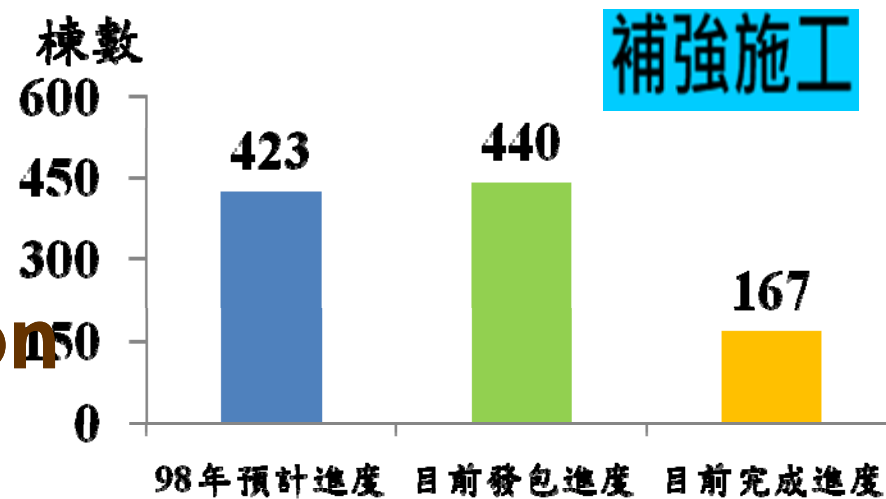


2009 Progress



Retrofit design
127%

Retrofit implementation
104% contracted



Retrofit Effectiveness

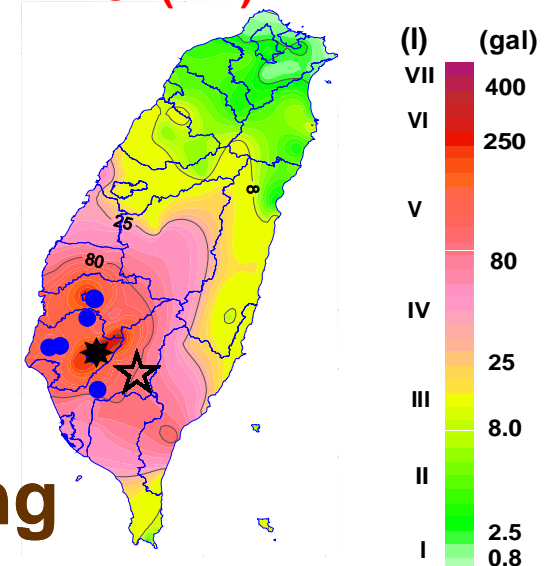
In 2010.03.04 Jia Xian earthquake, among buildings without retrofit, 9 schools 14 buildings were damaged.

2010/03/04 08:18:52 (ML6.4)

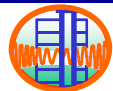
Data: 97sites



Observed
PGA(EW)



Yu Jing
Junior High School



Retrofit Effectiveness

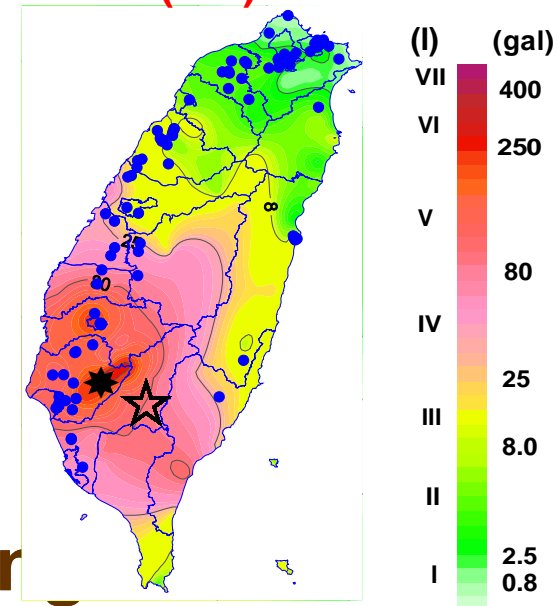
In 2010.03.04 Jia Xian earthquake, among buildings with retrofit, no building was damaged.

2010/03/04 08:18:52 (ML6.4)

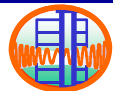
Data: 97sites



Observed
PGA(EW)



Yu Jir
Vocational School



Thank you!

