Engineering Contributions to Urban Heritage Conservation

C F Lee

Some Examples

- Enhancing structural safety of historic buildings through

  -strengthening (to meet safety standard or upgraded design standard)

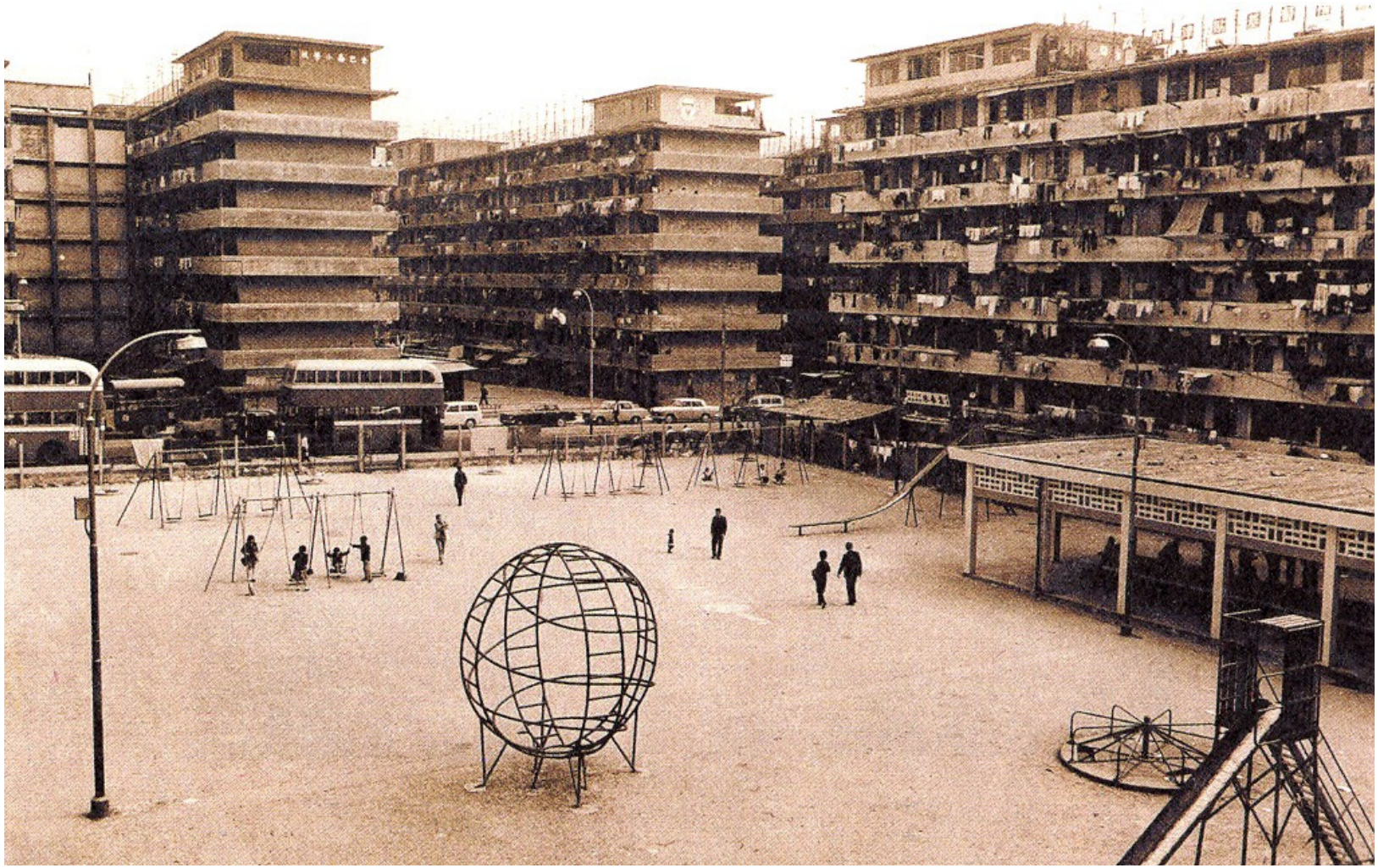
  -seismic retrofitting

- Stabilization of historic buildings

  -against differential settlement and excessive tilting (e.g. the Leaning Tower of Pisa)

  -against landslide-induced damages (e.g. Hong Kong)

Shek Kip Mei---first public housing estate in Hong Kong, built 1954



Note structural reinforcement

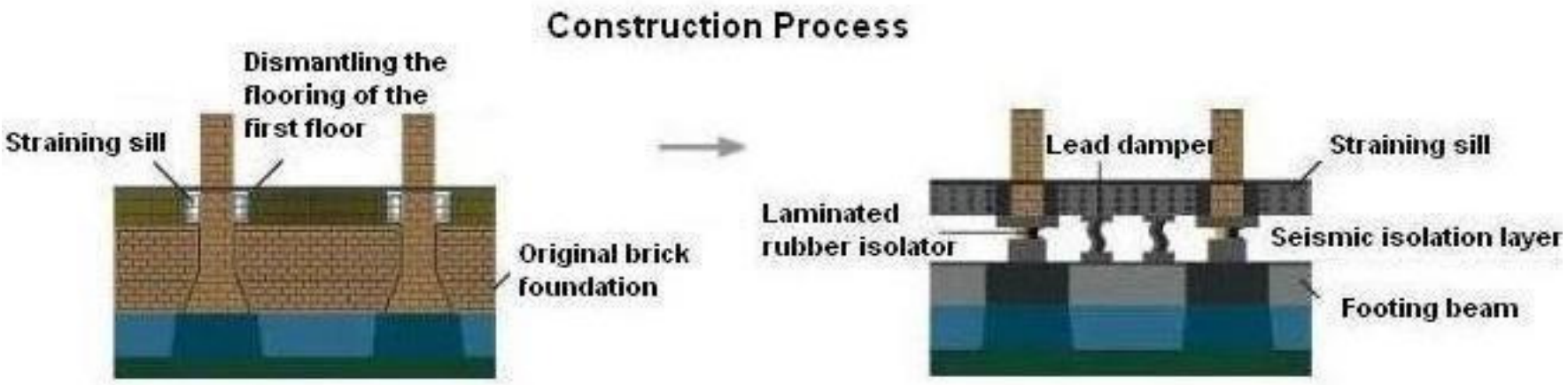
定慧禪寺

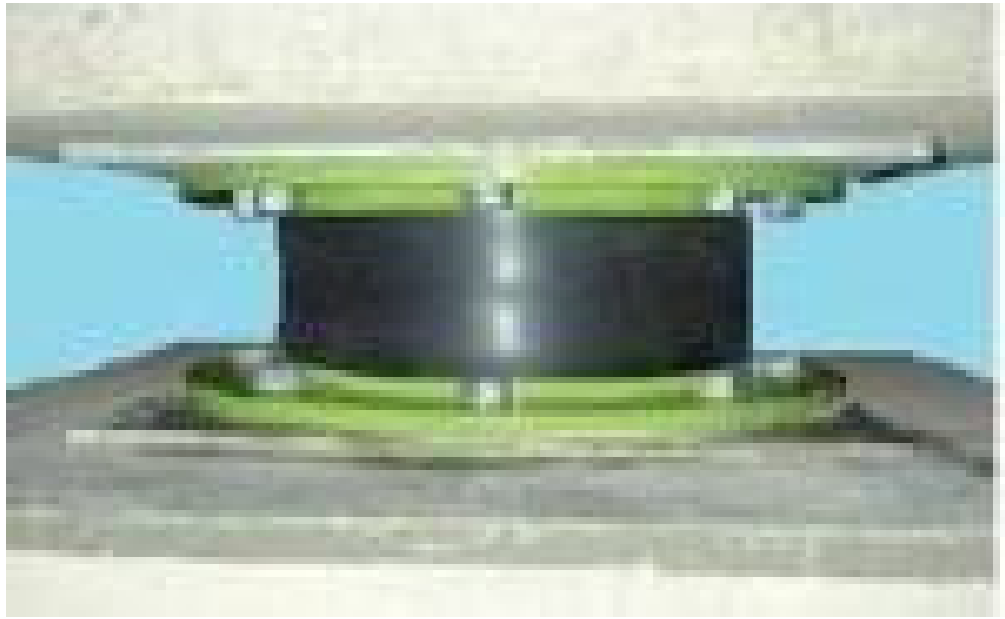
重修寺院慈善齋宴

位於大埔馬窩定慧寺乃十方叢林道場, 本寺建於1923年至今已有八十四年的歷史，由開山祖師增秀老和尚艱苦經營，本寺雖然連年盡力培修，**牆身已經出現裂縫，建築物有下陷跡象，木柱霉爛，每逢大雨瓦頂大部分漏水，**滲漏情況嚴重，重修刻不容緩。現有的部份建築已成危房嚴重影響常住僧眾、居士和來寺者的人身安全。然而，但由於重修寺院工程需資頗鉅，為了能早日重修定慧寺，特別舉辦『重修慈善齋宴』為籌募經費，敬希十方佛子善信發菩提心，踴躍參與或隨喜支持。

International Library of Children's Literature
-completed in 1906, Tokyo, Japan
-formerly part of Imperial Library and National Diet Library

Seismic retrofit 1996-98
Installation of seismic isolators



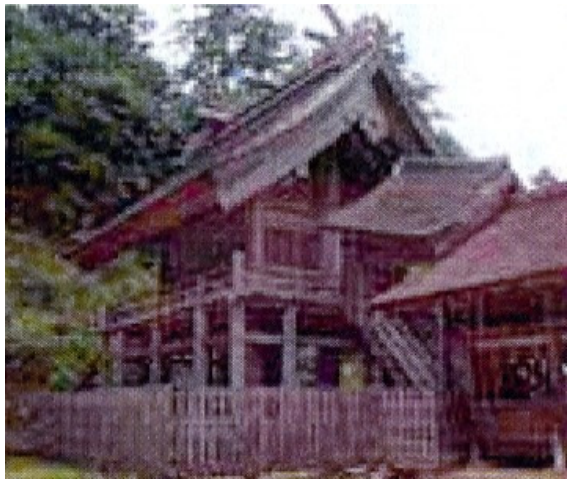


Laminated rubber isolator

Damper

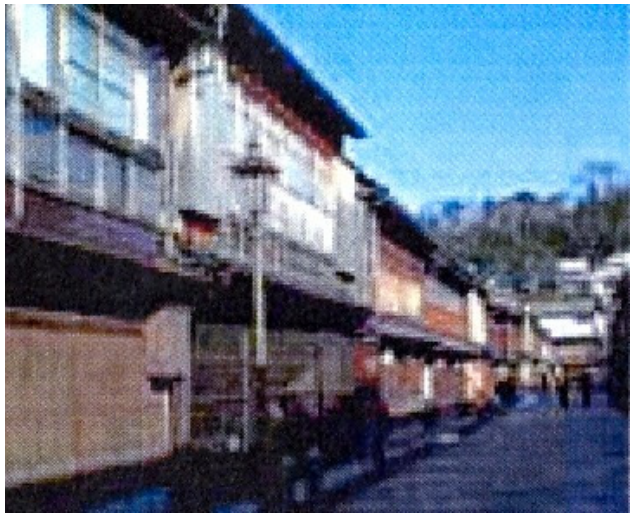
Nakanoshima Kokaido, Osaka
-public hall (with concert hall), built 1896
-seismic retrofit in 2000, after Kobe earthquake of 1995; isolation techniques used

Traditional wooden buildings in Japan

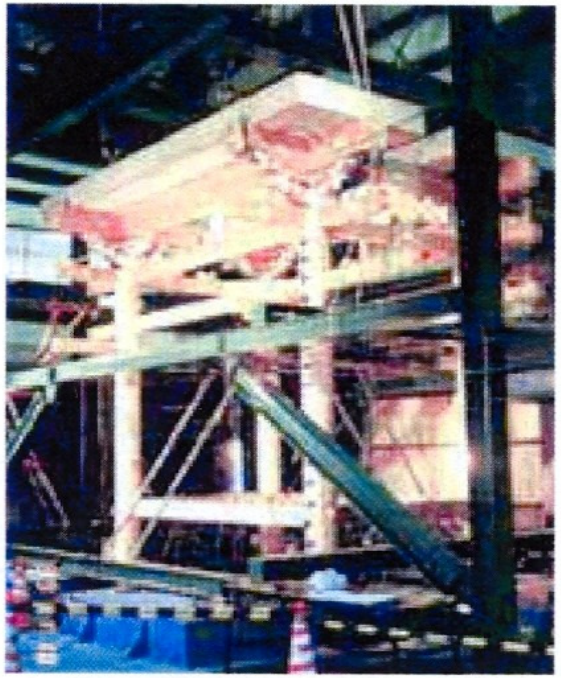


(a) Shrine in Matsue

(b) Temple in Kyoto



(c) Houses in Kanazawa



Vibration test on full-scale model of Japanese temple

The Golden Gate Bridge---
Need for seismic retrofit, following Loma Prieta earthquake of 1989

The Golden Gate Bridge

Three phases of retrofit for the Golden Gate Bridge:

- Phase 1: retrofit the Marin (north) Approach Viaduct (completed in 2002)
- Phase 2: retrofit the San Francisco (south) Approach Viaduct, San Francisco (south) Anchorage Housing, Fort Point Arch and Pylons S1 and S2 (to be completed in 2007)
- Phase 3: retrofit Main Suspension Bridge and Marin (north) Anchorage Housing

  (to be completed in 2012)

Phase 1

- Strengthening of foundations
- Replacement of 4 supporting steel towers
- Lateral bracing + vertical truss
- Isolator bearings + expansion joints

Hearst Memorial Mining Building at UC Berkeley

-seismic retrofit with base isolation + reinforcement

-following a 4-year seismic upgrade and renovation project, the building was reopened in 2002 and is one of the most striking architectural structures on campus

Martin Luther King Jr. Civic Center in Berkeley, California

Seismic renovation of the Building includes a state-of-the-art base isolation system. The completed building now rests on eighty-eight (88) lead rubber-bearing isolators and steel sliders, installed in the basement of the six-story structure. This system introduces a moat around the entire building perimeter to allow the base isolated building to move up to 30 inches in any direction.

111 Sutter Street, San Francisco

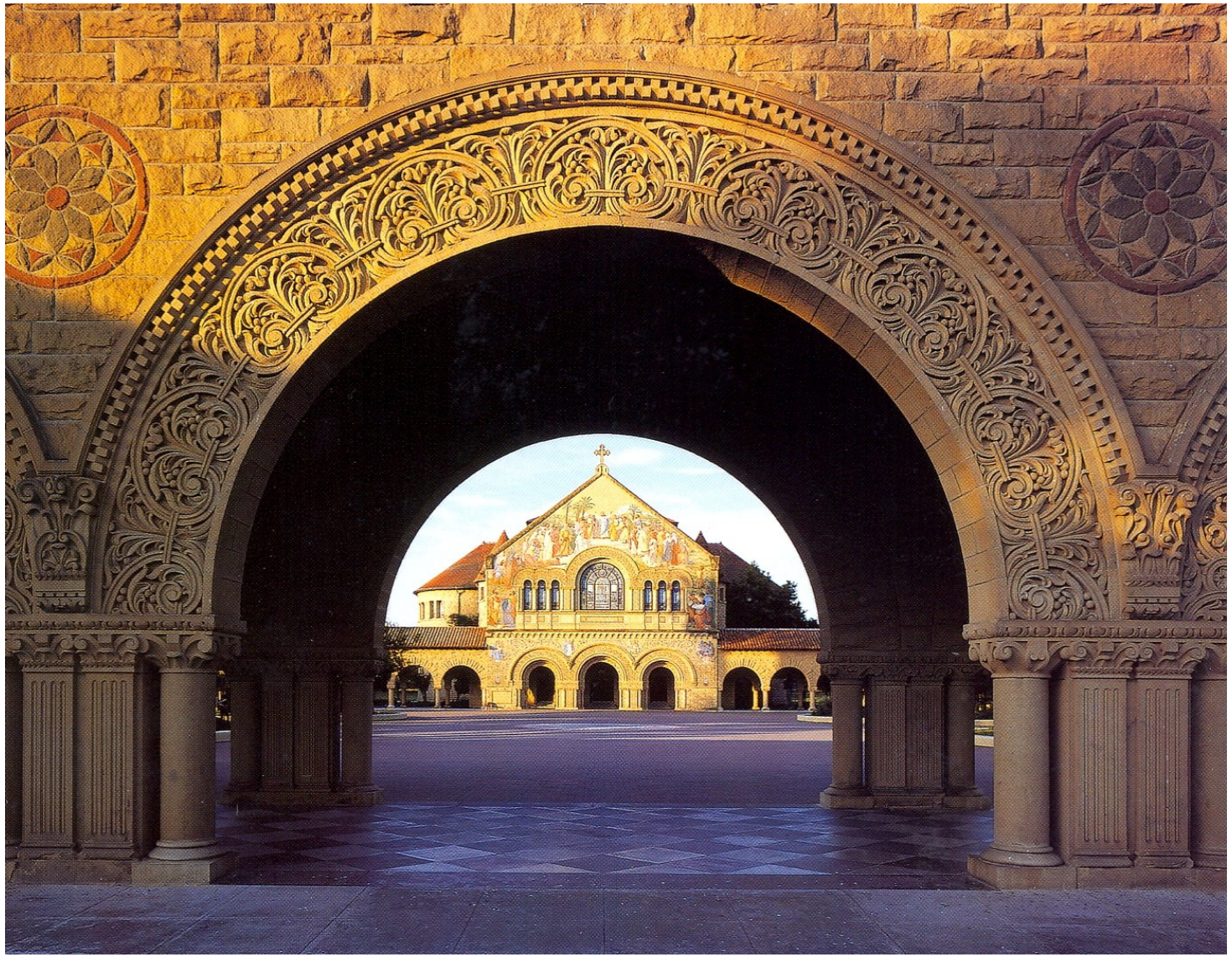
-a 24-storey 1920's vintage steel-framed office building.
The retorfit scheme included column strengthening and strategically placed concrete shear walls

Asian Art Museum Seismic Retrofit, San Francisco

-the original building was the “old” Main Library, which was opened in 1917

The Letitia Building in San Jose (built in 1889)
-seismic retrofit with shoving, framing and basement addition

Memorial Church at Stanford University



Pasadena City Hall (built in 1927)

In 2003, the City Council approved a plan for the seismic retrofit (through base isolation) historic restoration and infrastructure improvements of the City Hall.

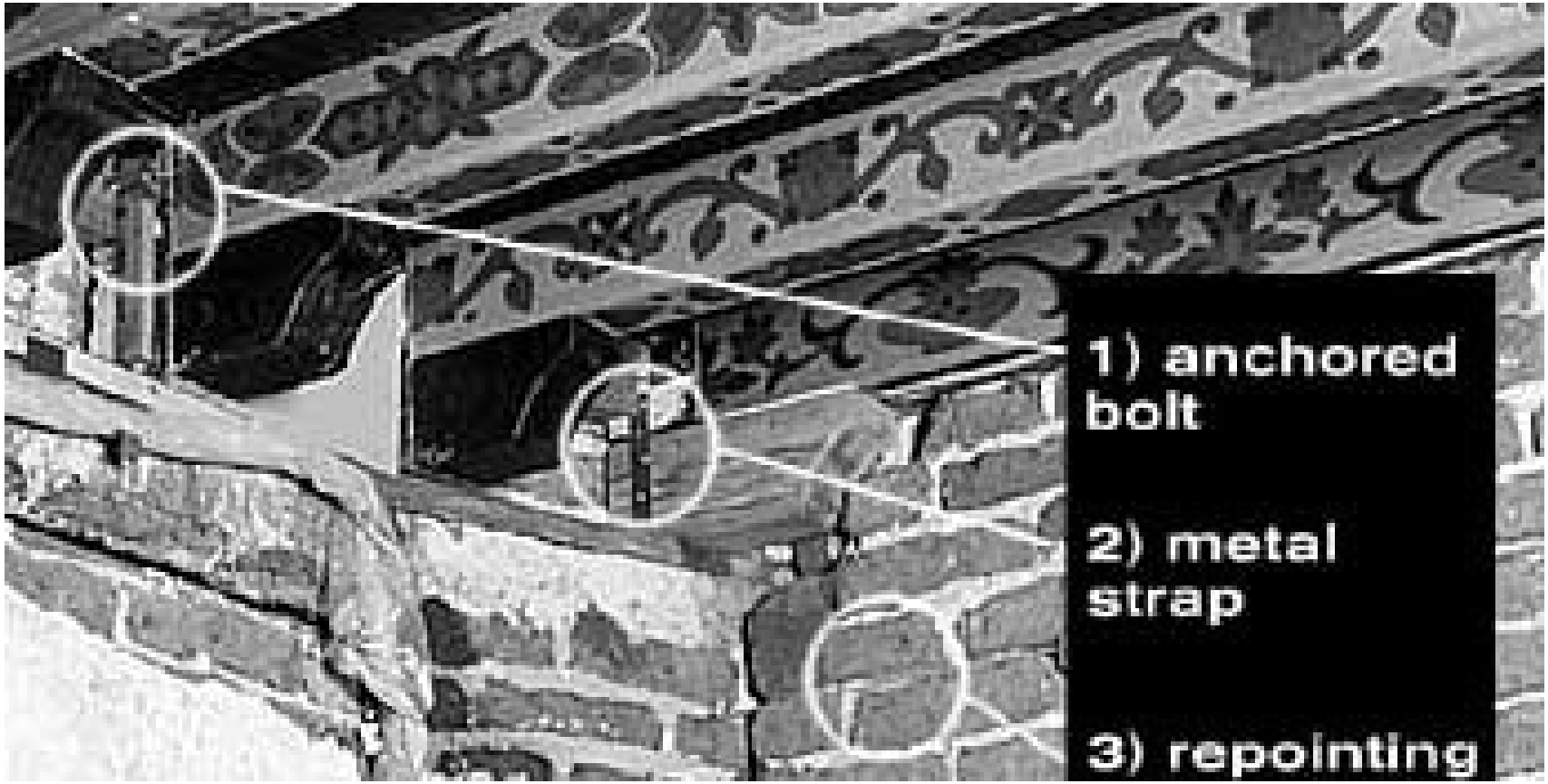
Salt Lake City and County Building (built 1894)
-seismic retrofit to accommodate a design basis earthquake of 0.2g, using lead rubber base isolators in 1989

Two important preservation principles in undertaking seismic retrofit projects:

- Historic materials should be preserved and retained to the greatest extent possible and not replaced wholesale
- Respect the character and integrity of the historic building

Restoration of historic building in Northridge California, after 1994 earthquake

Tying vulnerable elements together and repointing masonry



Damage of joints and prevention

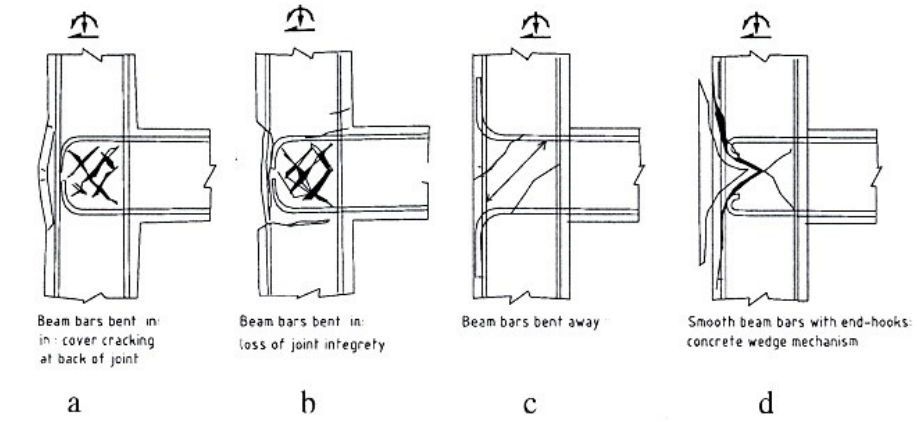


Figure 5. Alternative damage mechanisms for exterior tee-joints: a, b) beam bars bent inside the joint region; c) beam bars bent outside the joint region; d) plain round beam bars with end-hooks: "concrete wedge" mechanism (picture on right side)

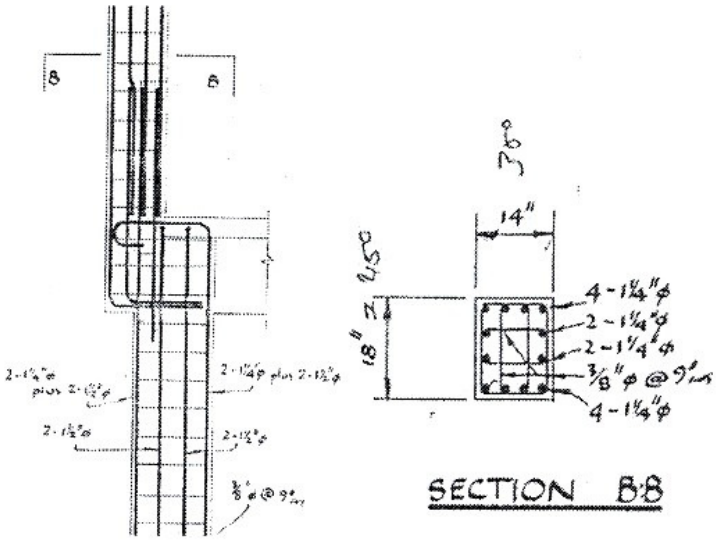


Figure 6. Typical reinforced concrete detail

[Credit: Connell Wagner Consultants Ltd.]

Significant seismic risk in southern Europe (Italy, Greece, Yugoslavia)— need for seismic retrofit as well; increasing interest and many research studies reported

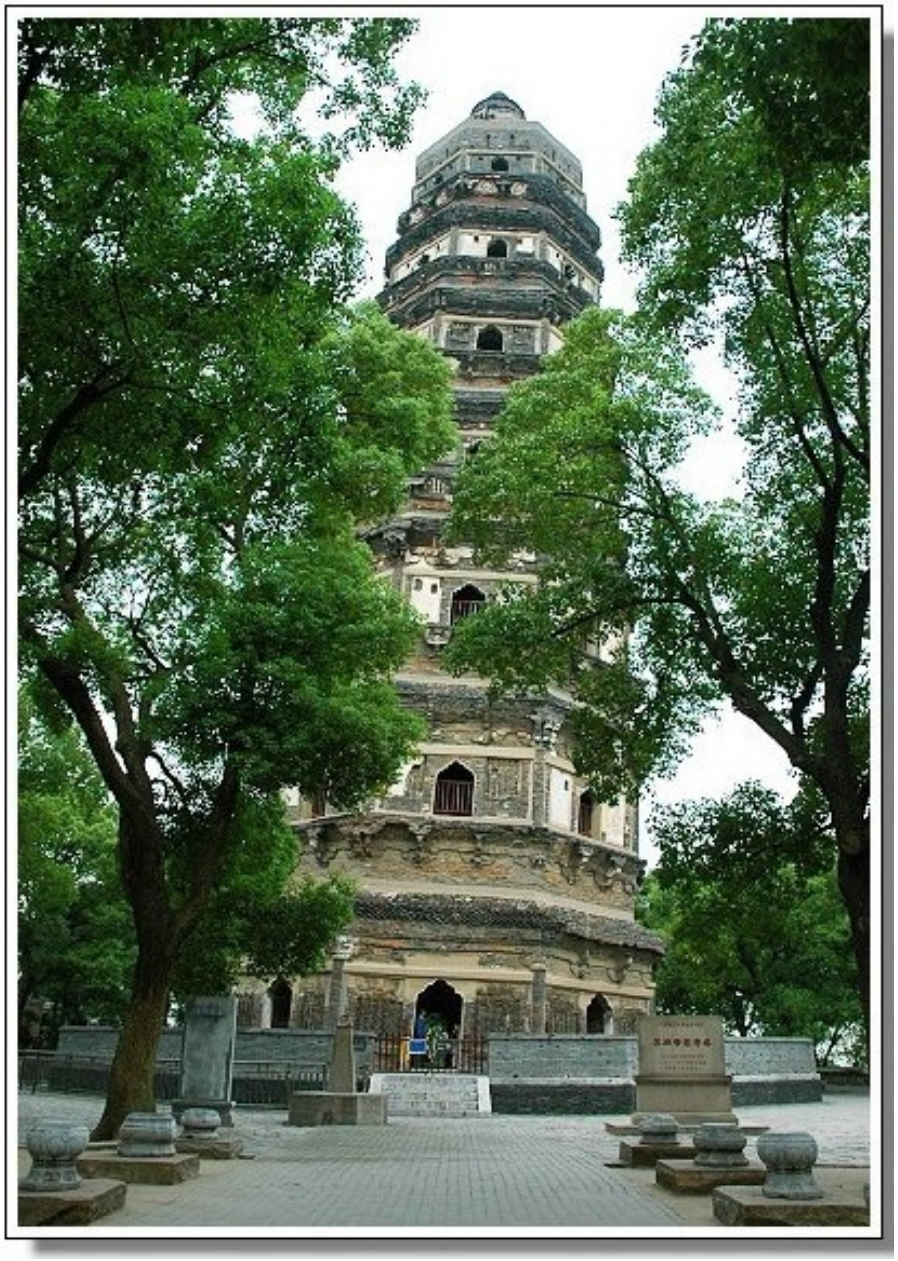
The Leaning Tower of Pisa, Italy

The Leaning Tower of Pisa

Engineering measures taken in mid-1990's to prevent possible collapse

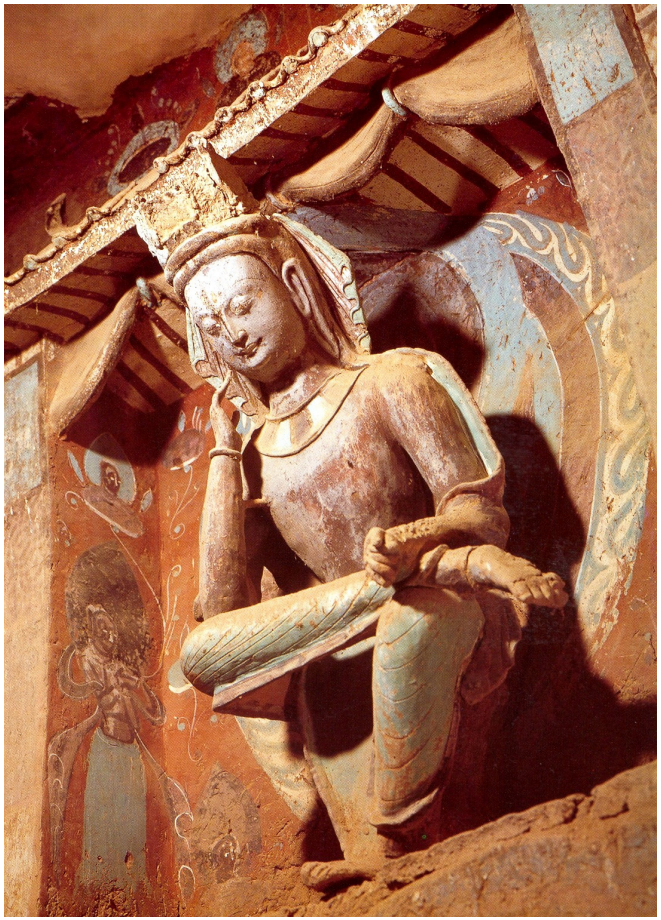
- Reversal of tilting movement by controlled removal of soil (via inclined boreholes) and induced subsidence of foundation on the north side of the tower (i.e. least compressed side)
- Sub-horizontal anchor stays as temporary safeguard during stabilization works
- Reduction of inclination by half a degree to 5°, with little change in visual impact

Leaning Tower of Huqiu 虎丘塔

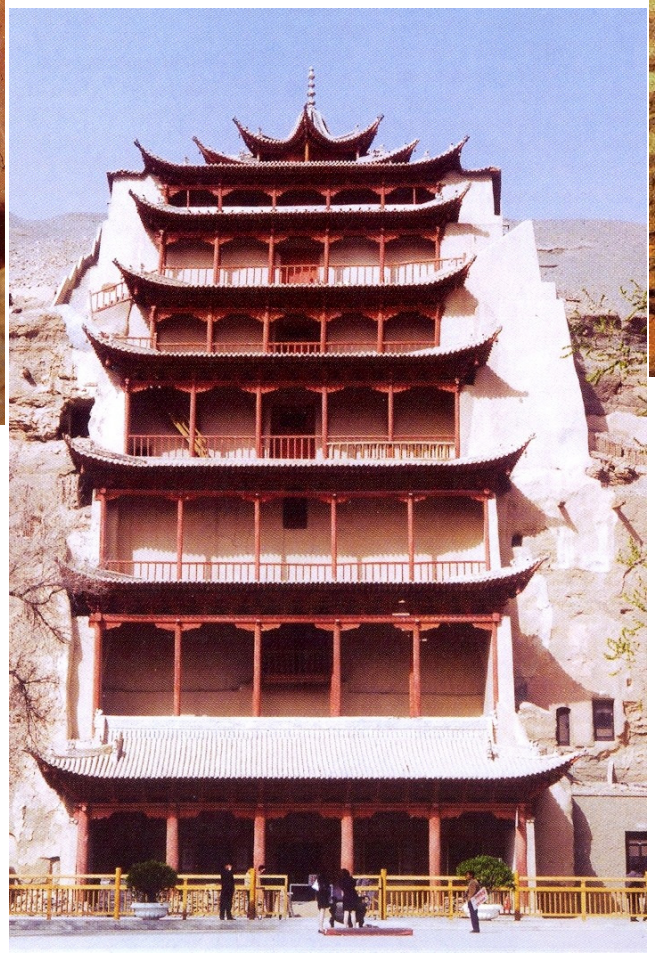


Similar technique used to stabilize and control the differential settlement of the Huqiu Tower, built in A.D.959-961, Suzhou, Jiangsu, China

Leaning buildings due to differential settlement



Dunhuang Cave Temple (敦煌)



Stabilization of Caves

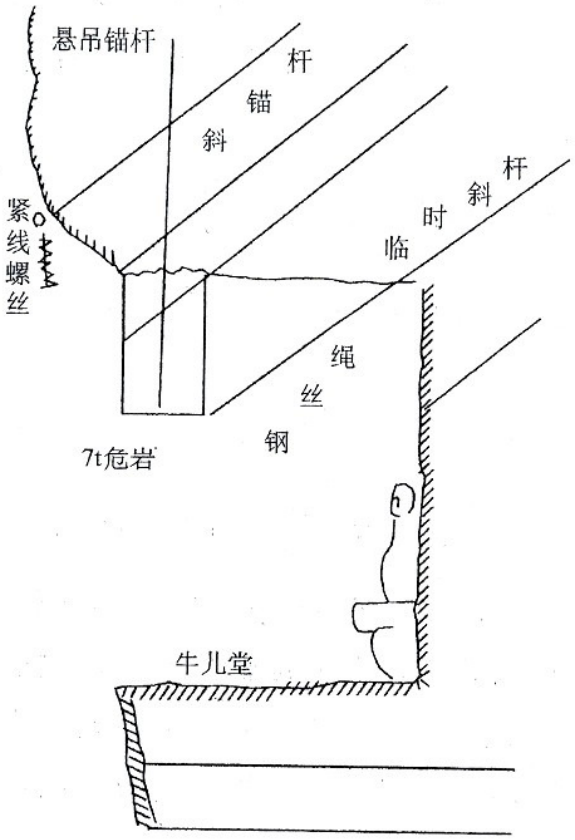


图 8-13　7t 危岩加固示意图

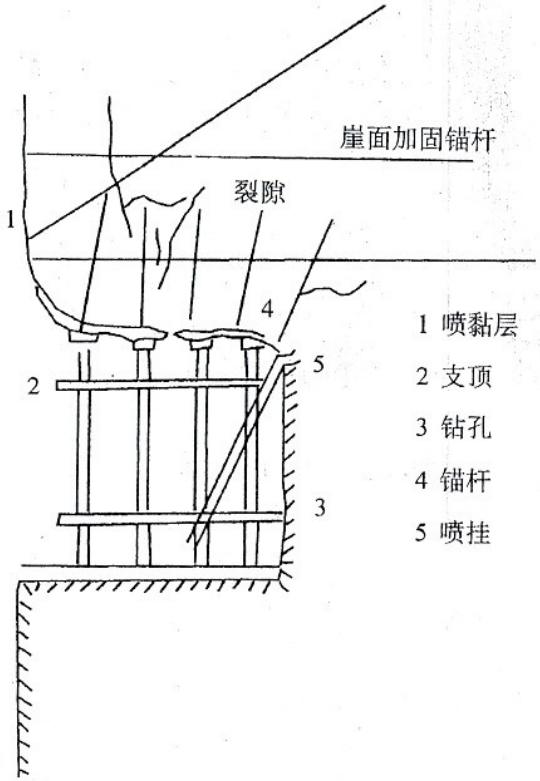


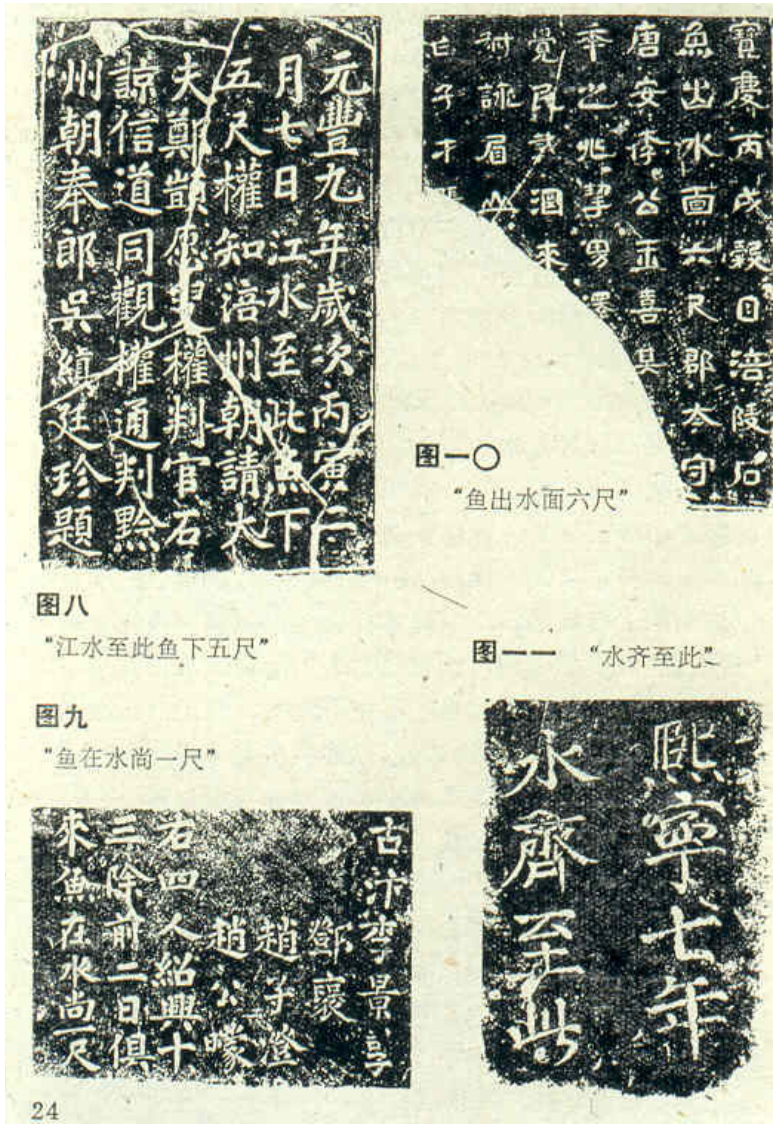
图 8-14　第 15 窟窟顶加固示意图

Relocation of ancient temple, Abu Simbel, Egypt, due to construction of Aswan Dam and Lake Nassar

Preservation of relics---Three Gorges Project
Stone Fish in Fuling (涪陵石鱼)

Stone Fish in Fuling

Stone engravings of low water levels
四川涪陵 枯水題記



图一〇
"鱼出水面六尺"

图八
"江水至此鱼下五尺"

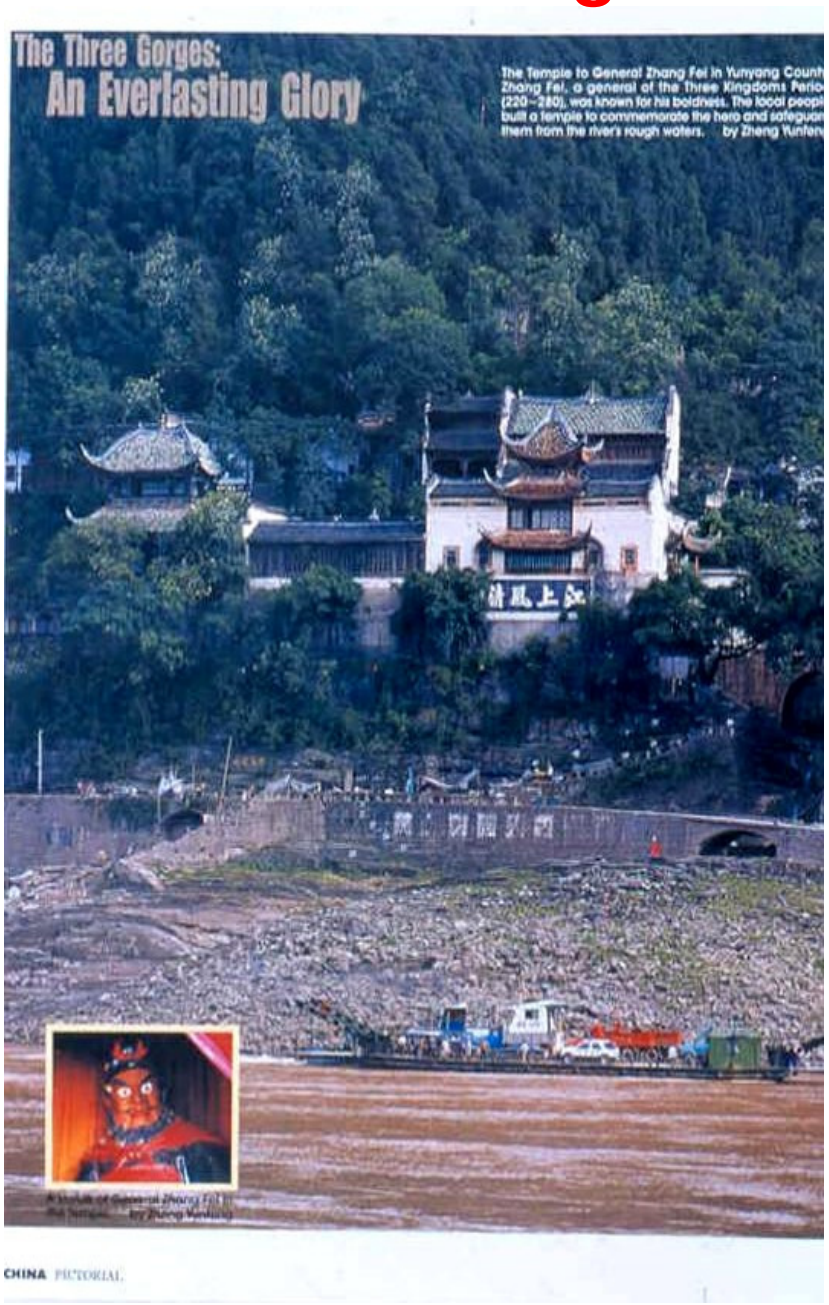
图一一 "水齐至此"

图九
"鱼在水尚一尺"

24

Underwater Museum of Ancient Hydrographic Records

Chang Fei Temple, Yunyang



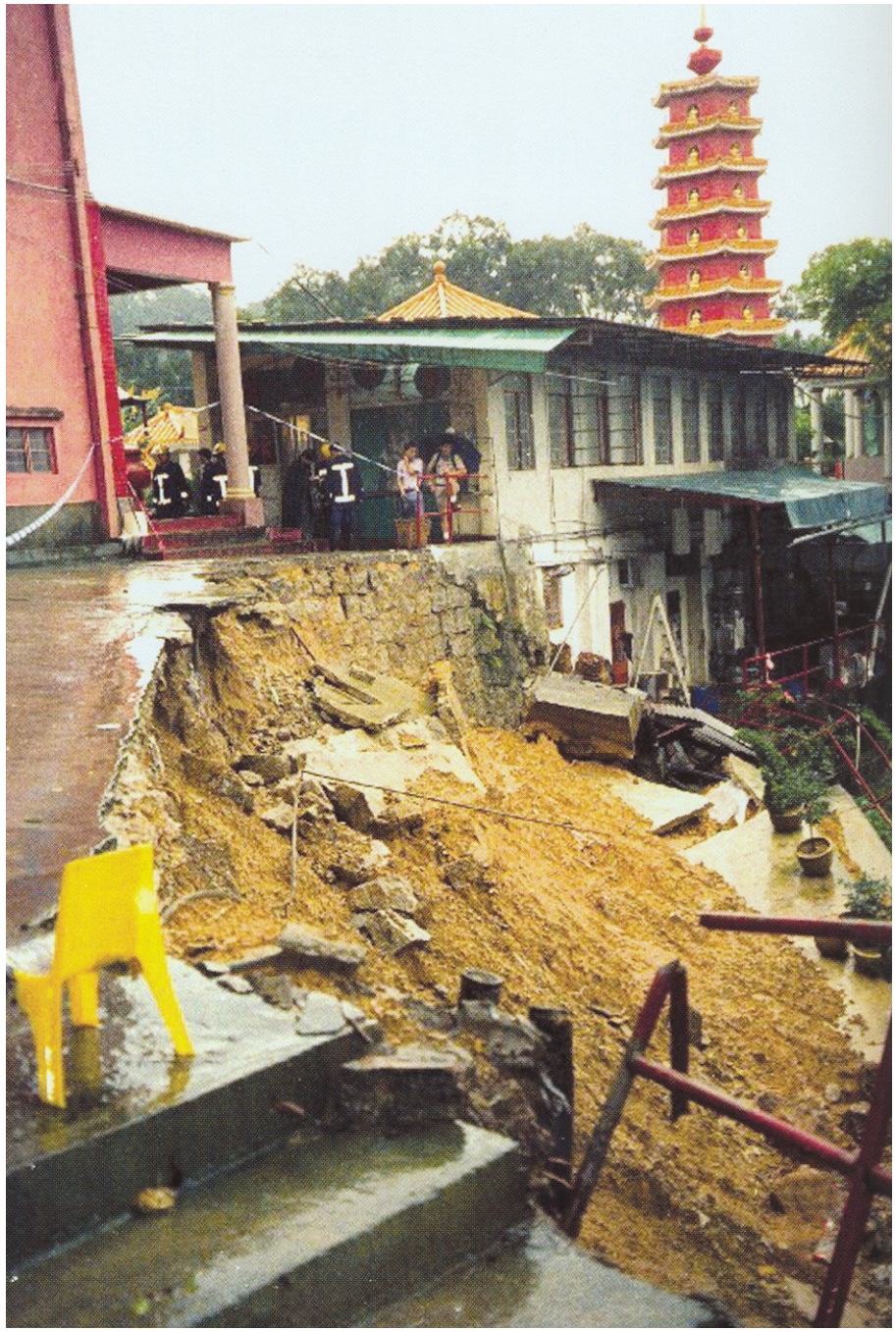
Slope stabilization to reduce landslide hazard

Protecting historic buildings against landslide hazards

The Hong Kong Experience

Stabilizing buildings against landslide in the 1920's

Landslide threat on historic building, June 12, 1966



A number of landslides occurred at the Ten Thousand Buddhas' Monastery, causing extensive damage

Old Halls, The University of Hong Kong

Hong Kong is now a leader in landslide hazard mitigation

Thank You!