

Second International Symposium on Rockfill Dams

October 27 to 28, 2011

Windsor Barra da Tijuca Hotel - Rio de Janeiro - Brazil



XXVIII SNGB

National Seminar on Large Dams

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Development of Concrete Face Rockfill Dams in China

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Hydrochina Corporation



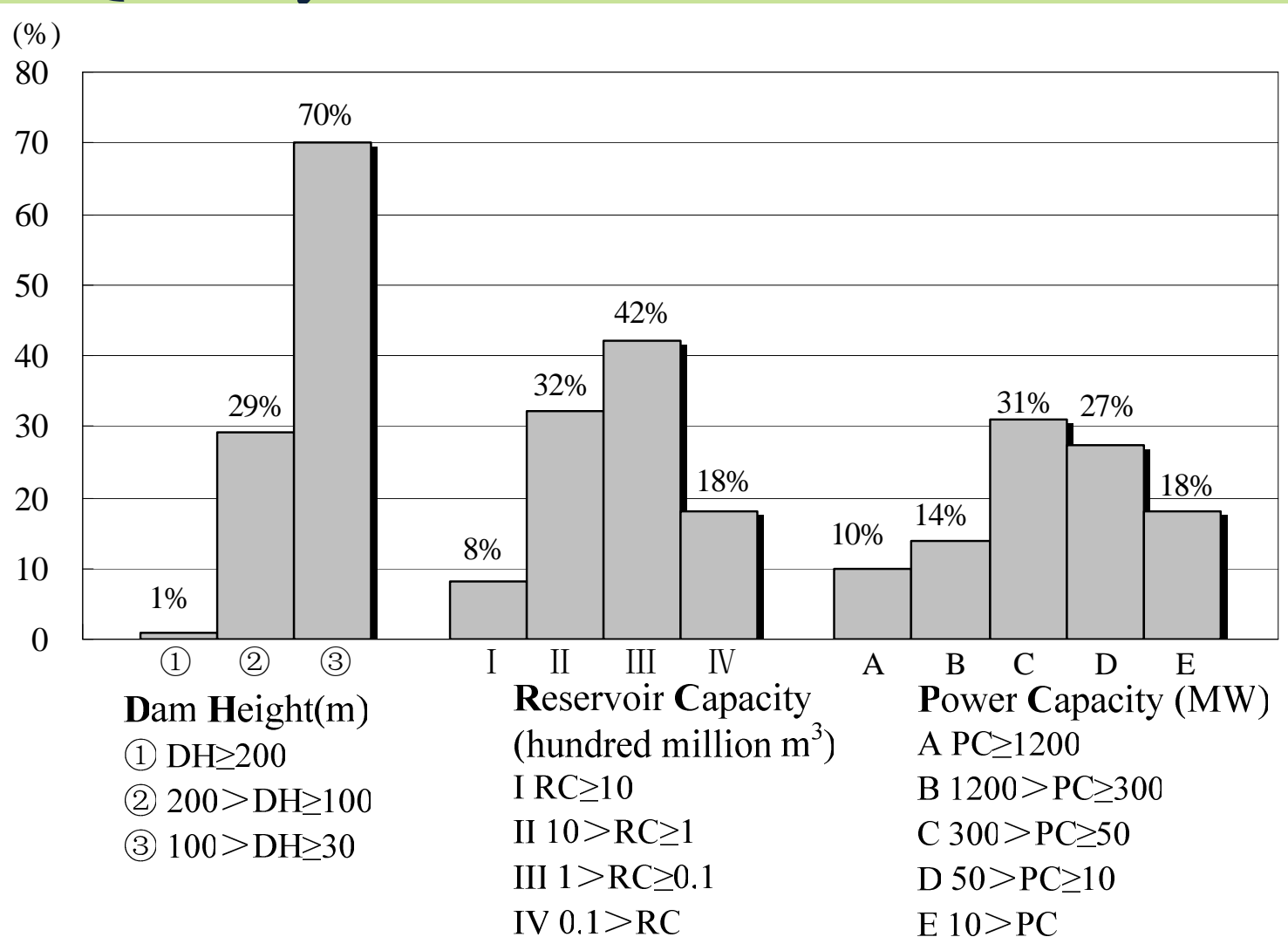
China institute of water resources
& hydropower research

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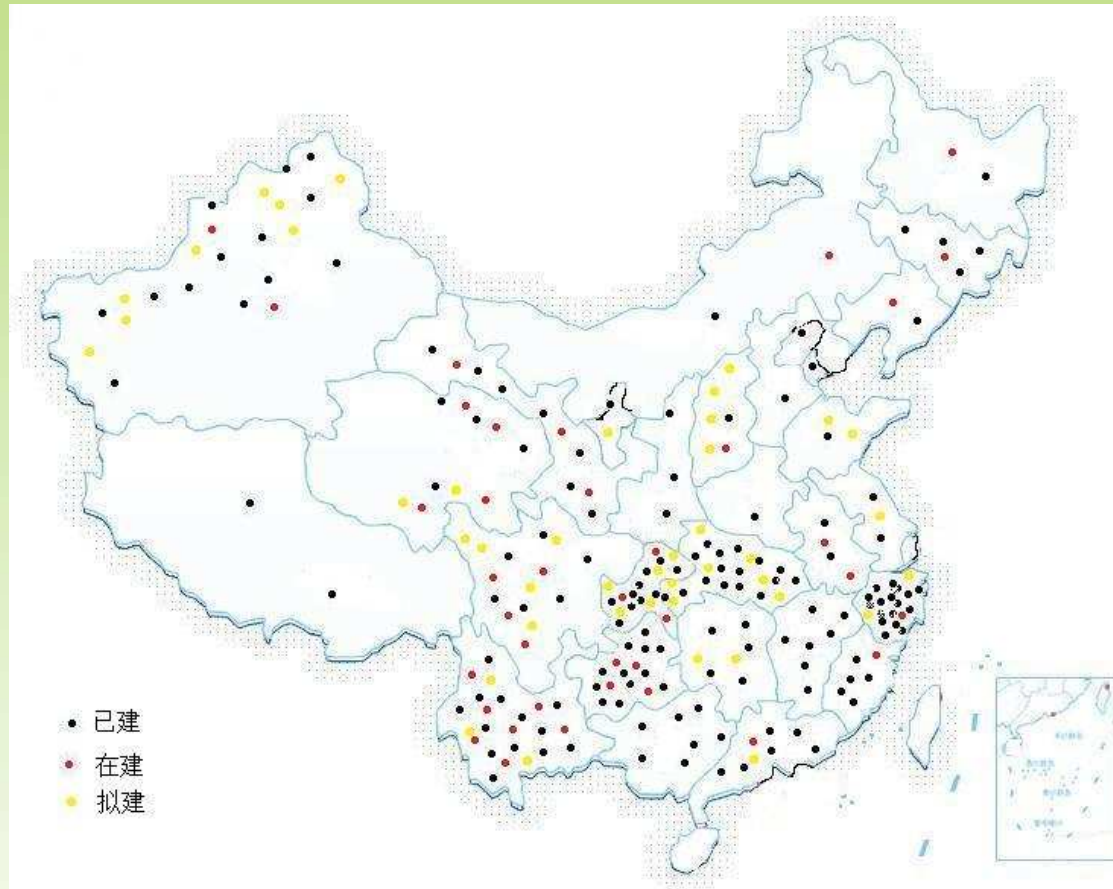
- Overview of CFRD construction in China
- Main technical progresses
- CFRD constructed under special conditions
- Experiences and lessons
- Development and challenges in the future
- Conclusions

1 Overview of CFRD construction in China

- 1.1 Quantity and distribution

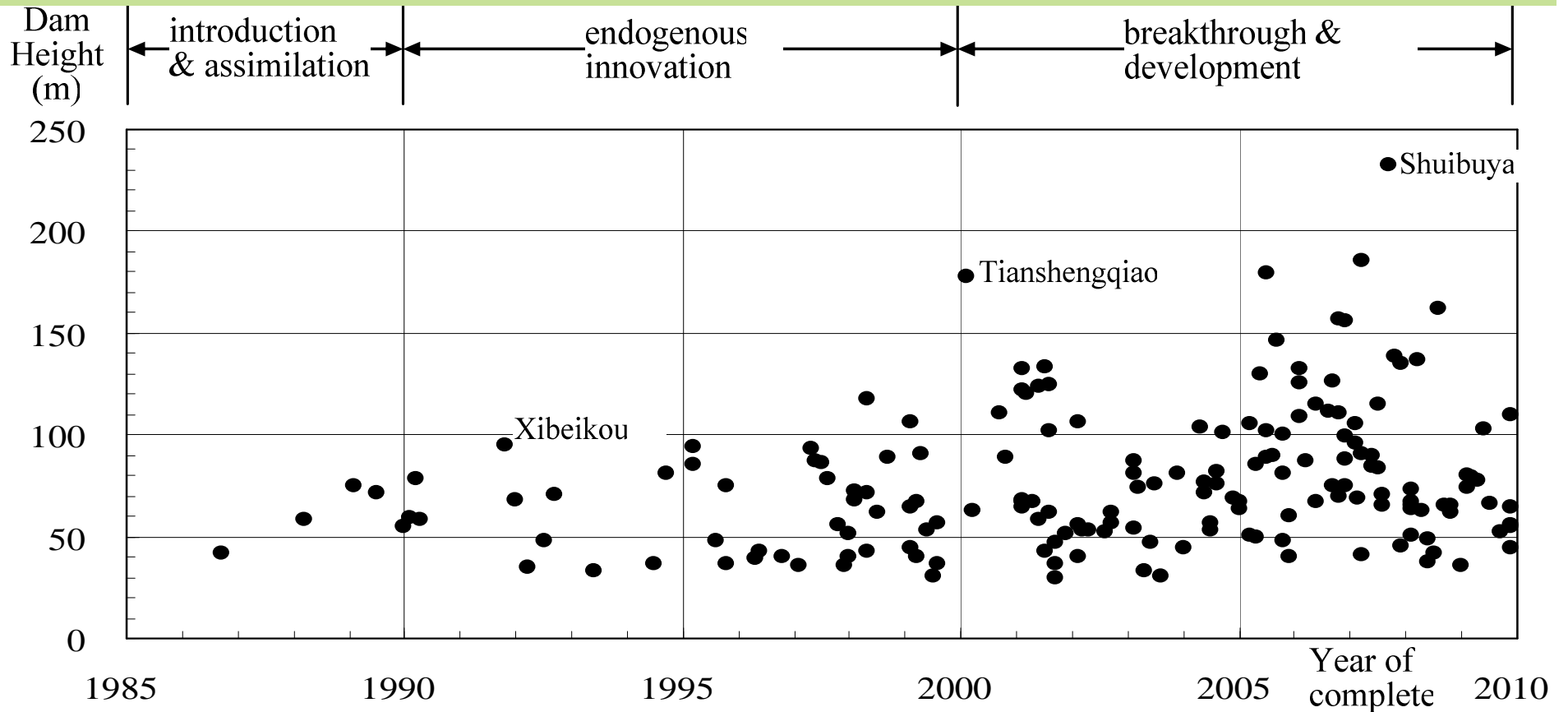


1.1 Quantity and distribution

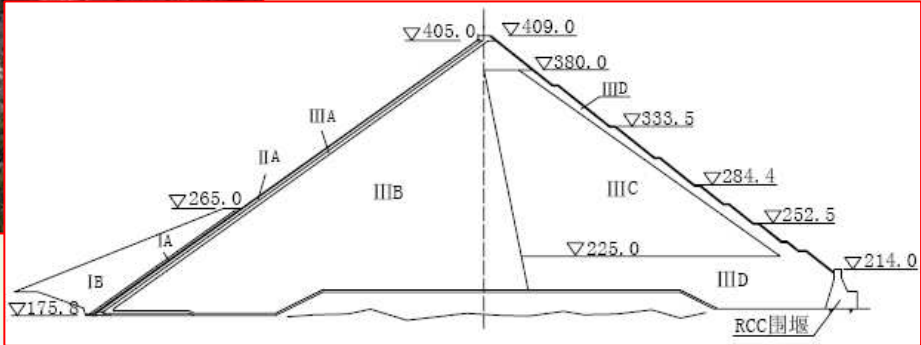
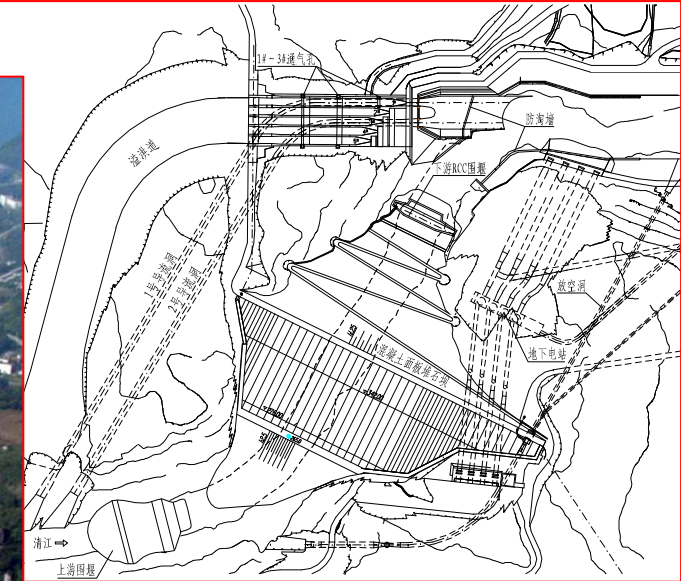


Zhejiang	Hubei	Yunnan	Xinjiang	Chongqing	Guizhou	Sichuan	Gansu	Guangdong	Others
43	26	22	18	17	15	16	10	8	73
17.34 %	10.48 %	8.87 %	7.26 %	6.85 %	6.05 %	6.45 %	4.03 %	3.23 %	29.44 %

1.2 Stages of development

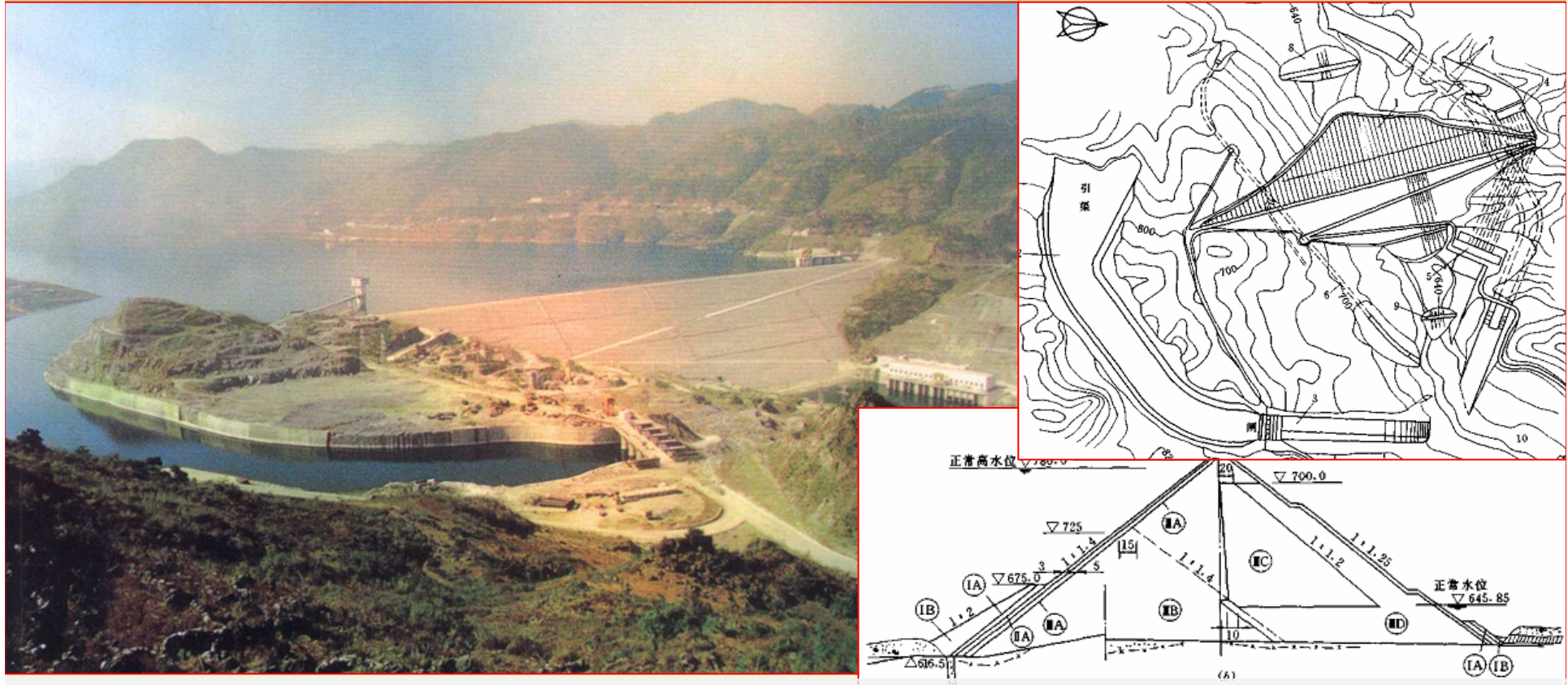


CFRD construction in China



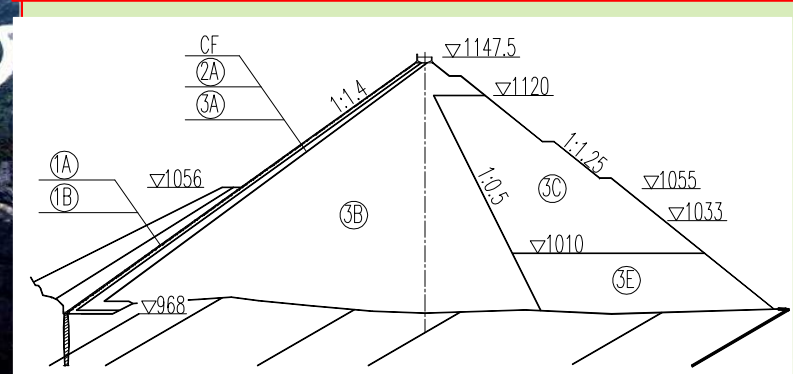
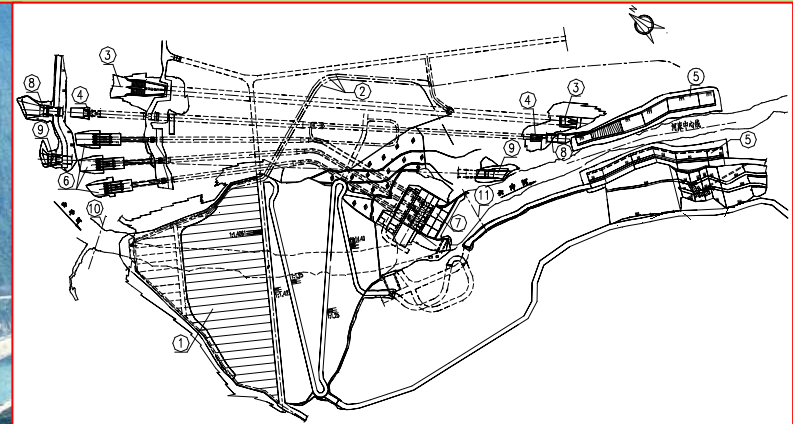
Shuibuya (Hubei, 233m high, Completed in 2008)

CFRD construction in China



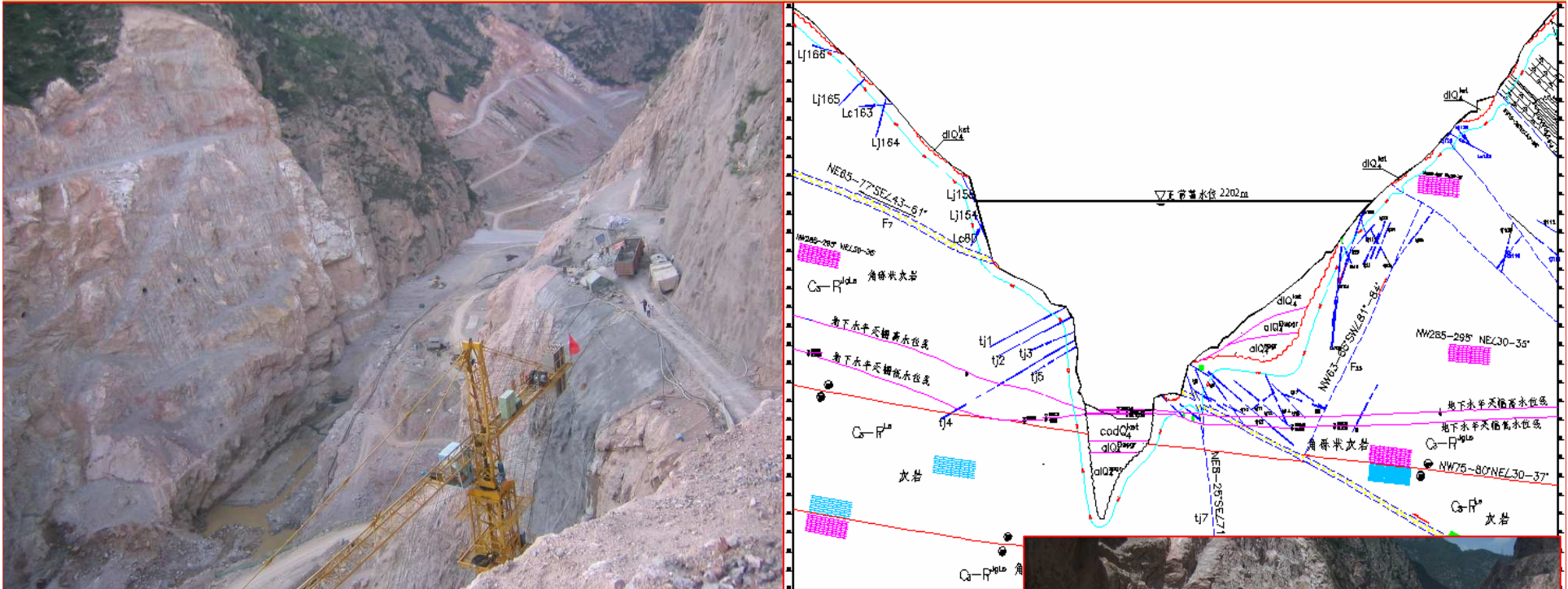
Tianshengqiao 1 dam (Guangxi & Guizhou, 178m high, 1104m of crest length, filling amount: **18 million m³**, total concrete face slab area: 177,000 m², total reservoir storage capacity: 10.257 billion m³;

CFRD construction in China



Hongjiadu (Guizhou, 179.5m high, built at very asymmetric valley with very high steep slope, plinth excavated slope is 310m high)

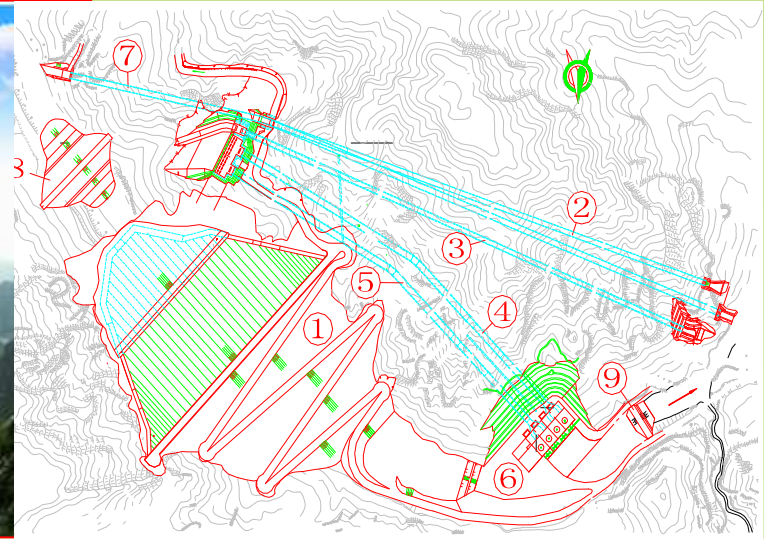
CFRD construction in China



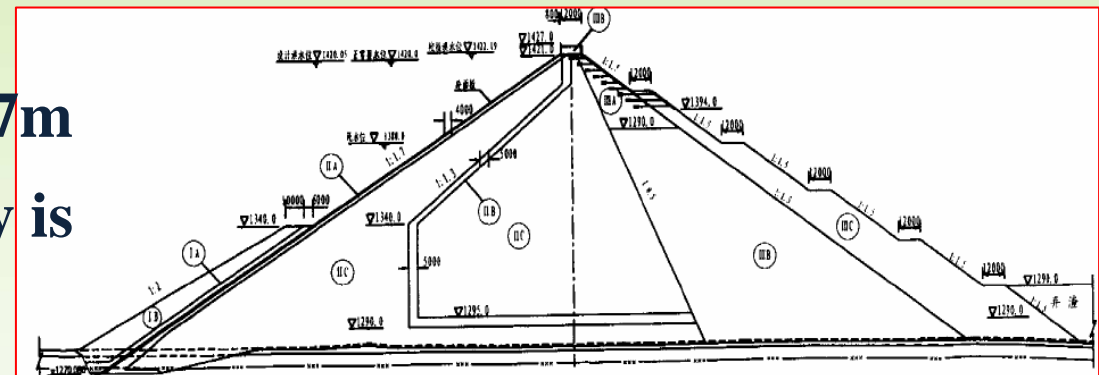
Jiudianxia (Gansu, 136.5m high, the highest CFRD built on 28m thick overburden under the plinth)



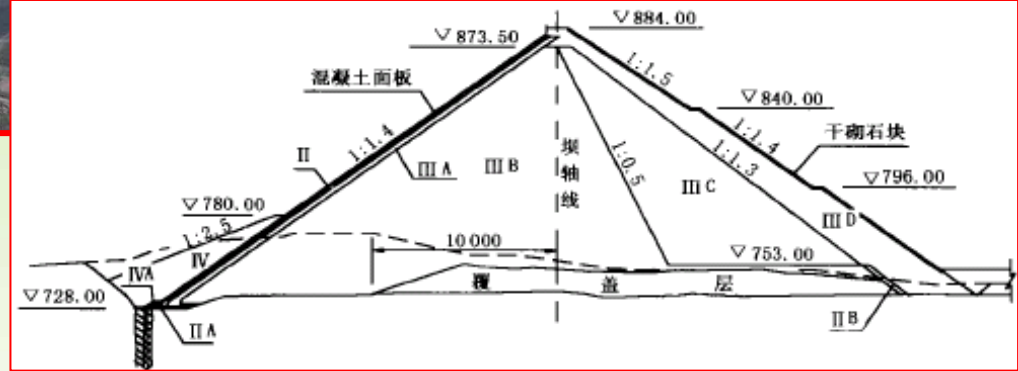
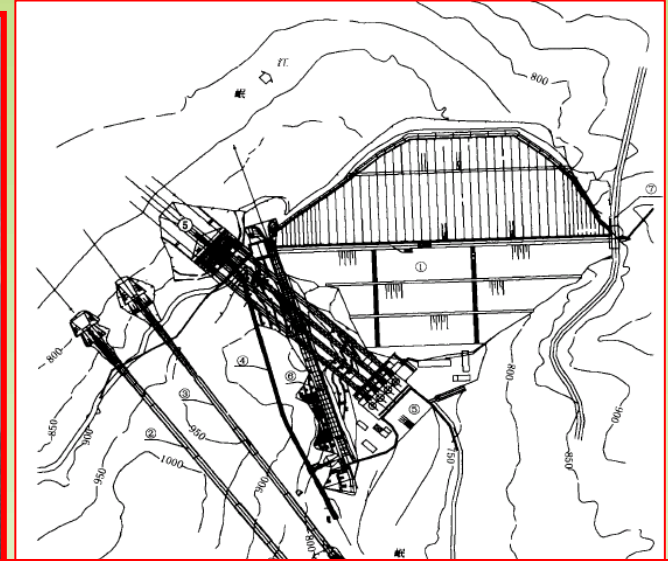
CFRD construction in China



Jilintai 1 (Xinjiang, 157m high, design seismic intensity is 9 degree)



CFRD construction in China



Zipingpu (Sichuan, 156m high, seismic intensity at dam site is 9 to 10 degree)

2 Main technical progresses

- 2.1 Dam site selection and dam layout
- 2.2 Dam body zoning and rockfill materials
- 2.3 Impermeable structures of the dam
- 2.4 Treatment of dam foundation
- 2.5 Diversion and passing flood season
- 2.6 Dam construction
- 2.7 Research on experiments and computation

- 2.8 Safety monitoring

3 CFRD under special conditions

- 3.1 Narrow valley with high steep slopes
- 3.2 Deep overburden foundations
- 3.3 High intensity regions
- 3.4 Cold regions

4 Experiences and lessons

- All defects of CFRD will be exposed in construction or operating period.
- In the past 25 years, accidents happened in more than 10 dams in China; the most serious one is collapse of **Gouhou Dam** and then severe leakage in **Zhushuqiao dam**.
- Structural cracks and extrusion destruction in face slab appear in some other dams. Reservoirs of several projects are emptied or lowed to examine and repair, and normal operation is regained.

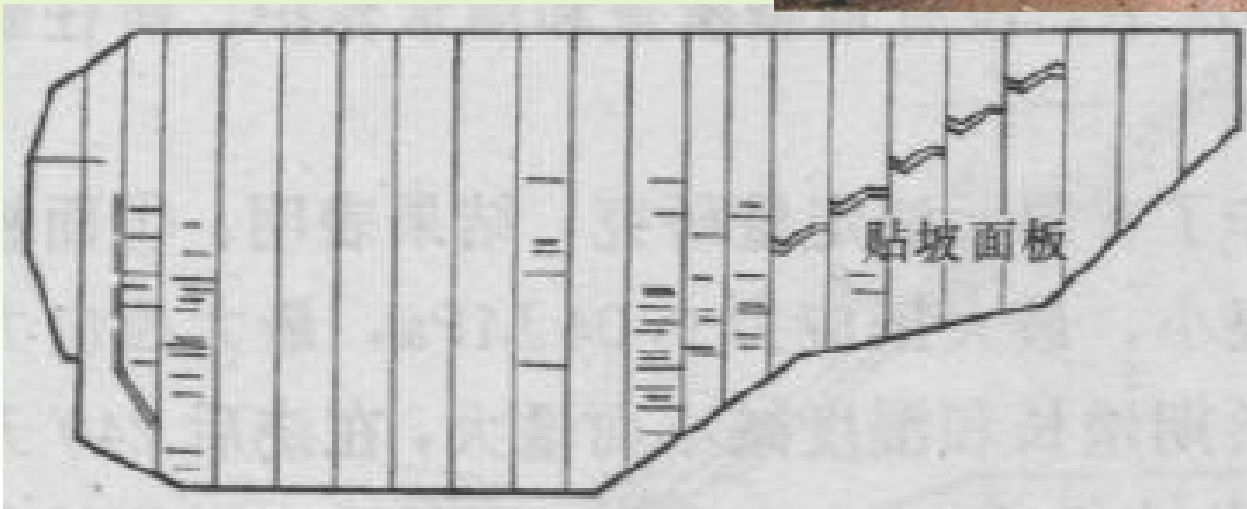
4 Experiences and lessons

Gouhou dam

71m high

Construct with sand
gravel materials without
special drainage

Collapsed in 1993



Zhushuqiao dam

78m high

97 cracks in the face

4 Experiences and lessons

- (1) **Temperature and shrinkage cracks in concrete.**
Since the 1990s, problem of temperature and shrinkage cracks in slab is basically solved with crack control measures, and relatively comprehensive crack control requirements are formed in current design and construction codes for CFRD.

4 Experiences and lessons

- (2) **Structural cracks and extrusion damage in the slab.**
Deformation control and measures to prevent structural cracks and extrusion damage are highlighted after 2000, therefore, accidents seldom happen.
- Soft rock content of mudstone material reaches about 30% in **Dongqing CFRD**, but no structural cracks are observed in face slab with the following measures:
 - strict control of dam settlement index.
 - increasing thickness of face slab appropriately.
 - measures against extrusion damage of vertical joints.

4 Experiences and lessons

- (3) **Seepage failure and hydraulic erosion.** Lessons are learnt from collapse of Gouhou dam and large amount of leakage in Zhushuqiao dam, the codes put forward the following requirements:
 - effective measures for seepage control is needed for dam utilizing gravel materials
 - hard-rock drainage layer is necessary at bottom of dam body
 - filter principles are required to be satisfied between transition and cushion materials.

4 Experiences and lessons

- **(4) Leakage of dam foundation.** The Karst cave filling with clay was pushed aside by high pressure water in **Xibeikou CFRD** foundation. Concentrated leaking channels occurred in plinth foundation in some other projects, the reservoir had to be emptied or lowed to examine and repair.
- So prophase investigation should be strengthened to expose possible geological defects and provide more basic data for design, and special treatment measures should be taken accordingly.

4 Experiences and lessons

- **(5) Reverse seepage failure.** Measures for preventing reverse seepage failure are listed in the current codes. However, there still are reverse seepage failures of several projects.
- Analysis indicates that it is important to choose right time and right way to plug reverse filtration drain pipe, and it is also very important to place weighted cover zone on the constructed slab timely.

4 Experiences and lessons

- **(6) Failure of joint water stops.** Accidents occurred in Gouhou and Zhushuqiao dam because of failure of joint water stops.
- Research and improvement of material and structure of joint water stops were focused in subsequent construction period, and the good effect was achieved.

5 Development and challenges in the future

- The dam height is higher.
- High CFRD built on deep overburdens.
- High CFRD built at very narrow valley.
- CFRD in extremely cold region.
- Aseismic research and engineering measures for high seismic intensity.
- Accurate test and computation.
- Safety monitoring of high dam and deep overburden foundation.

6 Conclusions

- (1) China has the largest number of CFRD and is at the forefront of the world in both project scale and technical difficulty.
- (2) The development of CFRD in China could be divided to three stages, and CFRD will gain more widely application with development of hydropower.

6 Conclusions

- (3) Based on lots of engineering practice of CFRD, comparatively complete technical standard system and industrialized system are established in investigate, design, construction, scientific research, safety monitoring and operation management.

6 Conclusions

- (4) From cases of Gouhou Dam's collapse and cracks occurred in slab of Zhushuqiao and Tianshengqiao 1 dam, reasons and lessons are analyzed and drawn; scientific research is strengthened and technologies for design and construction are improved; new breakthrough is made in deformation control, seepage control and crack control.

6 Conclusions

- (5) Through further effort in scientific research and engineering practice, a new level will be achieved in aseismic design and research of high CFRD, dam construction informationized and safety monitoring technology.

Thanks for your
attention!