International Symposium
Qualification of dynamic analyses of dams and their equipments
and of probabilistic assessment seismic hazard in Europe
31th August – 2nd September 2016 – Saint-Malo

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Session 7 : Qualification of equipment

COMPARISON JAPAN – FRANCE OF MECHANICAL DESIGN CRITERIA FOR GATES

SUMMARY

Introduction 1

- **Examples of gate ruin due to earthquake seem to be scarce and difficult to find**
  - Sefidrud Dam in Iran in 1990
  - Wenchuan earthquake in China in 2008
  - Vinça Dam in France in 1996
  - Shih-Kang dam in Taiwan in 1999 is the most spectacular, but the gates are still present

Introduction 2

- **In Japan :**
  - Many large earthquakes magnitude > 6.5
  - No damage reported on gates
  - Some cases of malfunction due to damage in hoisting machines or appurtenant structures

- **WHY so few damage?**

- **Hypothesis :**
  - Would Japanese gates be more resistant than others ?
  - Would this result from design criteria ?
- **Comparison :**
  - Would Japanese gates be more resistant than others ?
  - → Let's compare French and Japanese gates.

Comparison of design criteria

- **The standards :**
  - In Japan :
    - ❖ « Technical Standards for gates »
    - ❖ Very comprehensive (>460 pages)
  - In France :
    - ❖ German standard « DIN 19704 » (stahlwasserbau)
    - ❖ Refers to EUROCODE 1.3
    - ❖ EDF specifications in « CPC vannes »
- **Stiffness :**
  - Allowable stresses
  - Allowabale deflection
- **Architecture :**
  - Gate stiffening

Allowable stress

- **In Japan :**

$$\sigma_a = k_a \times \sigma_y / 2$$

- **In France**

$$\sigma \times \gamma_F = \sigma_y / \gamma_M$$

- **Normal case vs. earthquake case**

Allowable stresses for combined stresses, in MPa, for SMA490/ S355 steel

	Japan	France
Normal cases	195	239
Earth-quakes	266	293

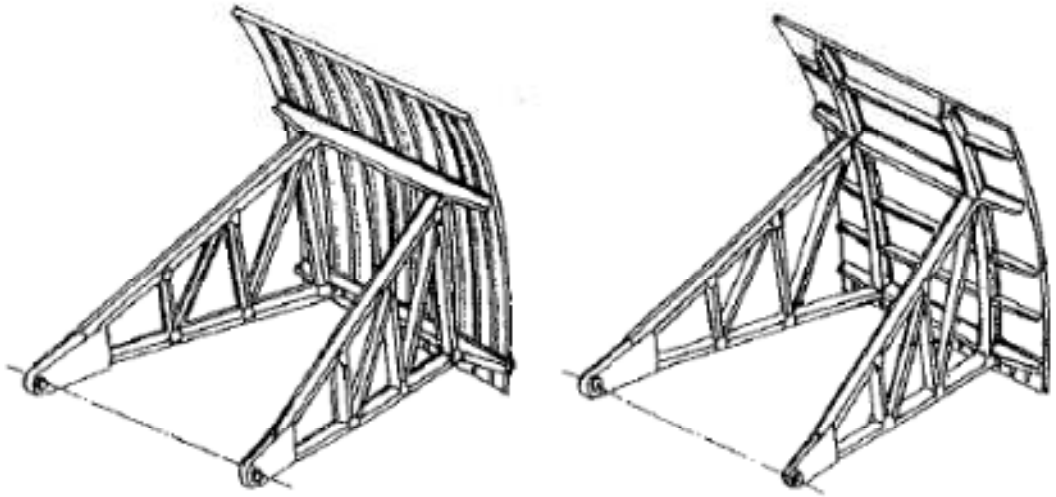
Allowable deflection

- **Deflection is important for gate water-tightness**
- **Allowable deflection is directly connected to gate stiffness**

- **Japan**
  - Table with 9 cases
  - Depends on position of gate and material of sealing
- **France**
  - No value required
  - Requires sealing deflection onto gate to be taken into account
  - Generally, manufacturers use 1/750

Allowable deflection, Dam crest gates, Rubber seals.	
Japan	**France**
1/800	1/750

Architecture



- **Vertically stiffened**
  - US design
- **Horizontally stiffened**
  - French design
- **In Japan**
  - Both designs

Illustrations of the 2 architectures

Japanese Vertically Stiffened gate;
Ohtori Dam : gravity arch;
Owner : J-Power;

French Horizontally Stiffened gate with flap;
Sainte Marguerite Dam: run-of-the-river;
Owner : EDF

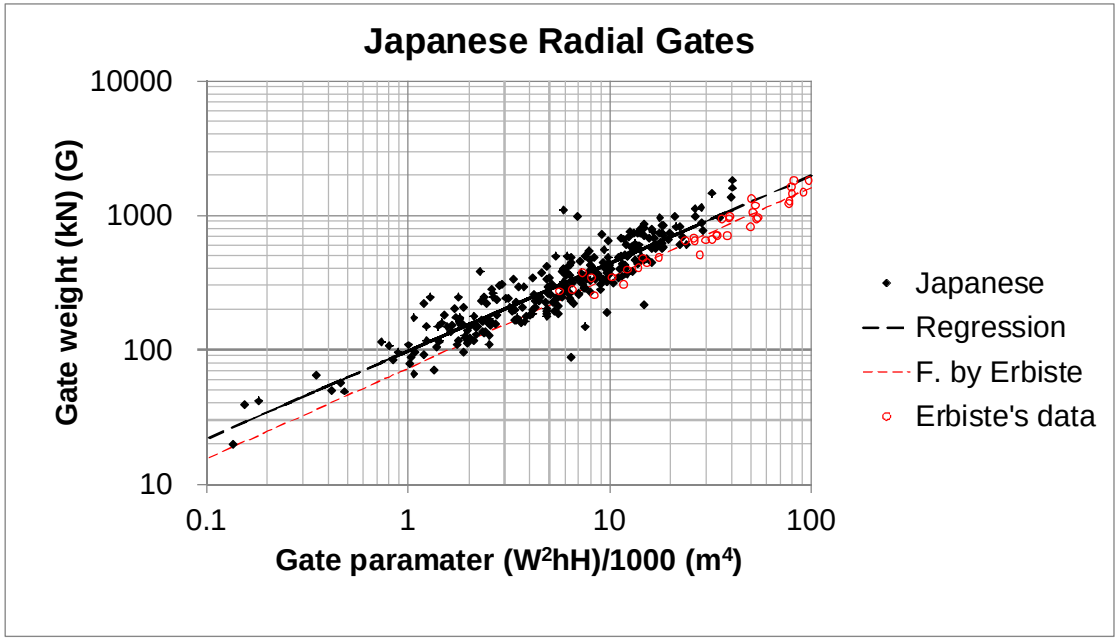
Comparison of weight 1

- **Mr. Erbisti's statistical formulae**
  - Analysis of weight of several gates
  - Excellent correlation for dam crest radial gates

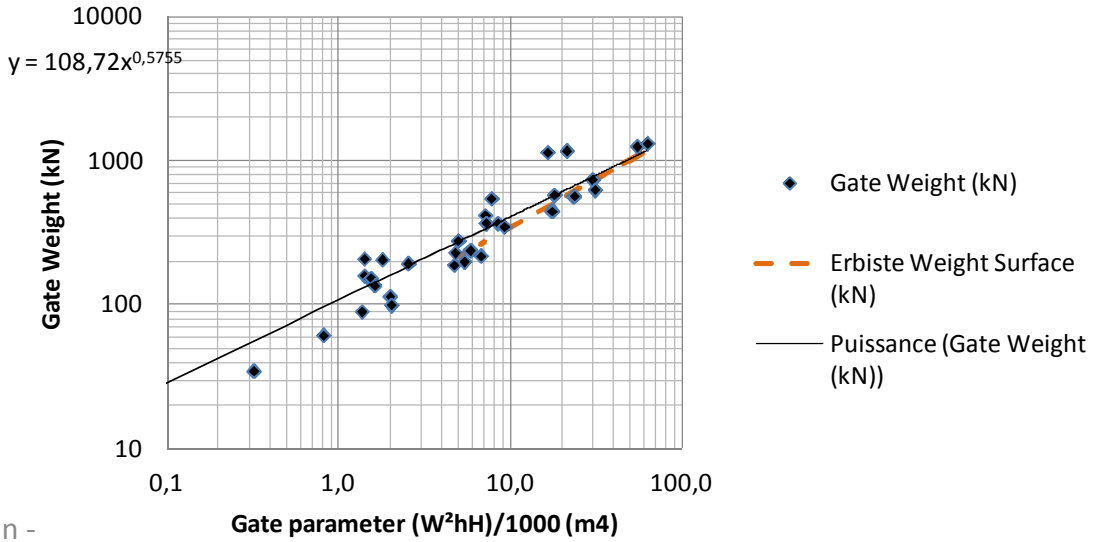
$$G = 0{,}3688 \times (W^2 hH)^{0.521}$$

- **Database for gates with dimensions and weight**
  - Japan
    - ❖ Very comprehensive and reliable
  - France
    - ❖ Just beginning; not all information available for the 8954 gates !

Comparison of weight 2



French Radial Gates



Conclusion

- **The aim of this document was to compare the Japanese and French design criteria:**
  - Indeed, allowable stresses are lower in Japan
  - It results in heavier (+10%) gates (at least for radial gates)
  - This leads to stiffer gates;
- **Regardless of seismic design loads, this higher gates stiffness may explain why Japanese gates suffered low damage throughout the many earthquakes they encountered;**
- **It may also be expected that taking into account earthquake for French new gates should lead to heavier ones;**
- **Nevertheless, hoists and appurtenant structures must not be forgotten.**


THANK YOU FOR
YOUR ATTENTION