International Seminar on Earthquake Engineering

Introduction and Basic Structural Dynamics

Dr. Martin Wieland
Chairman, ICOLD Committee on Seismic Aspects of Dam Design
Poyry Switzerland Ltd., Zurich, Switzerland

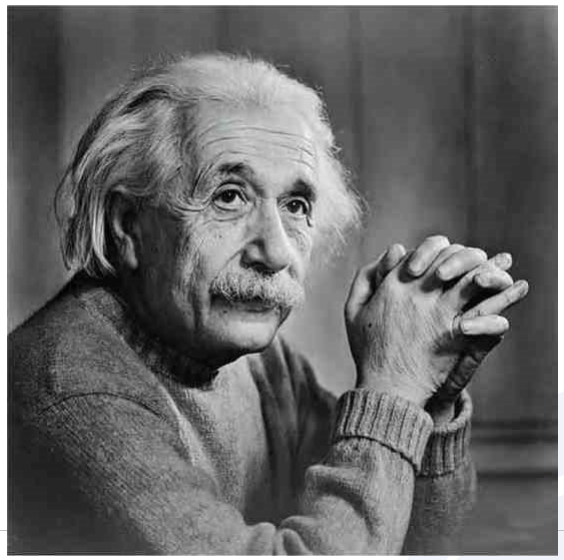
What is special about Switzerland?

Unique landscape: Eiger, Moench and Jungfrau

Roger Federer

PÖYRY

Albert Einstein, Swiss citizen, graduated from Swiss Federal Institute of Technology in Zurich (ETH)



PÖYRY

Leonhard Euler, Swiss citizen from my hometown Riehen near Basel, father of today's engineering analysis and much more

PÖYRY

Safety Problems: Recent dam failure in Laos (July 2018) (saddle dam)

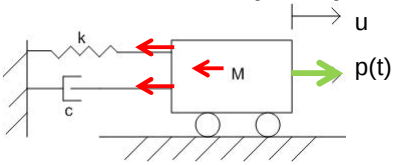
PÖYRY

Safety Problems: Recent event in Colombia during construction (April/May 2018)

PÖYRY

Basic Structural Dynamics: Single-degree-of-freedom oscillator

Single-degree-of-freedom oscillator (SDOF)



Equation of motion for **harmonic loading** (excitation frequency $\bar{\omega}$ in rad/s, frequency in Hz: F = $\bar{\omega}$/6.283)

$$m\,\ddot{u}(t) + c\dot{u}(t) + k\,u(t) = p_0 \sin(\bar{\omega} t)$$

Dynamic response amplitude: $u_{max} = u_s\, D$

Dynamic amplification factor: D

Static amplitude: $u_s = p_o/k$

Eigenfrequency of SDOF in rad/s: $w^2 = k/m$, and in Hz: f = w/6.283

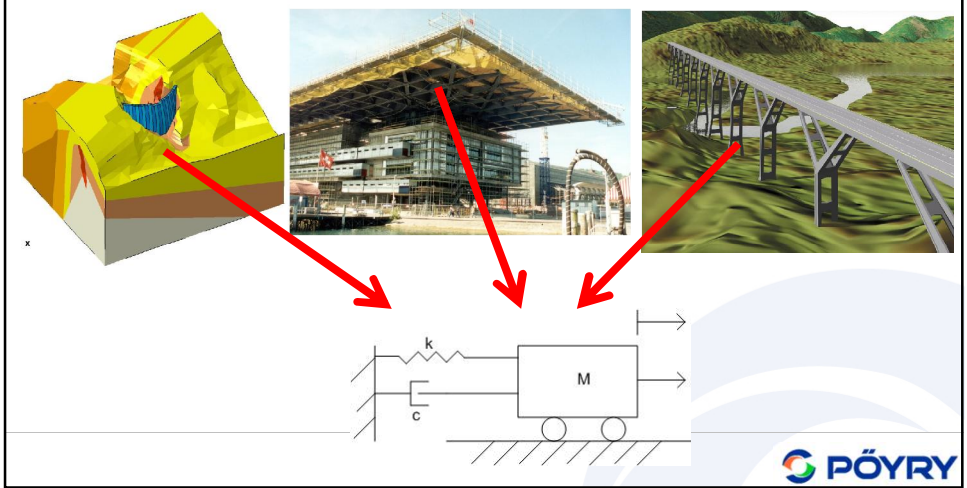
Damping ratio: $\xi = \frac{c}{2m\omega}$

Frequency ratio: F/f = $\bar{\omega}$ /w

PÖYRY

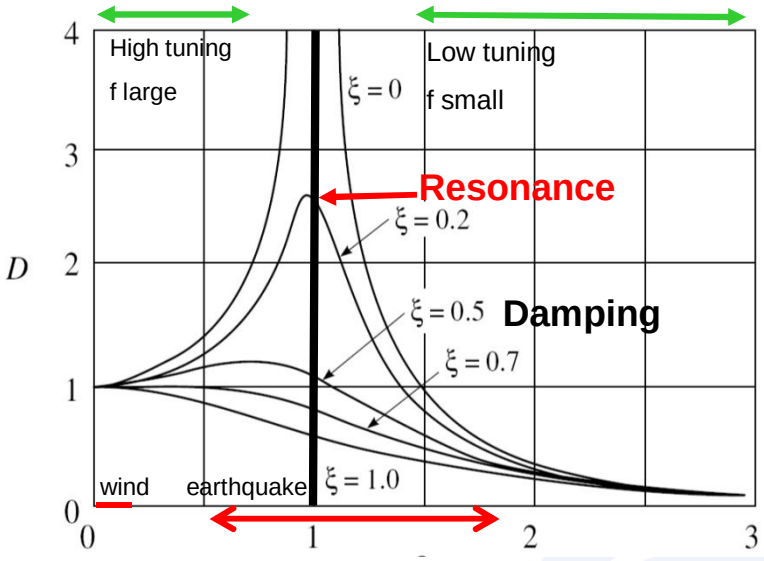
Generalized SDOF oscillator

As a first approximation, any linear-elastic structural system can be represented by a «generalized» SDOF oscillator. Therefore, a qualitative assessment based on the results of a SDOF oscillator is possible for these structures as well.



PÖYRY

Qualitative assessment of vibration problems



Dominant excitation frequency (F)/lowest eigenfrequenc of structure (f)

PÖYRY

Examples of excitation frequencies and eigenfrequencies of structures

Characteristc excitation frequencies F

- Wind gusts: <0.1 Hz
- Earthquake acceleration: 2-5 Hz

Fundamental (dominant) eigenfrequencies of structures f

- Low-rise buildings, most bridges: 2-10 Hz
- High-rise buildings, long-span bridges: <1 Hz
- Large concrete dams: 1.5-8 Hz
- Reservoirs of storage dams, long penstocks, pipes: <<0.1 Hz

Examples of frequency ratios F/f

- Wind on buildings: 0.1/(2 to 5) = 0.02-0.05
- Earthquake on dams: (2 to 5)/(1.5 to 8) = 0.25-3.33

PÖYRY

Climate Change and Existing Infrastructure

How to deal with time-dependent hazards including climate change

Most hazards from the natural and man-made environment change with time in nature and in codes due to increased safety requirements and/or new data or information

How to deal with changes in hazards?

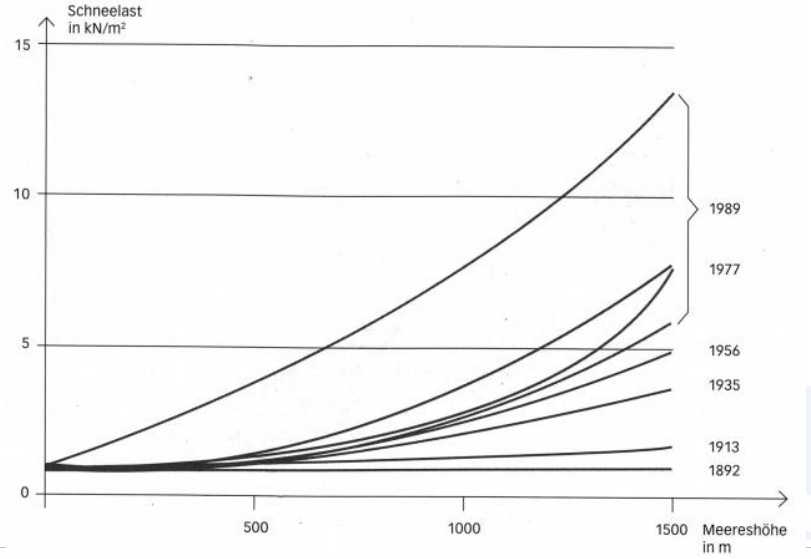
(i) periodic review of hazards

(ii) periodic safety check if hazard has changed or new safety criteria apply

(iii) rehabilitate or strengthen structure if safety is less than acceptable on specified in codes

PÖYRY

Change of Snow Loads in Swiss Code with Time (changes made prior to climate change concerns!)



PÖYRY