INTRODUCTION TO VIBRATIONS









Definition

Vibration refers to mechanical oscillations about an equilibrium point. The oscillations may be periodic such as the motion of a pendulum or random such as the movement of a tire on a gravel road.



Vibrations around us



Vibrator in cell phone



Sound



Tools



Shaver



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Rotating machines



Tram

Mechanism of vibrations



Mechanism of vibrations







Traditionnally, vibrations have not been a big concern in civil engineering, except for high levels of vibrations due to earthquakes



But

- Vibration sources are increasing
- Comfort demands are increasing
- Health issues are appearing
- In some cases, high precision technologies require very low vibration levels
- New designs make some structures more susceptible to vibrations

Civil engineering structures have evolved towards <u>slender structures</u> with low level of damping, where vibrations become an issue



An old arch bridge



The Millau viaduct

This trend is also visible in other areas (automotive, aerospace) : reduction of weigth for optimal use of material results in higher levels of vibrations

Vibrations in civil engineering

The Millenium bridge in London









https://www.youtube.com/watch?v=gQK21572oSU

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Vibrations in civil engineering

Vibrations of cables in cable-stayed bridges



https://www.youtube.com/watch?v=SsfQN1ilcGU



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Vibrations in civil engineering

High rise buildings



https://www.youtube.com/watch?v=i1sHJRCJPS4

A (catastrophic) example: Takoma Narrows bridge, USA, 1940



https://www.youtube.com/watch?v=XggxeuFDaDU





Vibrations in mechanical engineering

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Reduction of weigth for optimal use of material results in higher levels of vibrations

Vibrations in mechanical engineering

Aeroelastic flutter in aircrafts



https://www.youtube.com/watch?v=pEOmCkZyXzk

Vibrations in mechanical engineering

Car vibration



https://www.youtube.com/watch?v=kuV7xyRETzU

Vibrations in mechanical engineering

Vibrations leading to failure



https://www.youtube.com/watch?v=ZcdYIkrQVzA



Vibration sources

EXTERNAL SOURCES

Civil engineering

Seismic activity Traffic Construction equipment Wind, Waves Pedestrians

Mechanical engineering

Road / track Aerodynamic loading Environment (building) Acoustic perturbation

INTERNAL SOURCES

Ventilation systems Elevator and conveyance systems Fluid pumping equipment Machines and generators Aerobics and exercise rooms – human activity

Engine Pump Generator Actuators Rotating elements (wheels, ...)

Undesirable effects of vibrations

- Fatigue
- Noise
- Comfort
- Health
- Performances
- ...
- (collapse)



https://commons.wikimedia.org/

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Positive effects of vibrations

- High frequency vibrations to decrease friction in engines (formula 1)
- Electric toothbrush, sander
- Musical instrument, loudspeaker
- Vibrating seats





Engineering vibrations

The study of vibrations in objects/structures/systems is a 4 steps procedure :

- 1. Identify the source and type of excitation
- 2. Model the effects of the vibrations
- 3. Modify the design to reach desirable vibration levels
- 4. Use remedial measures if the desired vibration levels are not reached



Practical cases in civil engineering



Pedestrian induced vibrations of footbridges



Machinery induced vibrations in buildings



Vibrations of highrise buildings

Vibrations

caused by

traffic

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Practical cases in mechanical engineering



Payload comfort in space launchers



Engine vibration



Car suspension

Aircraft tail/wing vibration



Fatigue of wind turbines

