Budapest University of Technology and Economics

Department of Mechanics, Materials and Structures

English courses

General course /2016

Fundamentals of Structures

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Lecture no. 1:

Introduction
Aims of the course
Building design problems
Loads and effects acting on loadbearing structures of buildings

Introduction

Our subject:

FUNDAMENTALS OF STRUCTURES

Lecturers: Dr. András Draskóczy, Dr. András Sipos

Department: DEPARTMENT OF MECHANICS, MATERIALS AND STRUCTURES

Building K 2nd floor 61.

Topics schedule and requirements are available on the website of the Department: www.szt.bme/english courses/fundamentals of structures/2016.hu

To get information about the subject, choose: English, Download, English courses, Fundamentals of Structures, 2016

Weekly reception hours are communicated on the home page and at the entrance of the Department

András Draskóczy: Tuesdays 11.00-12.00 am.

Use also the online Q&A platform piazza (piazza.com)!

A**ims of the course**

-review some of the most important topics of *kinematics* and *statics*

-acquire *general overview about problems of architectural and structural design and construction* through *site visits* at:

an existing building,
a material testing laboratory,
a construction site,
an architectural design buro and

discussing the experiences gained at the above visits

-making *preparatory steps in numerical problem solution in the field of kinematics and statics:* resultant and equilibration of coplanar forces

-help to decide definitively to continue studies in architectural (or civil) engineering

Problems related to building design

Functions? Magnitude, dimensions?

Way of handling of local conditions?

Characteristics of the natural and built environment, local building prescriptions, culture, climate, orientation, slope, underground conditions

Materials (products, constructions) to use?

Availability of local materials, economic, functional and aesthetical considerations

Aesthetical considerations?

Way of handling of the

requirement of the unity of form and function,

materials, forms and styling, colours, surface structures to apply?

Economic considerations?

Safety considerations?

The need of a *design team*

Parts of buildings	the designer of the parts
The house as a whole	architect,
composition of building constructions	the chef of the design team
Installations	
Piping (water, waste water, heating)	building mechanical engineer
Electric supply, informatics	electric and informatics engineer
Loadbearing structures	*civil or structural engineer*

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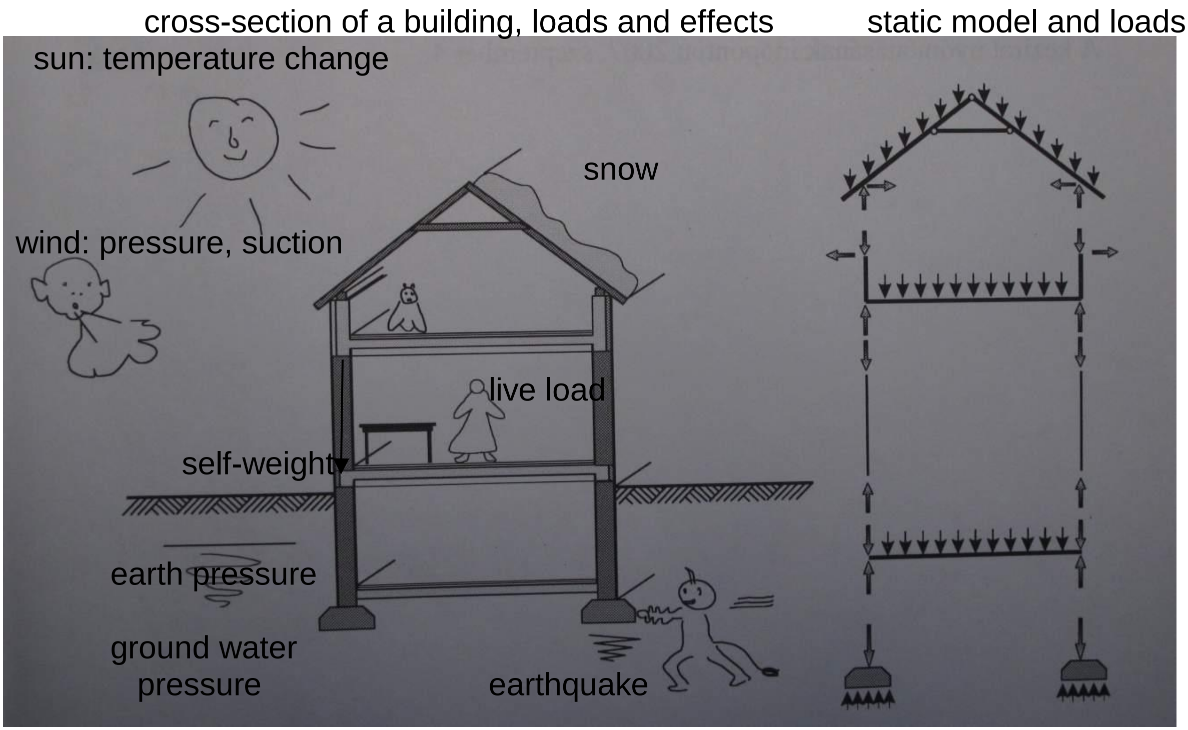
Furnishing	architect of the interior
Surroundings of the building	garden architect

Most of the *safety requirements* refer to the *loadbearing structures*

Safety against	Requirement
rupture and collapse: adequate	***bearing capacity*** of the members of the loadbearing structure
buckling, overturning, sliding:	***stability*** of the loadbearing structure and of all of the structural members
corrosion or *fatigue failure*	***durability*** of the structural materials:
fire collapse:	***fire resistance*** of the structural members

Buildings and loads



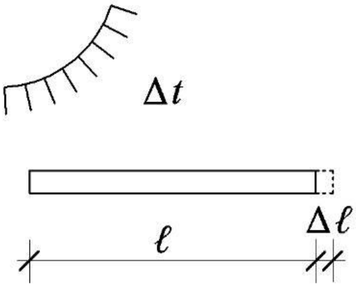
Loads and effects

According to present international terminology, loads are also effects

According to traditional terminology:

Examples for **effects** are:

- *temperature effects*: that give rise to volume (length) changes:



$$\Delta l = \alpha l \Delta t \text{ (mm)}$$

where Δl means alongation (contraction) (mm)

α: linear coefficient of thermal expansion of the material (1/°C)

(For axample for concrete: $\alpha_{concrete} = 10^{-5}$ 1/°C)

l: length of a linear member (mm)

Δt: temperature change (°C)

-*corrosion effects*: for example oxidation of steel

-*aging*, for example plastics become more brittle with time
brittle behaviour: rigid rupture without previous deformation

Loads according to traditional meaning of the word are **forces** that are acting onto the structure

Definition of forces

2nd law of Newton:

$$F = ma$$

Where: *m* stands for mass (kg)
a means acceleration (m/sec^2)
unit of forces: 1 kgm/sec^2 = 1 N (Newton)

The most commonly known kind of acceleration is caused by the *gravitational attraction of the Earth*: $g = 9{,}81 m/sec^2$

Self-weight of masses:

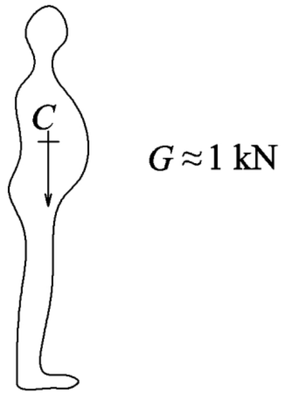
G=mg (N)

The selfweight of 1 kg mass is: $G = 1 \cdot 9{,}81 \approx 10 \text{kgm}/\text{sec}^2$ = 10 N

The most commonly used *unit of forces* (loads) is 1 kN= 1000 N

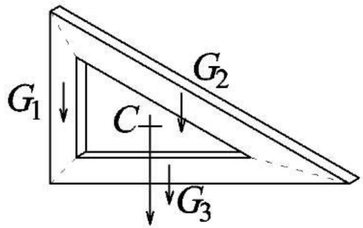
A frequent case of occurance of 1 kN is the appr. weight of 1 thick man:

C: centre of gravity
(point of application)



The vector character of forces

The selfweight *G* is an **idealization**, the resultant of a distributed parallel force system: the sum of the weights of the elementary parts of a body (mass), acting in vertical direction and passing through the *centre of gravity* (C) of the body. The self-weight of a set-square for example:



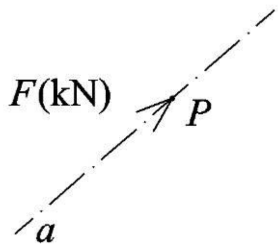
$$G = G_1 + G_2 + G_3$$

The self-weight *G* as an idealized resultant force is called a ***concentrated force***.

The vector character of concentrated forces

means further idealization, that is a generalized force in the space can be defined by the following data:

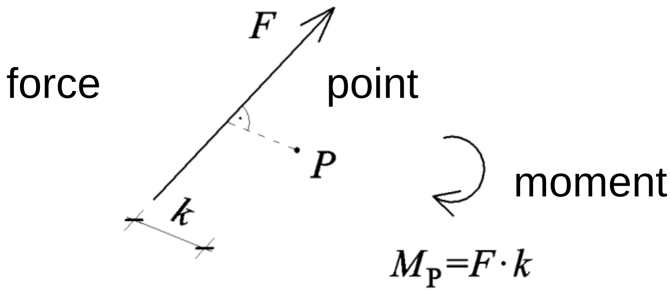
1. point of application (*P*)
2. line of action (*a*)
3. direction (arrow head)
4. magnitude *F* (kN)



The vector character of forces is exploited by determining the resultant of planar or spatial force systems and by equilibration problems, and will be practiced in the subject Statics.

The effect of a force *F* will not change by shifting the force along its line of action.

The moment of a force



The moment of a force *F* with respect to a point *P* is $M = Fk$ (kNm) where *k* is the distance of point *P* from the line of action of the force *F*, called also *lever arm*.

The *sense* (direction) *of a moment* is indicated by an arrow head on the sign (semicircle) of the moment.

The effect of a moment *M* will not change by shifting the moment parallel to its plane in any position in the space.

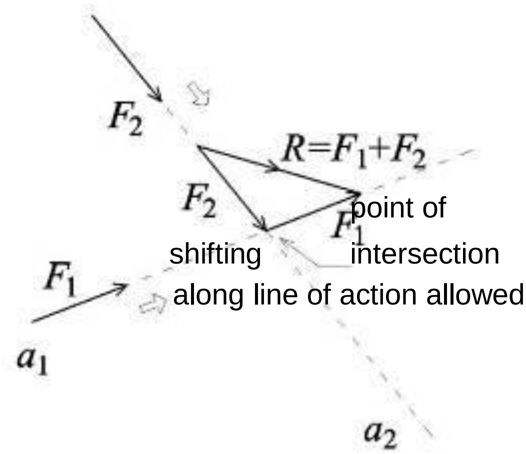
The summation of forces in the plane: the resultant force, the couple

Geometrical (graphical) method:

Use of *force scale*:

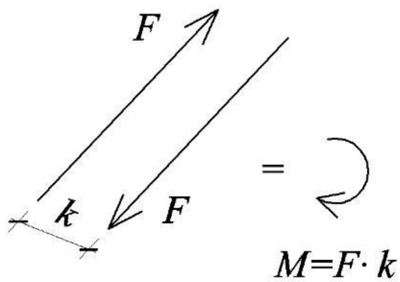
1 kN ≡ 1 cm

F_1 and F_2 lie in the same plane



The couple

The resultant of two parallel forces F of equal magnitude, opposite direction and distance k is a moment *M=Fk*. The two forces are called a *couple*.



Classification of loads

1. According to ***mode of actuation***:

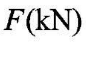
Static loads:
slowly increasing to the total intensity
example: snow load, imposed loads (live loads)
Dynamic loads:
rapidly increasing to the total intensity
example: earthquake loads, explosion, brake forces of cranes
Cinematic loads:
forced dislocations
example: uneven settlement, thermal expansion

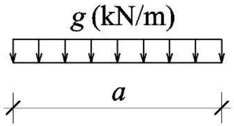
2. According to ***duration of application* and variation**

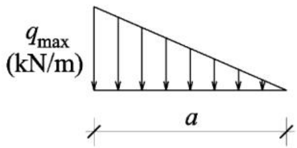
Permanent loads	*Variable loads*
self weight	imposed loads (live loads)
weight of equipments	meteorological loads (snow, wind)

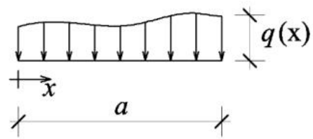
3. According to ***distribution*** of loads
Concentrated load (a)
Distributed *planar* (or coplanar) loads
uniformly distributed load (b)
triangular (linearly variable) (c)
general (d)

Examples for planar loads:







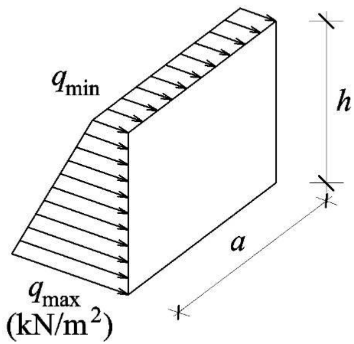


concentrated load | uniformly distrubuted load | triangular load | general distributed load

*Spatial l*oad system

Examples:

earth pressure



uniformly distributed
gravity forces acting on a surface
(self-weight of a floor construction or
live load intensity on a floor)