



Budapest University of Technology and Economics

Department of Mechanics, Materials and Structures
English courses
General course /2015
Fundamentals of Structures

András Draskóczy
Lecture no. 1:

Introduction
Aims of the course
Aspects of building design, example
Actions and loads effecting loadbearing structures

Introduction, general information, ways of communication

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/2015.hu

To get to informations of the subject, choose: English, Download, English courses, Fundamentals of Structures, 2015

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

András Draskóczy: Tuesdays 11.00-12.00 am.

General aims of the course:

-review the most important topics of *matematics* as educated in Hungarian middle-schools

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

an existing building

a construction site

a material testing laboratory

a design buro and

discussing the experiences gained at the above visits

-making *preparatory steps in numerical problem solution in the field of statics* (one of our basic subjects): determination of the resultant and equilibration of coplanar force systems.

-*help the students to decide definitively to continue studies in direction of architectural engineering*

Aspects of building design

Variety of considerations emerging when designing buildings

Functions?

Magnitude?

Placing?

Local conditions? Characteristics of the natural and built environment, local building prescriptions? Climate, orientation, slope, underground conditions?

Materials (products, constructions) to use?

Availability of local materials, economic and aesthetical considerations

Aesthetical considerations

Way of handling of the requirement of the unity of form and function, styling, materials, forms, colours, surface structures to apply

Economic considerations

Safety considerations

The need of a design team

Parts of buildings	the designer
The house, the building constructions	the architect
	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
Furnishing	architect of the interior
Surroundings of the building	garden architect

Most of the safety requirements refer to the loadbearing structures:

Safety against *rupture and collapse*:

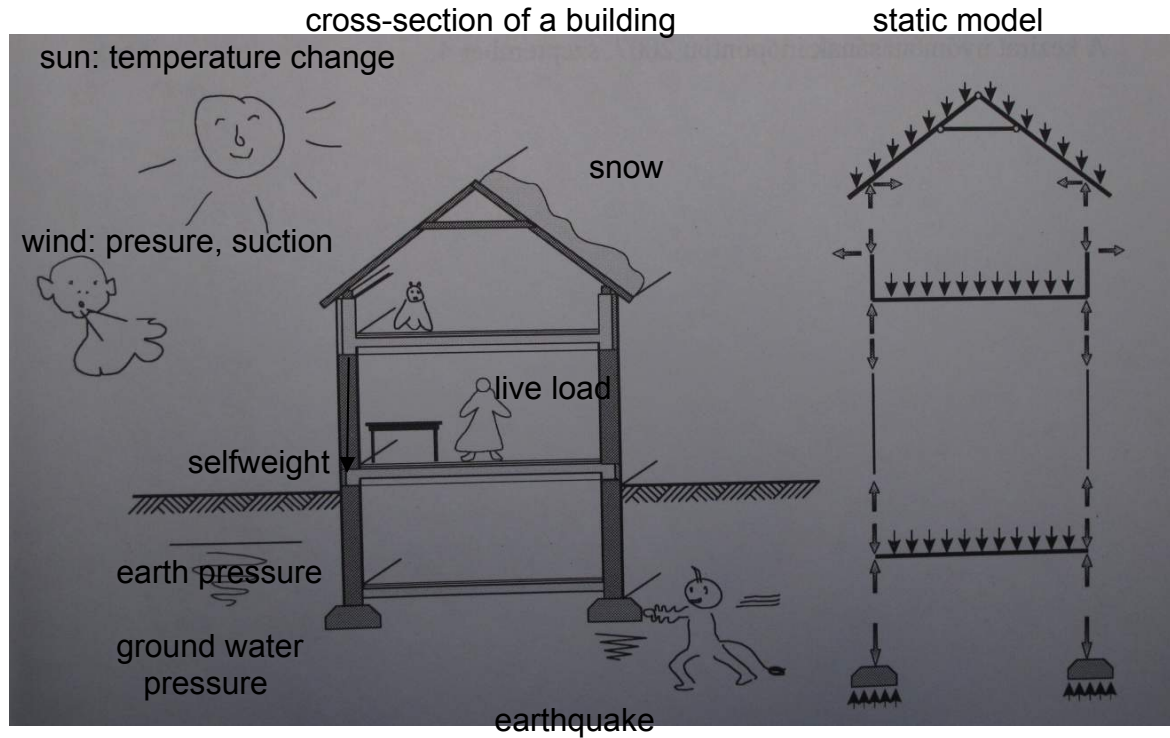
adequate ***bearing capacity*** of the members of the loadbearing structure

Safety against *buckling, overturning, sliding*: ***stability*** of the loadbearing structure and of all of the structural members

Durability of the structural materials: no rupture can occur due to *corrosion* or *fatigue*

Safety against fire: adequate ***fire resistance*** of the structural members

Buildings and loads



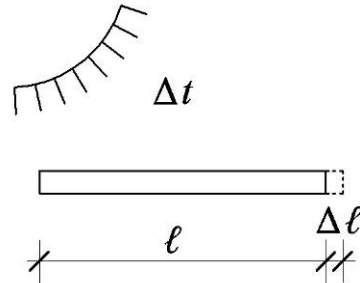
1. Loads and effects

According to present 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 elongation (contraction) (mm)

α : linear coefficient of thermal expansion of the material ($1/^\circ\text{C}$)

(For example for concrete: $\alpha_{\text{concrete}} = 10^{-5} 1/^\circ\text{C}$)

l : length of a linear member (mm)

Δt : temperature change ($^\circ\text{C}$)

-*corrosion effects*: for example oxidation of steel
-*aging*, for example plastics become more brittle with time
-*creep and shrinkage* of concrete (will be discussed in detail later)

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

2. Forces

Definition of forces by the 2nd law of Newton:

$$F=ma$$

where: *m* stands for mass (kg)
a means acceleration (m/sec²)

unit of forces: $1 \text{ kgm/sec}^2 = 1 \text{ N (Newton)}$

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

which produces the **(self)weight** of masses:

$$G = mg \text{ (N)}$$

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

The most commonly used unit of forces (loads) is $1 \text{ kN} = 1000 \text{ N}$

A frequent case of occurrence of 1 kN is the weight of 1 thick man:

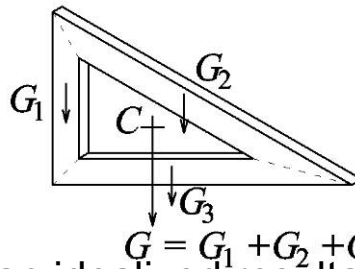
C: center of gravity
(point of application)



$G \approx 1 \text{ kN}$

3. The vector character of forces

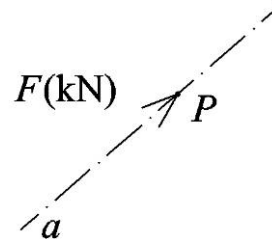
The selfweight G is an **idealization**, the resultant of a distributed (parallel) force system: the sum of the weights of the elementary parts of a body (mass), acting in vertical direction and passing through the centre of gravity (C) of the body. The selfweight of a set-square for example:



The selfweight 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:

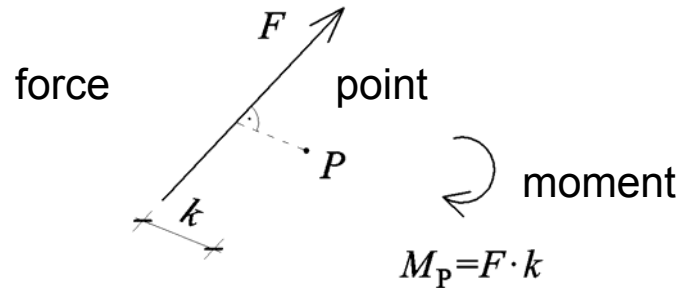
1. point of application (P)
2. line of action (a)
3. direction (arrow head)
4. magnitude F (kN)



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.

4. 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.

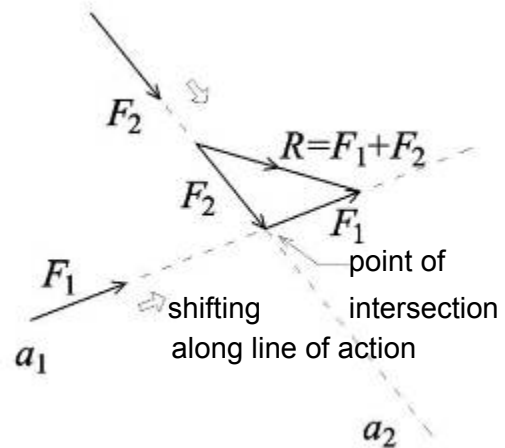
5. The summation of forces in the plane: the resultant force, the couple

a) Geometrical (graphical) method:

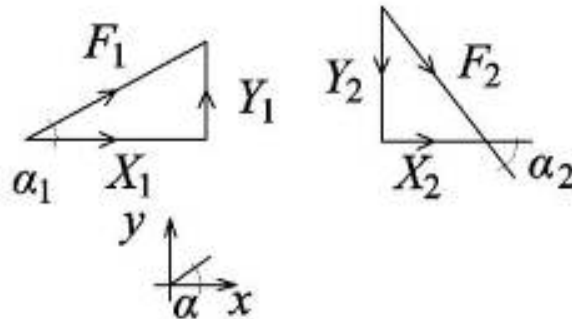
Use of *force scale*:

$$1 \text{ kN} \equiv 1 \text{ cm}$$

F_1 and F_2 lie in the same plane



b) Analytical (numerical) method



$$R_x = X_1 + X_2$$

$$R_y = Y_1 + Y_2$$

$$R = \sqrt{R_x^2 + R_y^2} \text{ (kN)}$$

$$X_1 = F_1 \cos \alpha_1$$

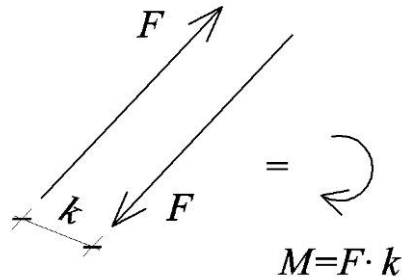
$$X_2 = F_2 \cos \alpha_2$$

$$\alpha_R = \arctg \frac{R_y}{R_x}$$

Line of action of R passes through the point of intersection of the lines of action of F_1 and F_2 .

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*.



6. Classification of loads

6.1 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

6.2 According to **duration of application and variation**

Permanent loads

self weight

weight of equipments

Variable loads

imposed loads (live loads)

meteorological loads (snow, wind)

6.3 According to **distribution** of loads

Concentrated (a)

Distributed *coplanar* loads

uniformly distributed (b)

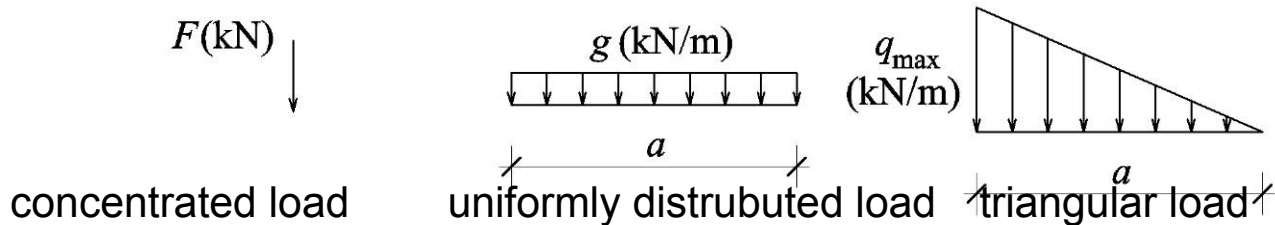
triangular (linearly variable) (c)

general (d)

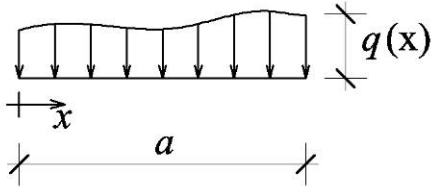
Spatial load system: gravity forces (e)

earth pressure (f)

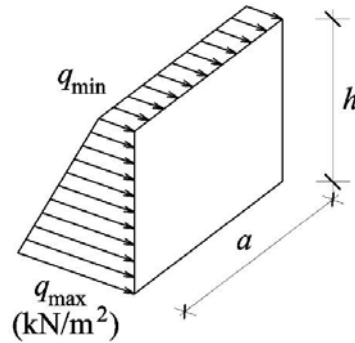
Examples for planar loads:



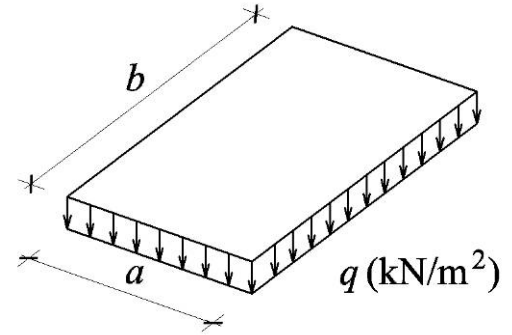
Examples for spatial loads:



general distributed
load



earth pressure



uniformly
distributed spatial load

7. Different values of loads

Due to safety considerations, in different investigations of the structure different values of the loads are to be used

Characteristic value: F_k, G_k, Q_k, g_k, q_k

Different characteristic values of variable loads are used in different loading situations:

Combination value: $\psi_0 q_k$

Frequent value $\psi_1 q_k$ $\psi_2 < \psi_1 < \psi_0 < 1$

quasi permanent value $\psi_2 q_k$

Design value:

$G_d = \gamma_G G_k$ $\gamma_G = 1,35$ **partial safety factor** of permanent loads

$g_d = \gamma_G g_k$

$q_d = \gamma_Q q_k$ $\gamma_Q = 1,5$ **partial safety factor** of variable loads

The determination of the characteristic value of loads is made through **statistical evaluation** of measurement data.

8. Magnitude of loads

Permanent loads

Design tables contain **specific weights** of

-building materials (kN/m^3)

-stored materials

-structures, building constructions (kN/m^2)

Variable loads

Imposed loads (**live loads**): varying according to the functions of buildings

uniformly distributed vertical load
intensity (kN/m^2)

Residential, hospitals, hostels: 2-4

Offices 3

Areas susceptible to overcrowding 5

Department stores 5

Meteorological loads

Snow load varying according to

Geographical location

Altitude

Slope of the roof

Exposure

$s_k = 1,0 \text{ kN/m}^2$ uniformly distributed vertical load in Hungary acting on horizontal surfaces and altitudes $\leq 400 \text{ m}$

Wind load

Wind pressure (kN/m^2) influenced by

Reference mean velocity pressure

Exposure

Reference height

External pressure coefficient

Air density

$w_k = 0,5 \text{ to } 1,0 \text{ kN/m}^2$ uniformly distributed load acting in perpendicular (or parallel) direction to the surfaces of the building:
wind pressure (+), wind suction (-) (friction)

9. Area and position of the **centre of gravity** of simple plane figures

-rectangle: $A=ab$

-triangle: $A=ah_a/2$

-circle, semicircle: $A=r^2\pi$ and $A=r^2\pi/2$

-area under and above a second degree parabola: $A=2x_1y_1/3$ and $A=x_1y_1/3$

