Budapest University of Technology and Economics

Department of Mechanics, Materials and Structures
English courses
General course /2018
Fundamentals of Structures

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Lecture no. 2:

I. Building design requirements
II. Forces, loads and effects

I/1. General problems related to building design

Main components of buildings

Spaces		Constructions
(main) functional spaces		building constructions
services for	circulation	loadbearing constructions
	social activities	installations
	installations	

Main design characteristics of the components

Connections	Connections
Form and dimensions	Form and dimensions
	Materials

Main design requirements

Functionality	Functionality
Human comfort	Safety
Economics	Economics
Aesthetics	Aesthetics

Fundamental requirement of architectural design:

Unity of function, construction and form

Some questions to put about the way of fulfilment of requirements

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, loadbering and aesthetical considerations

Aesthetics?

Way of handling of the general architectural *requirement of the unity of function, construction and form*

Materials, forms (space ratios, dimensions) and styling, colours, surface structures to apply?

Economic considerations: prize/performance rate?

Safety considerations: Safe use? Danger of slip, air pollution etc.

Numerical verification of safety against rupture and collapse of the loadbearing structures

The need of a *design team*

Parts of buildings	the designer of the parts
The house as a whole composition of *building constructions*	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

2. Investigation of the fulfilment of the fundamental requirements in case of the K-building

that of its *functional units* (spaces)
and of *constructional units* (building constructions)

-*functionality*: that is to serve well the purpose they were designed and are used for

-*safety*:

safe use without health damage or accidents

no rupture or collapse of the load-bearing structure

-*aesthetics*

-*economics*: advantageous prize/performance rate

expenses: the total sum of money spent for design and construction, maintenance, rehabilitation and demolition

Try to put questions and formulate critical observations!

Detailed content of the fundamental requirements

-functionality, requirements of human comfort and use

acoustic insulation
heat insulation
water and humidity insulation
natural illumination, orientation to sunshine, orientation to panoramic view, aspects of intimacy
space dimensions fitting to use
materials used fitting to use
cleanable surfaces, possibility of maintenance, reconstruction, demolishment

-safety

dust-free, slip-proof pavement
anti-hurt details, rounded edges and corners
safe bearing capacity of the loadbearing structural system
well operating ventillation system
fire resistance of the loadbearing structural system

durability of the load-bearing structural system

-*aesthetics* (human aspect, that can not be prescribed in detail, and is motivated by the latest fashion)

interior and exterior *forms* and textures

colours applied, harmony of colours

material use

surfice *decoration*

light propagation, distribution (l. introduction, reflexion)

environmental *harmony*, harmony of the different components

-*economic solutions*

prize/performance rate which proofs to be acceptable by all the investor, the user and the taxpayer citizens

Many of the design decisions have influence onto the fulfilment of several main requirements, for example:

-*material use* (the choice of a given material for a given purpose) has all functional, safety, aesthetical and economic aspects (consequences)

Analysis of the way and rate of fulfilment of the general and detailed requirements
of the *functional units* and of the *construction units*
of the central (K) building of the TUB

service areas
- corridors, staircases, elevators
- sanitary rooms
- bureaus
- departments

educational areas
- classrooms
- lecture halls

communal areas
- assembly hall
- aula

roof constructions
top floor constructions
intermediate floor constructions
pavement constructions
facade wall constructions
intermediate load-bearing walls
columns
partition walls
doors and windows
pavements

diff. kinds of installations:
piping and conducts (water, electricity, heating, waste-water, comm. lines, lighting, radiators, sanitary inst.) etc.

The way of analysing of the fulfilment of the fundamental requirements

by answering *questions* *concerning*

spaces of the building or *constructions* of the building:

for example:

1. -What are its functions? Does it serve well all the important functions that were to be considered by design?

For example in the K building:

aula doors of the classrooms

- -

Or another question:

2. -Is its use safe, considering all aspects of safety? What is the rate of danger of accidents, or of getting ill by normal use, or of losing the bearing capacity (if it is a loadbearing structure)?

Concerning other examples in the K building, like:

classrooms floor constructions

- -

Or :

3. -Does its outlook meet the aesthetical requirements of the present? (Unity of function and form, colour harmony, aspects of material use, surface textures harmony, environmental harmony etc.)

Considering the examples in the K building:

aula doors of the classrooms

- -

Or:

4. -Is its prize/performance rate acceptable by all participants interested in construction, use and demolishment?

Examples in the K building

classrooms stair flights

And so on…

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

Safety requirements of loadbearing structures

Safety against	Requirement
rupture and collapse due to overloading	***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

III. Forces, loads and effects

Definition of forces

2nd law of Newton:

$$F=ma$$

Where: *F* is (concentrated) force (Newton= kg·m/sec^2)
m stands for mass (kg)
a means acceleration (m/sec^2)

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

Self-weight of masses:

$G = mg$ (N)

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

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

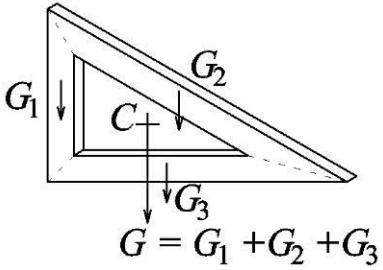
A frequent case of occurance of 1 kN is the appr. weight of 1 thick man:

C: centre of gravity
(point of application)

$G \approx 1$ kN

The vector character of forces

The selfweight *G* as a concentrated force 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:

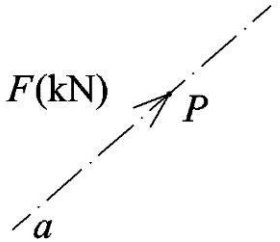


The self-weight *G* as an idealized resultant force is called a ***concentrated force***.

The vector character of concentrated forces

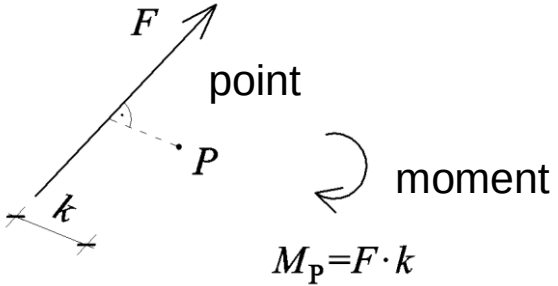
means further idealization, that is a generalized force in the space can be defined by the following data:

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 during this course and 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)

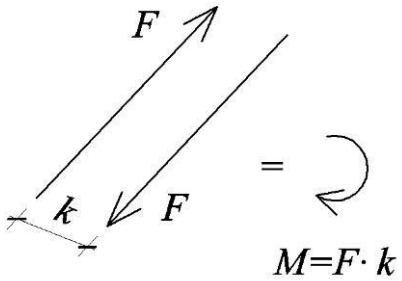
where *k* is the distance of point *P* from the line of action of the force *F*, called also *lever arm*.

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 couple

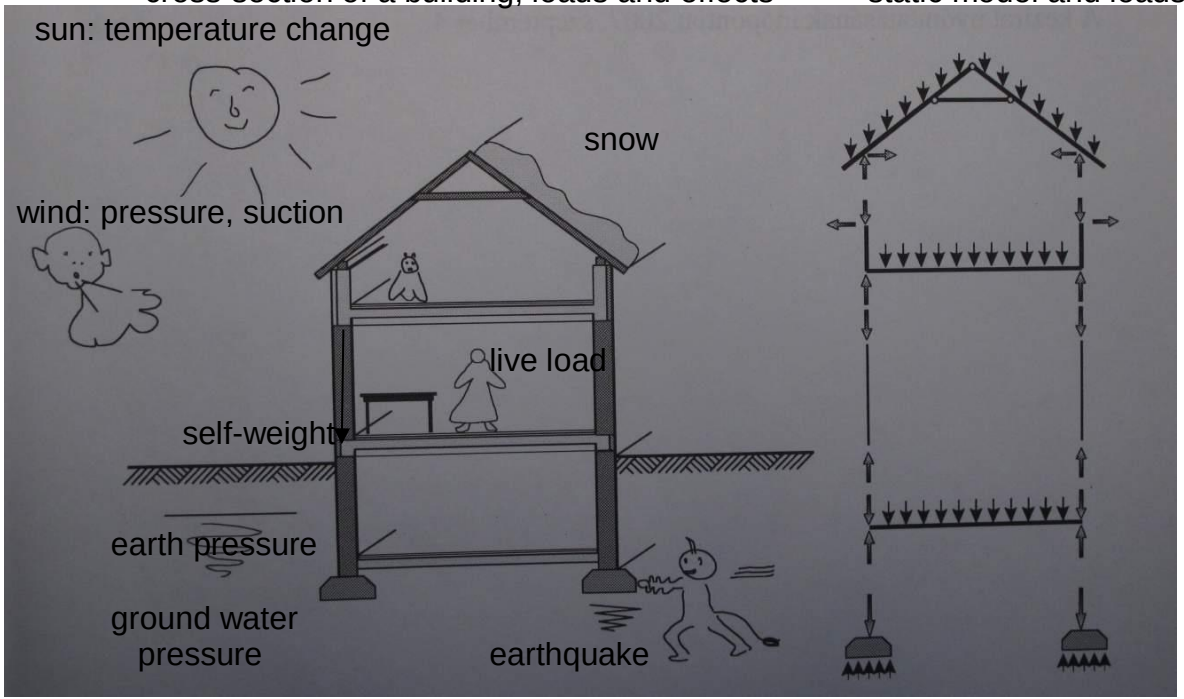
The resultant of two parallel forces F of equal magnitude, opposite direction and distance k is a moment *M=Fk*. The two forces are called a *couple* or *couple of forces*.



Buildings and loads

cross-section of a building, loads and effects

static model and loads



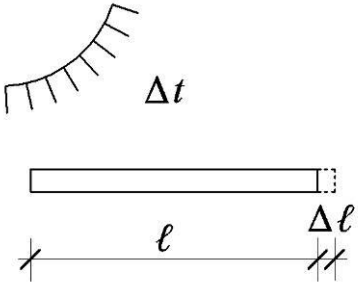
Loads and effects

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:



$$\Delta l = \alpha l \Delta t \ (mm)$$

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
-kinematic effects:
-uneven settlements
-dynamic effects:
-vibrations (due to traffic)
-earthquake
-shocking of vehicles

Slowly applied static loads according to traditional meaning of the word are **forces** that are acting onto the structure.

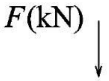
-permanent loads acting due to
selfweight of the structures, constructions
-variable loads acting due to
-meteorological loads: snow and wind
-live loads: weight of people and furniture

Classification of loads according to ***distribution***

Concentrated load (a)
Distributed *planar* (or coplanar) loads
- uniformly distributed load (b)
- triangular (linearly variable) (c)
- general (d)

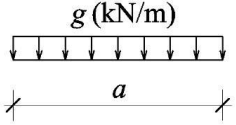
Examples for planar loads:

a)



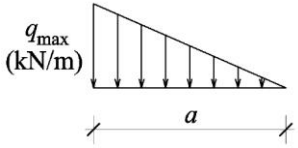
concentrated load

b)



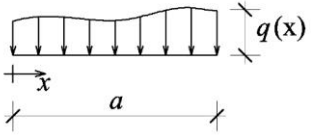
uniformly distributed load

c)



triangular load

d)

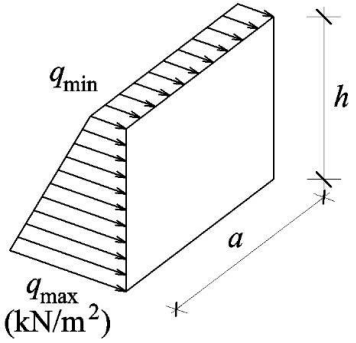


general distributed load

*Spatial l*oad system s

Examples:

earth pressure



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