

CityGML and FEM based simulations – Requirements and Challenges

CityGML 3.0 International Workshop
Technical University Munich
June 20 – 21, 2013

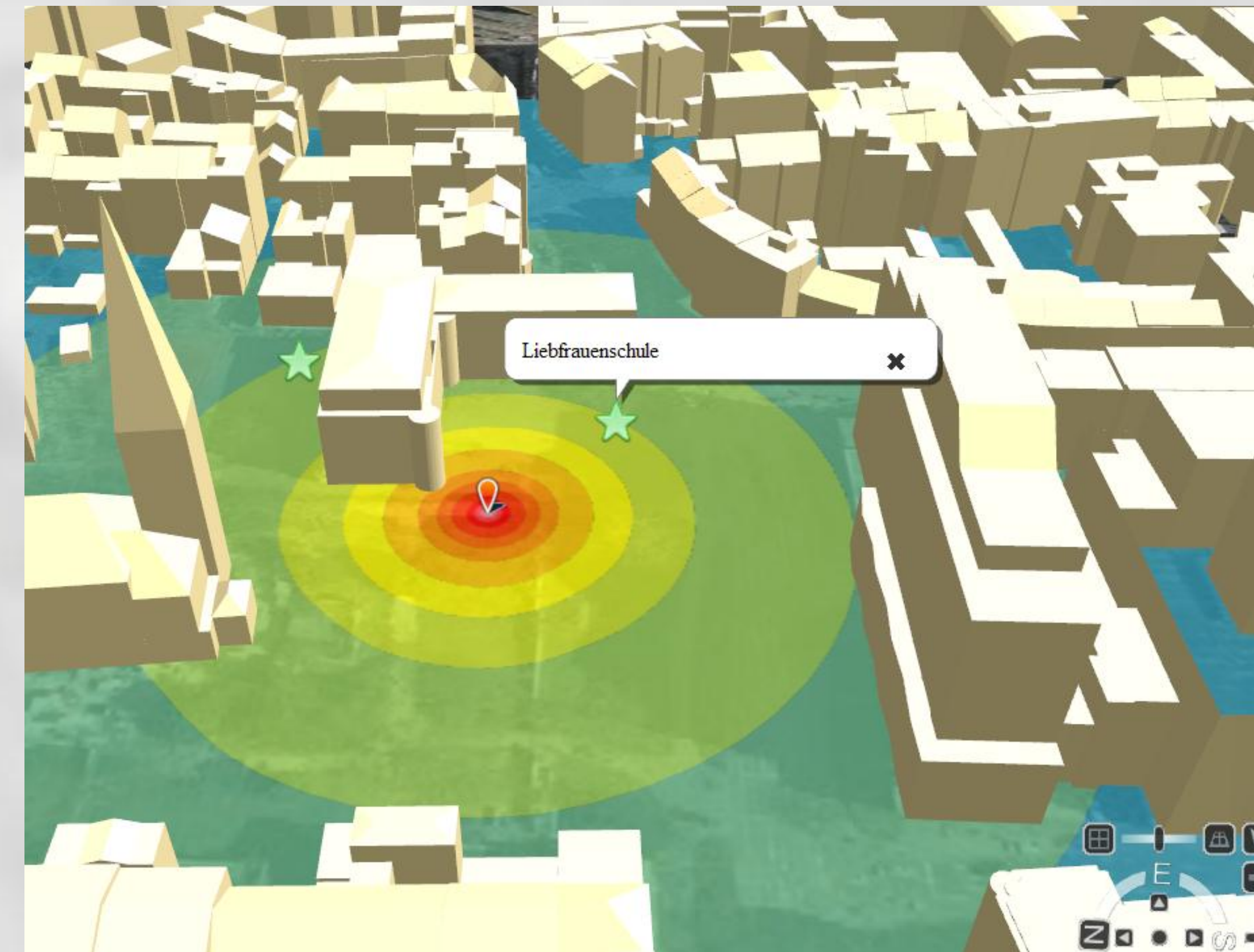
Claus Nagel, M.Sc.
cnagel@virtualcitysystems.de

- For over 10 years, **virtualcitySYSTEMS** has provided GIS services for customers in the private and public sector. GIS consulting, software development, project implementation and systems integration are our core competencies. The company has further distinguished itself by becoming one of the leading experts in 3D spatial data infrastructures based on the OGC standard CityGML, with customers and business partners all over the world.
- **Our mission:** To consistently deliver high quality, end-to-end 2D and 3D GIS solutions by leveraging our experience, technology, Best Practices and strategic partnerships to extend our global reach to offer products and services for the lifecycle management of digital cities.

DETORBA

Analysis of detonation scenarios in urban environments and assessment of direct impact. The aim is to support authorities (disaster and emergency manager) in their activities, e.g. when defining evacuation areas and assessing potential damage.

virtualcitySYSTEMS uses **CityGML** for Urban Information Modelling and the **3D City Database** for storing the CityGML models.



Early risk assessment of blast impact
(source: virtualcitySYSTEMS)

SPONSORED BY THE



Federal Ministry
of Education
and Research

DETORBA

Example Munich, Germany 2012:
Controlled detonation of 250kg
bomb from WW2

Evacuation area



Controlled explosion

bomb



Damage

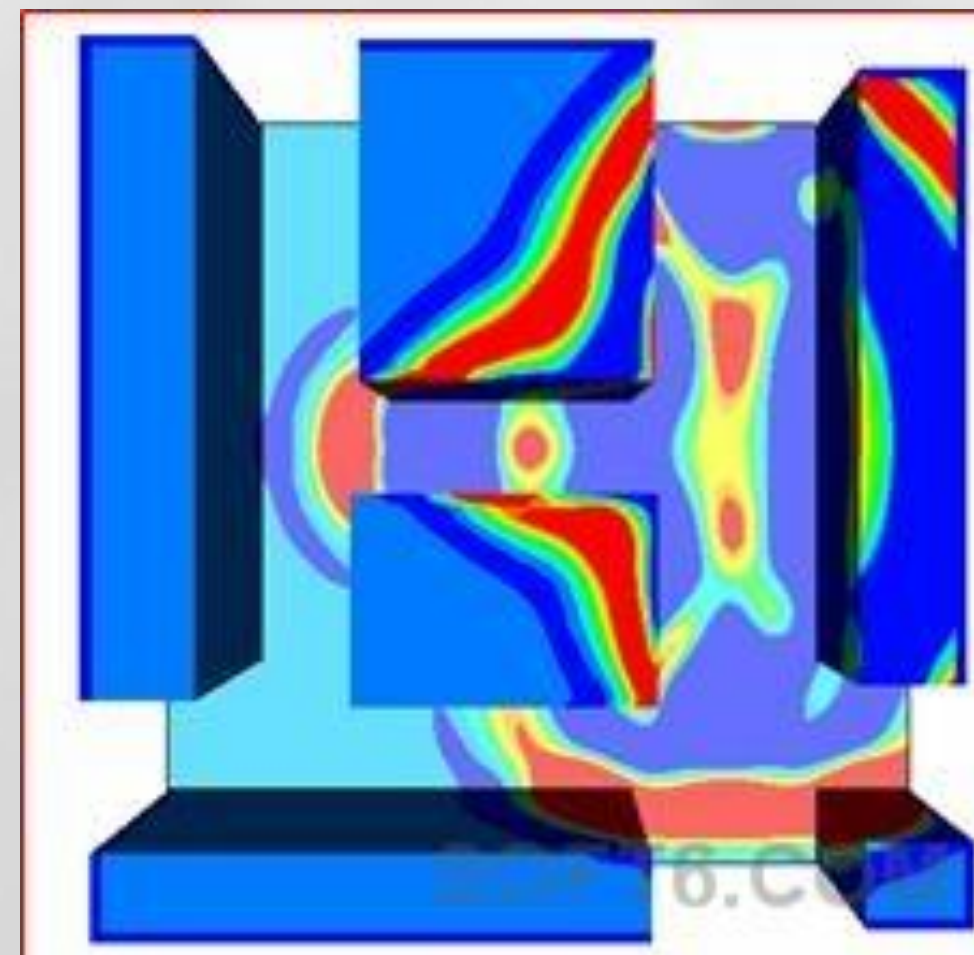
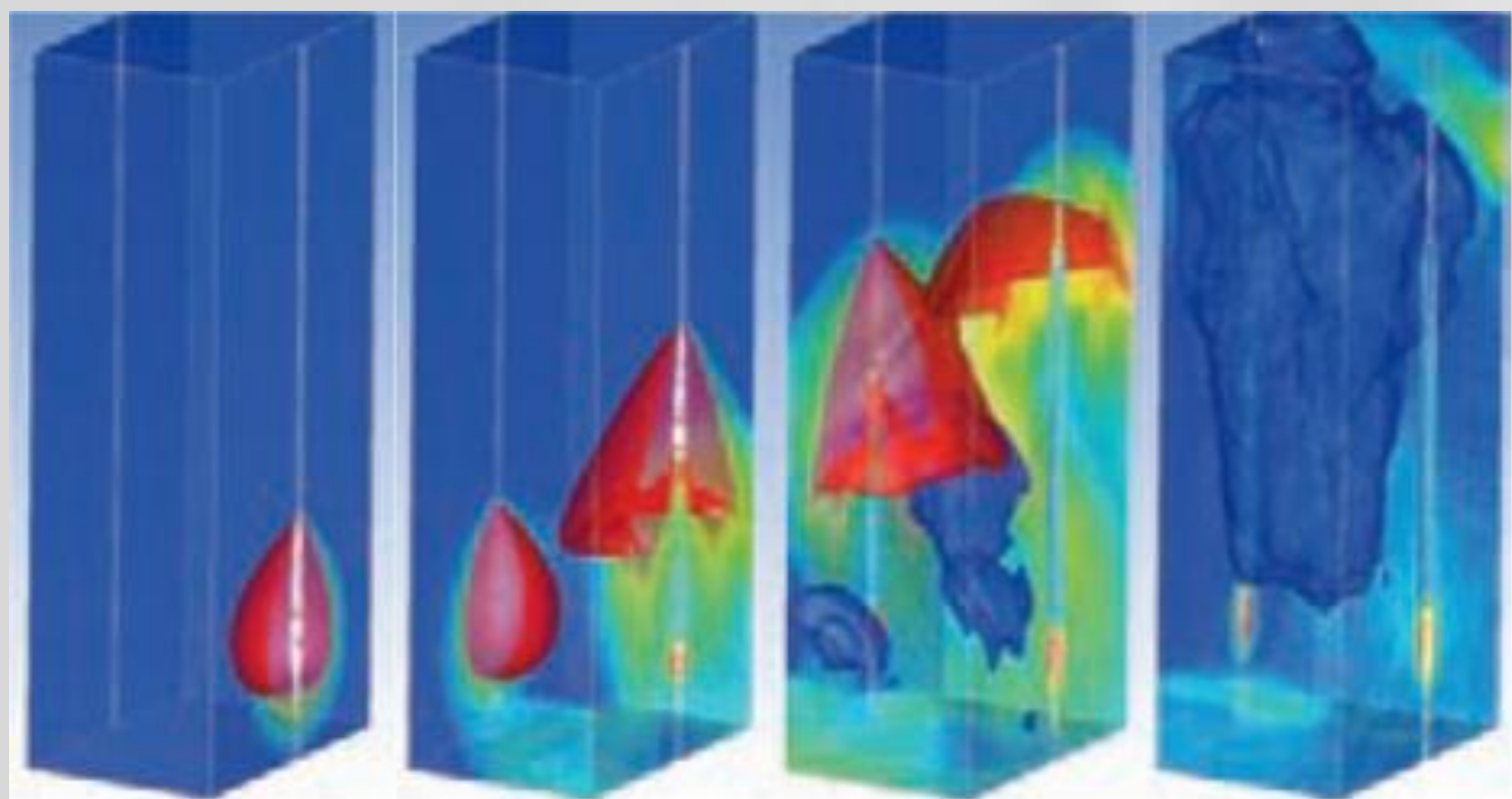


Fire fighters

DETORBA

Physical simulation software based on Finite Element Method (FEM) computations is used to compute the effects of a blast.

The impact on buildings is measured and combined with empirical data. For instance, windows will burst at a pressure of approx. 2,5 kPa, buildings will be structurally damaged at approx. 200 kPa.

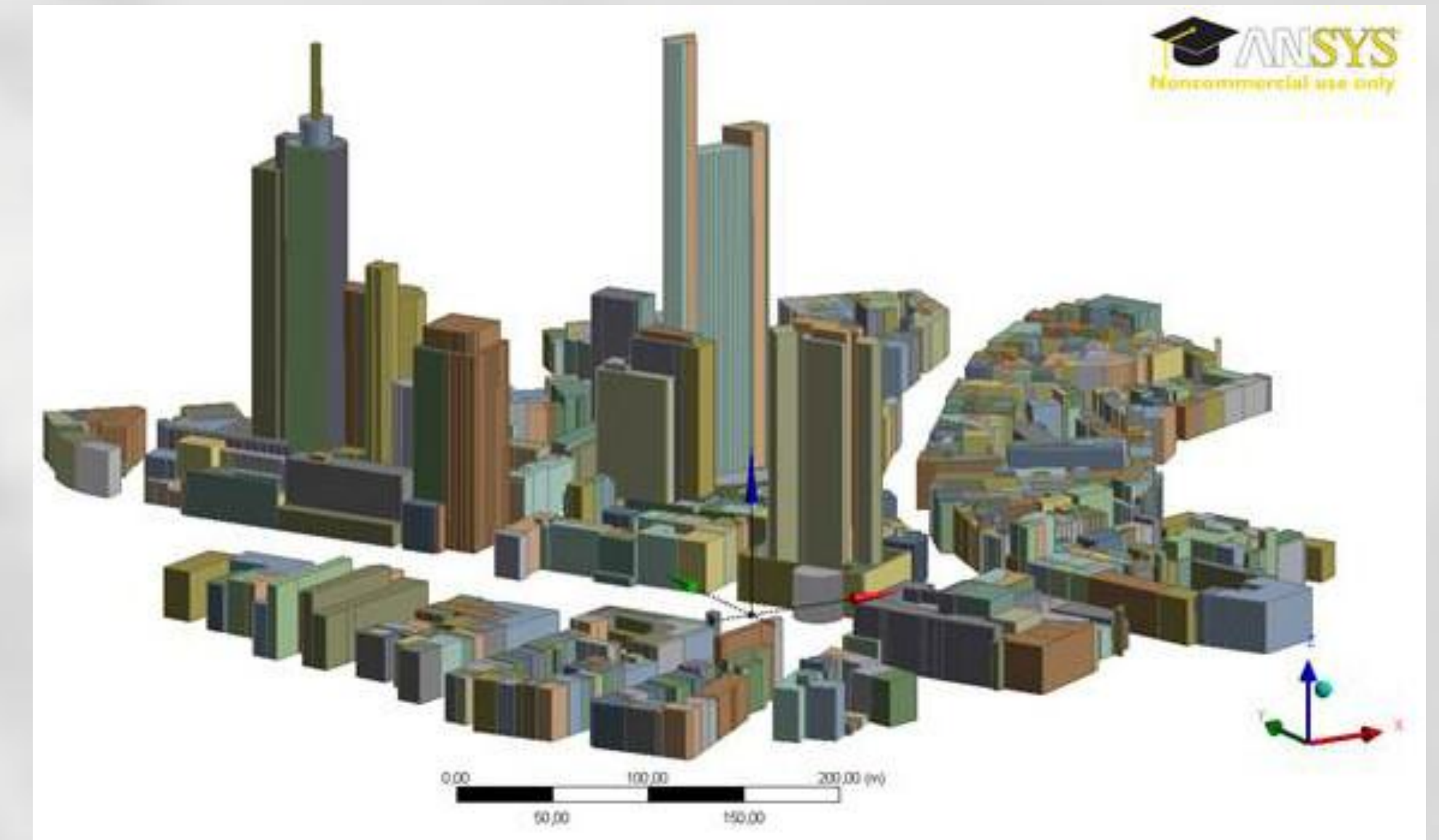


Simulated shockwave propagation (source: ANSYS)

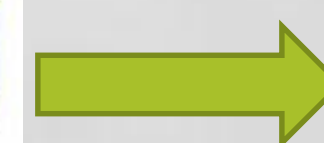
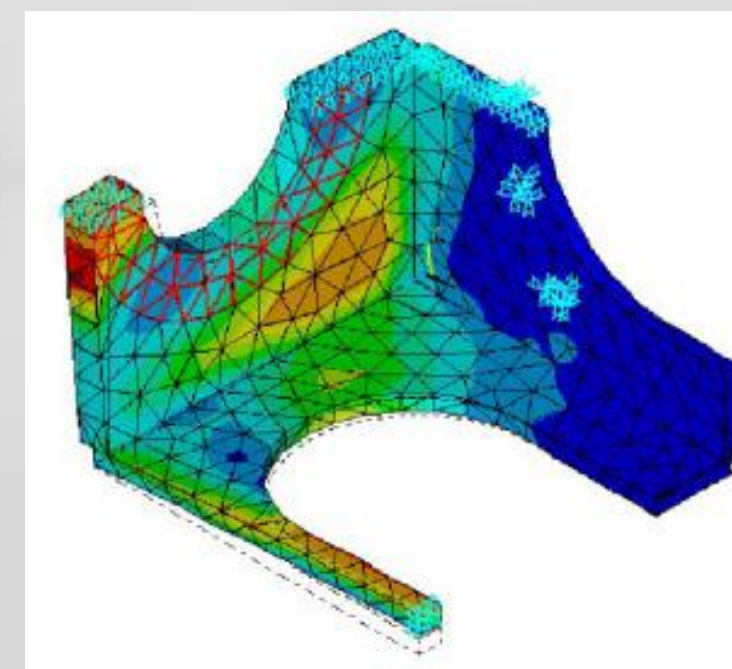
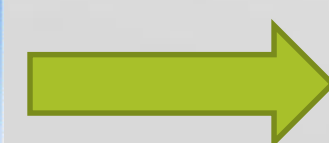
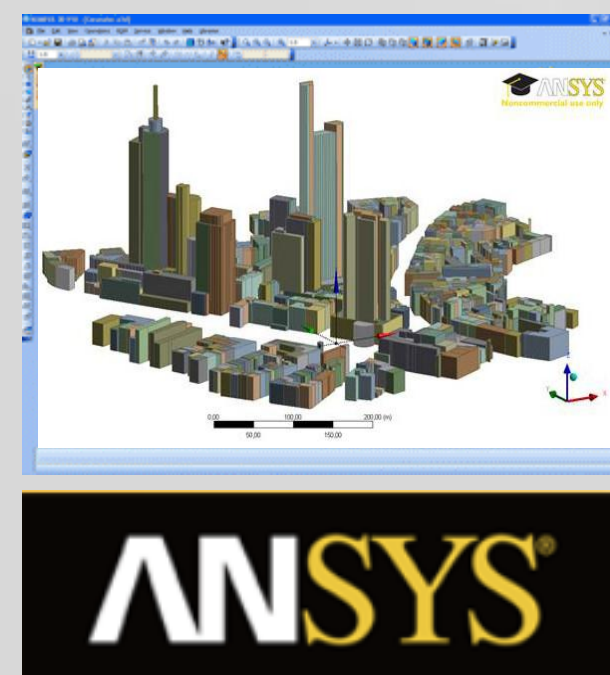
Simulation

Loading CityGML into simulation software requires a conversion process from GML to CAD to Finite Elements.

In the DETORBA project, ANSYS is used for simulations. Results are fed back into the city model.



Frankfurt LOD2 in ANSYS simulation software



FEM mesh used for actual mechanical simulations

SPONSORED BY THE



Federal Ministry
of Education
and Research

Material Properties

Physical simulation requires information about **material properties**. Commercial databases specialized for computer aided engineering (CAE) exist for looking up parameters. Material information must be attached to solid bodies.

MATDAT.com

Material Properties Database and Estimation Tools

Material search results - DETAILED REPORT

GENERAL INFORMATION

RECORD INFORMATION

Material ID:

90

Contributed by:

MATDAT

Entry date:

01.06.2011

Source:

Boile, C., Seeger, T.: Materials data for cyclic loading, Part A, Elsevier, Amsterdam 1987.

Other reference(s):

Reik, W., Mayr, P., Macherauch, E.: Untersuchungen zum Schwingfestigkeitsverhalten von Ck 45, EGKS research program, final report, part B, 1979

MATERIAL INFORMATION

Material designation:

DIN

Ck 45

AISI

1042 ; 1045

BS

060A47 ; 080M46

ISO

C45E4 ; C545

SAE

1042 ; 1045

Other&Commercial

W.Nr. (DIN 17007)

1.1191

AFNOR

XC45 ; XC48H1

GOST

45

JIS

S 45 C

SS

1672

EN

ASTM

HRN

JUS

Č1531

UNS

G10420 ; G10450

ACRONI JESENICE

C45E ; Č1531

JEKLO ŠTORE

CK45

JEKLO-LIVARNA RAVNE

VALJI ŠTORE

METAL RAVNE

CK45

Designation additional remarks

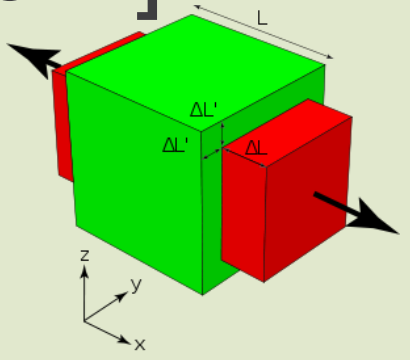
Material group

Unalloyed steel

Steel subgroup

Commercial material database containing testing results

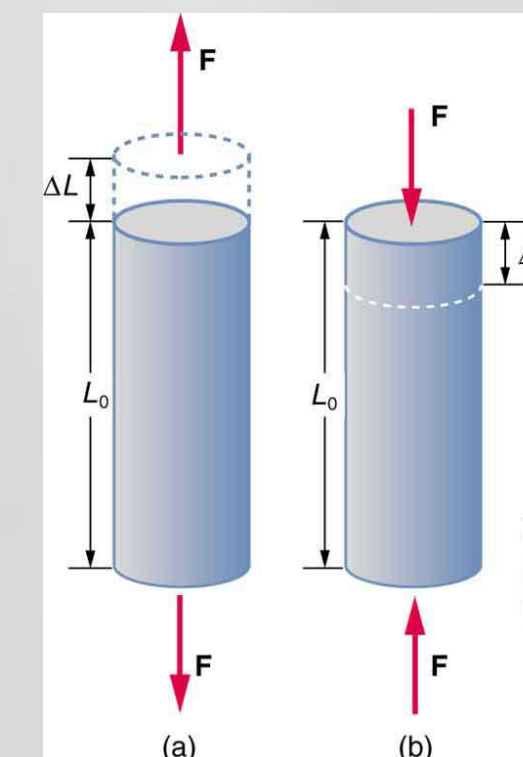
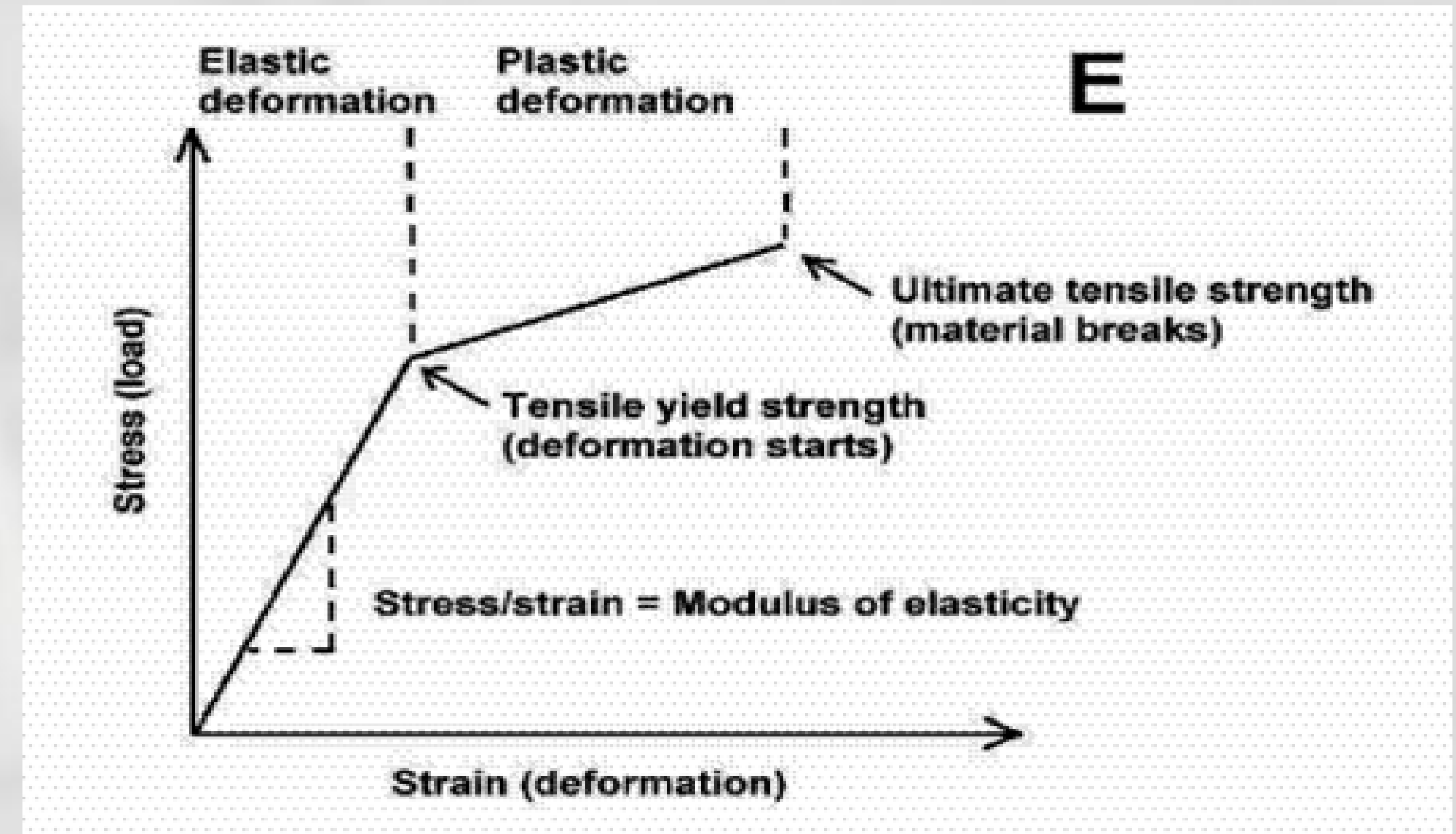
Material Properties

Physical	Mechanical	Electrical	Thermal
Density [g/cm ²]	Modulus of Elasticity [Gpa]	Electrical Resistivity [ohm-cm]	Thermal Expansion, linear [μm/m-°C]
	Bulk Modulus [GPa]		Specific Heat Capacity [J/g-°C]
	Poissons Ratio [0-1] <div>  </div>		
	Shear Modulus [GPa]		
	Young's Modulus [GPa]		

Modulus of Elasticity

Material's tendency to be deformed elastically (i.e., non-permanently) when a force is applied to it.

Important for simulating elastic materials, e.g. steel, rubber.

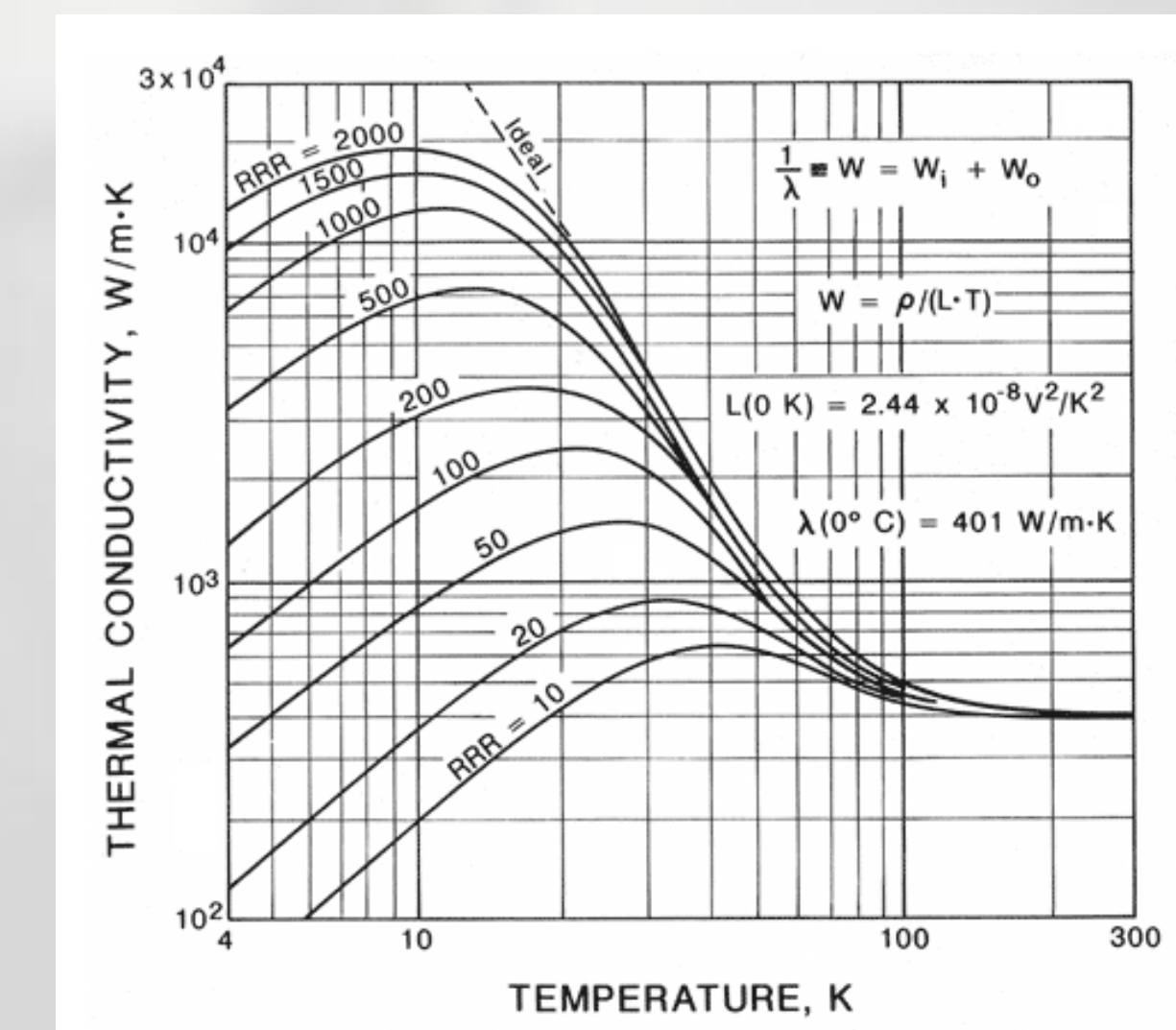
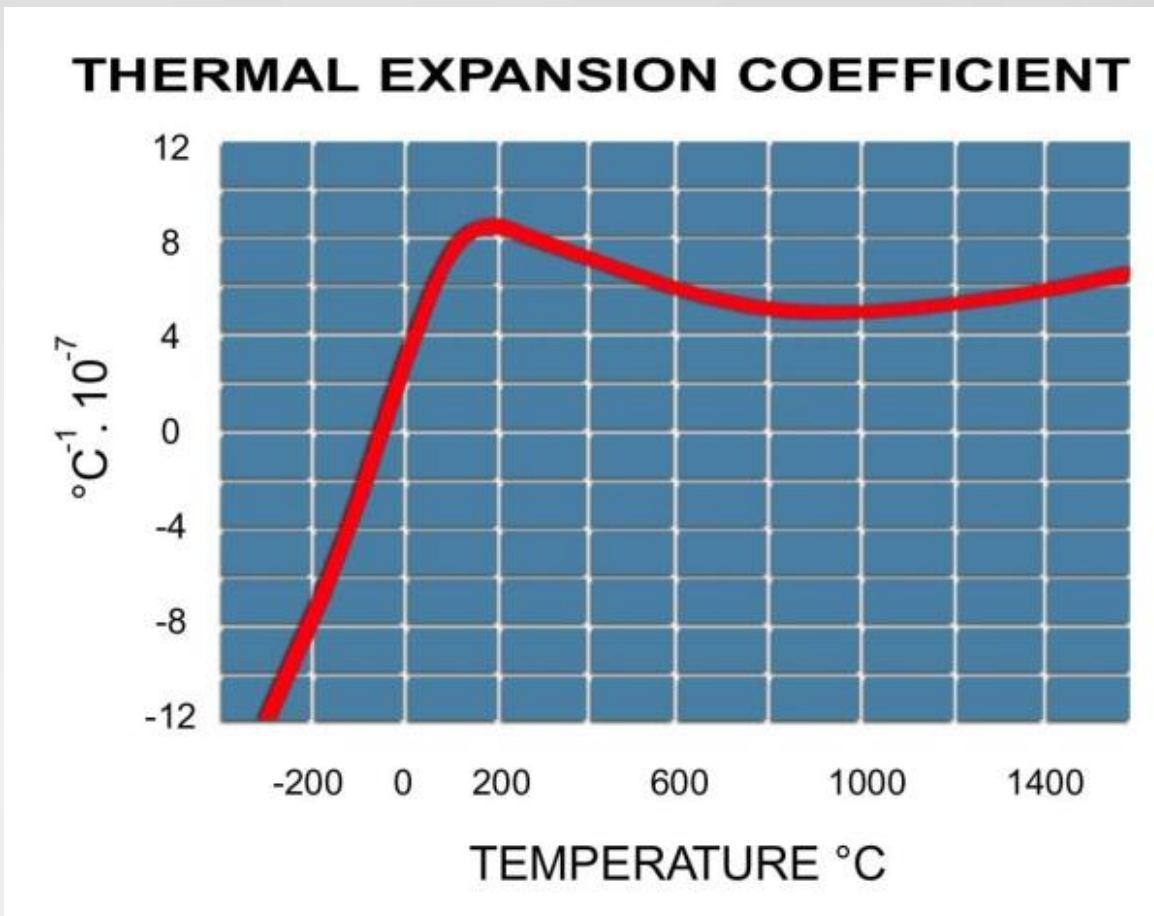


Thermal Expansion

When an object is heated or cooled, its length changes by an amount proportional to the original length and the change in temperature.

Thermal Insulation

Reduction of heat transfer (the transfer of thermal energy between objects of differing temperature) between objects in thermal contact.



Time Dependencies

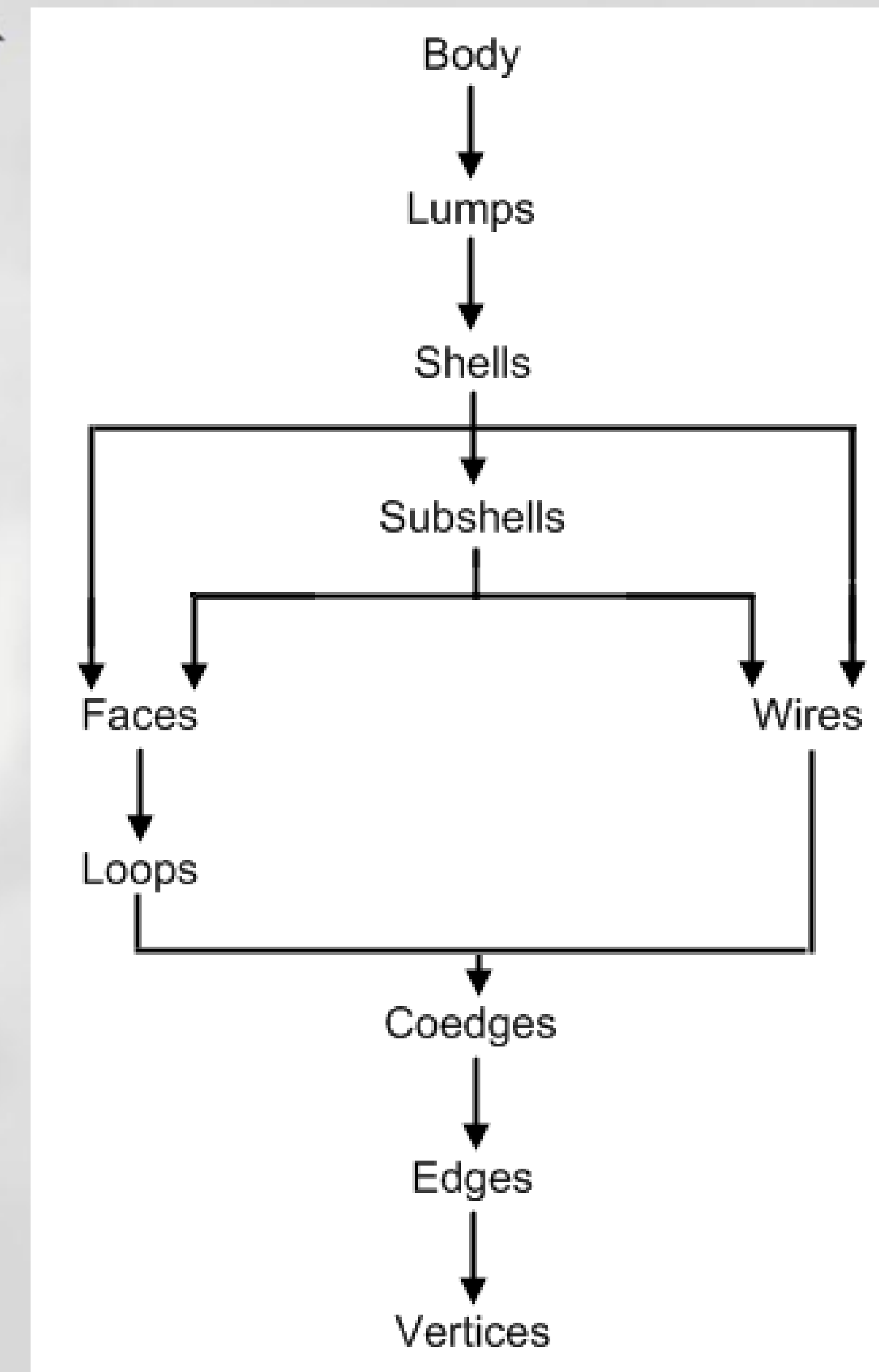
Corrosion	Fatigue	Creep
Gradual destruction of materials (usually metals) by chemical reaction with its environment.	Progressive structural damage from repeated loading	Tendency of a solid material to slowly move or deform permanently under the influence of stresses.

CityGML and FEM Data Model

CityGML	FEM
Geometrical data model	Topological data model
CityObject <ul style="list-style-type: none"> .. WallSurfaces <ul style="list-style-type: none"> MultiSurfaces <ul style="list-style-type: none"> Polygons <ul style="list-style-type: none"> Points 	Assembly <ul style="list-style-type: none"> .. Bodies <ul style="list-style-type: none"> Shells <ul style="list-style-type: none"> Faces <ul style="list-style-type: none"> Edges <ul style="list-style-type: none"> Vertices
In LOD2 Material can be attached to e.g. WallSurfaces	Material can be attached to Bodies

Material

Material



ACIS Data Model

What is missing in CityGML?

- **Material properties** for boundary surfaces, windows, doors, etc.
- **Function-based** properties values
- **Functional dependencies** between properties and entire features
- **Time-dependent** property values
- **Solid volumes** for FEM mesh decomposition