LECTURE I: PERFORMANCE, PROPERTIES AND SELECTION

EMERGENT MATERIALS WORKSHOP

THE ECOLOGY OF CONSTRUCTION MATERIALS

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PERFORMANCE

- Complex system: materials components, assemblies, devices, building systems
- Complex process: extraction, refining, processing, manufacturing, construction
- Inception, life cycle

PROPERTIES

- Material properties: intrinsic, extrinsic
- Material families
  1. Metals
  2. Polymers
  3. Ceramics
  4. Composites
  5. Natural materials

SELECTION

- Current process
- Analogs for design
- Methodologies of selection

PERFORMANCE

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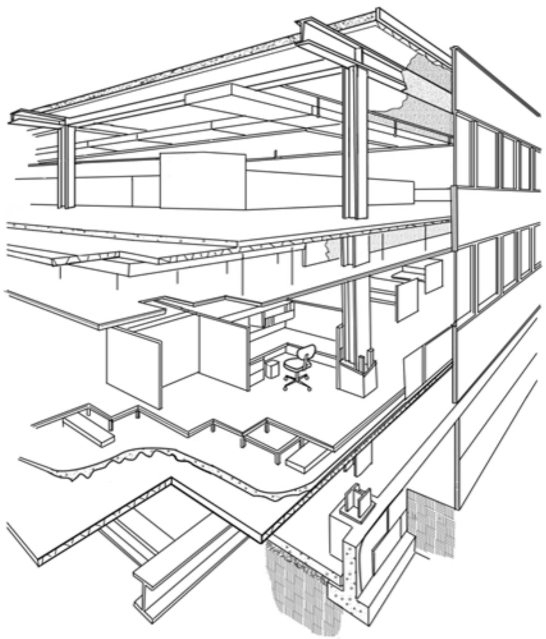

PERFORMANCE

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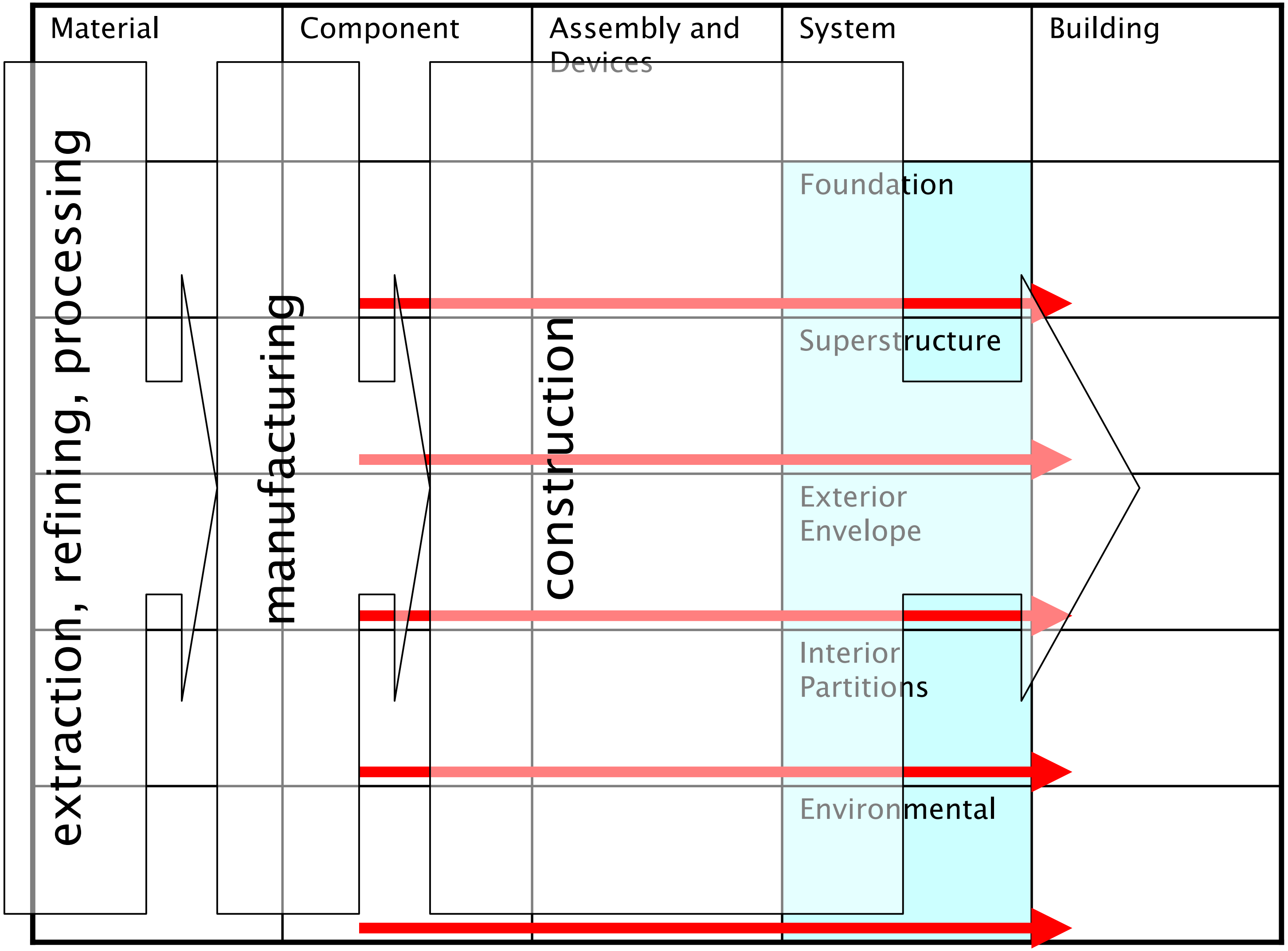

PERFORMANCE

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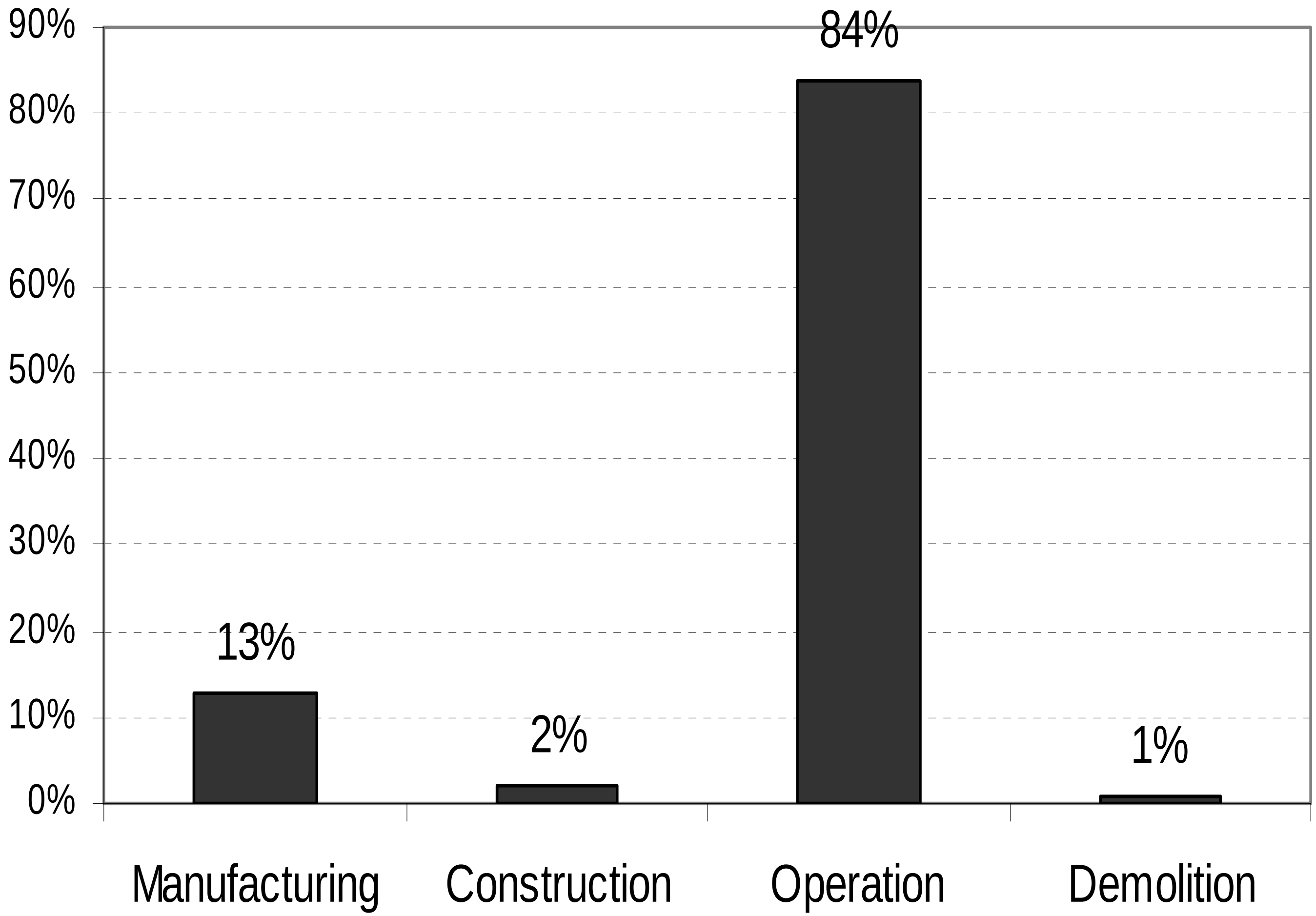
Consumption of energy over lifetime of ‘typical’ contemporary building



PERFORMANCE

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References

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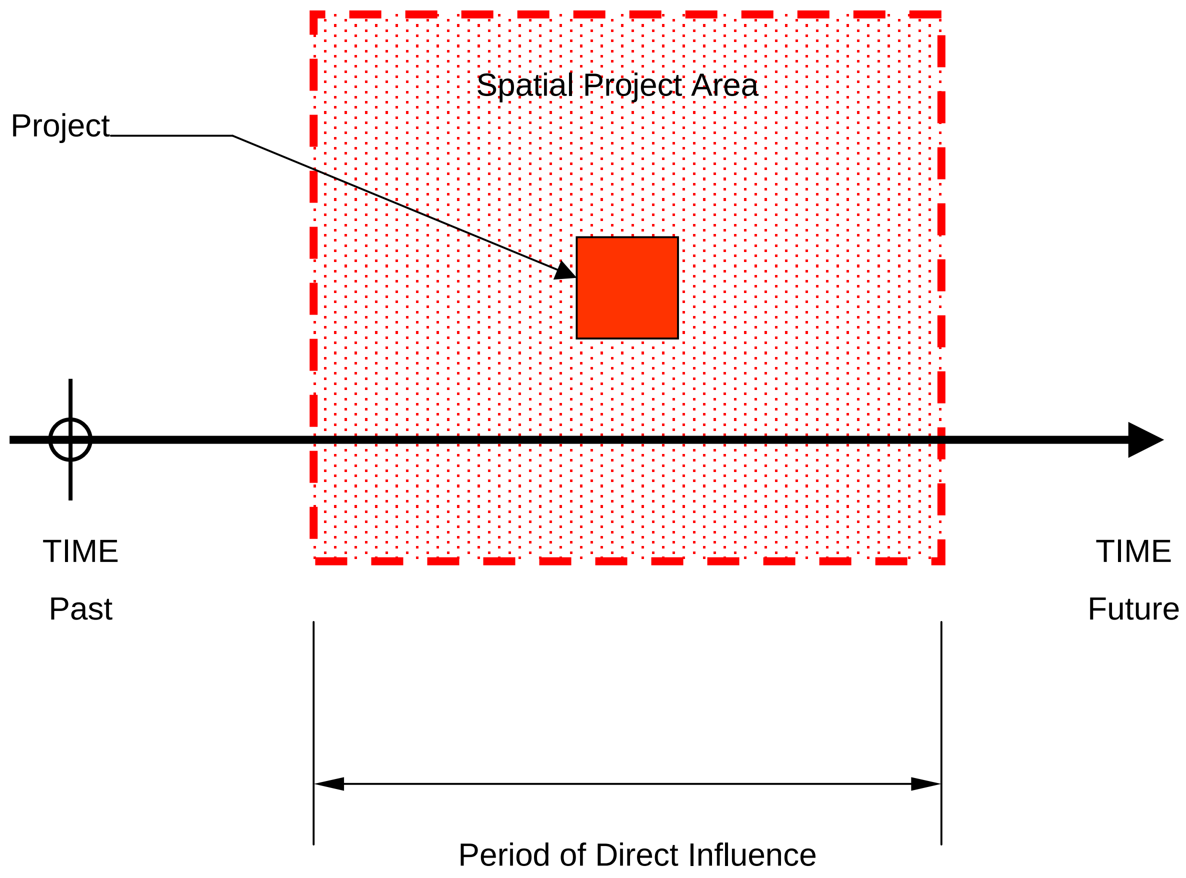

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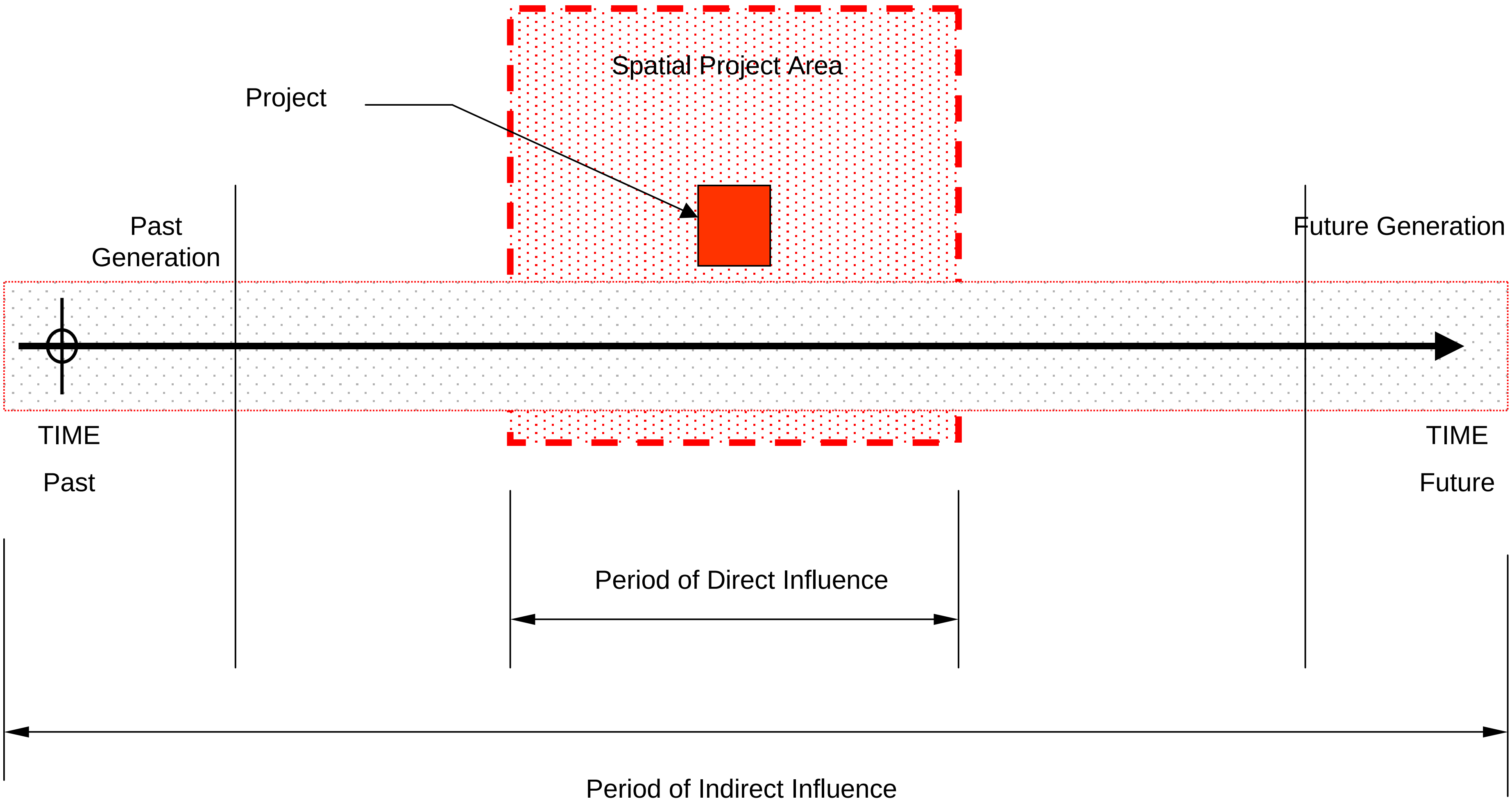

- Material properties
- Material families

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PROPERTIES

SELECTION

Material properties:
- Intrinsic
    - mechanical
    - physical
- Extrinsic

References

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A: aluminum

B: brick

C: concrete

G: glass

P: polymers

R: copper

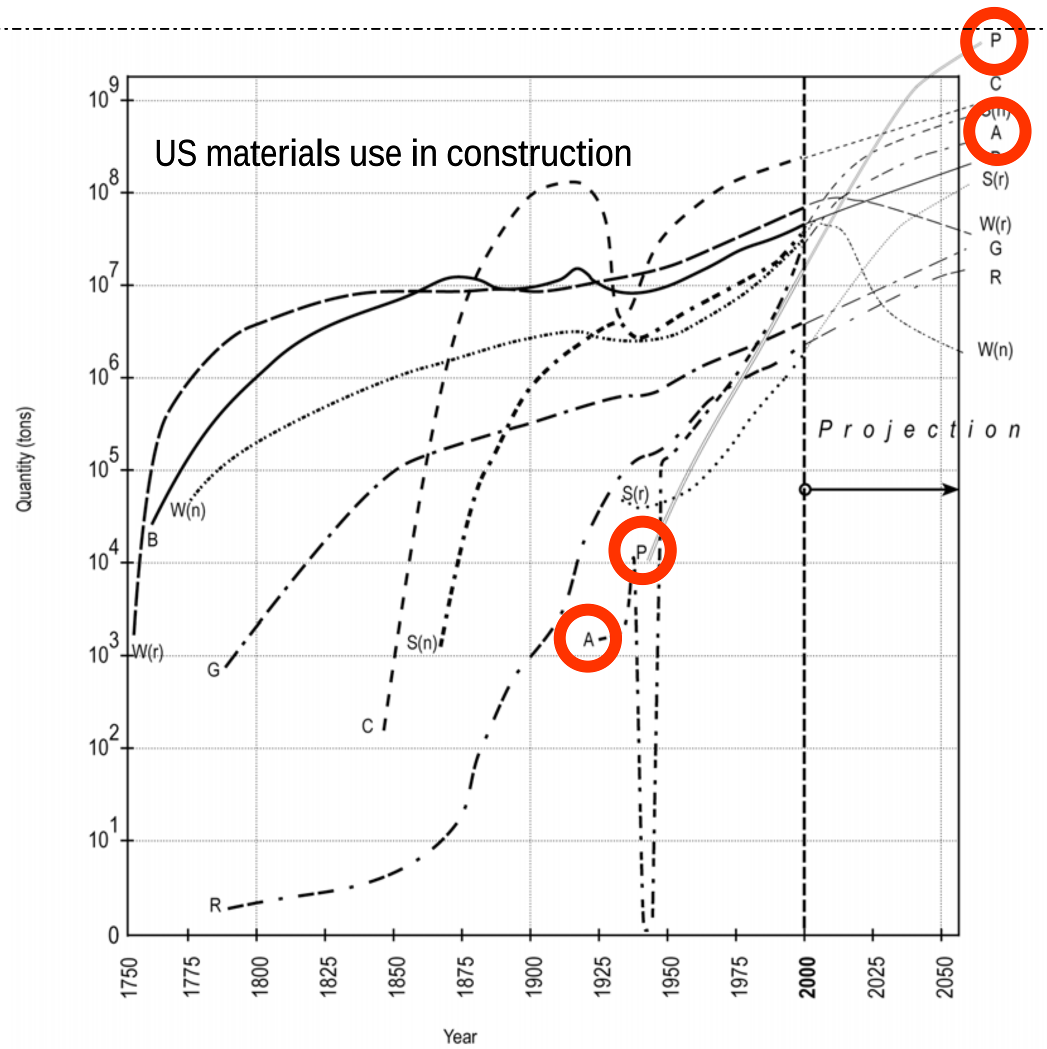
S(n): steel, non residential

S(r): steel

W(n): wood, non-residential

W(r): wood, residential

Sources: various



US materials use in construction

Assembled with data from the following sources:

PERFORMANCE

PROPERTIES

SELECTION

Material properties:
- Intrinsic
  - mechanical
  - physical
- Extrinsic

References

CES InDepth

And previous Ashby pubs.

For **metals**, the compressive strength is the same as the tensile yield strength.

Polymers are approximately 20% stronger in compression than in tension.

Foams are linearly elastic up to a strain of between 0.5 and 5%. Beyond the elastic limit the stress-strain curve has a much lower slope: low density foams have an almost horizontal plateau; denser ones have a rising stress-strain curve. The database stores three measures of the compressive strength. The first is the stress at a compressive strain of 5% (roughly, at the elastic limit in compression), the second is the stress at 25% strain (roughly the middle of the plateau) and the last is the stress at 50% strain (the end of the plateau).

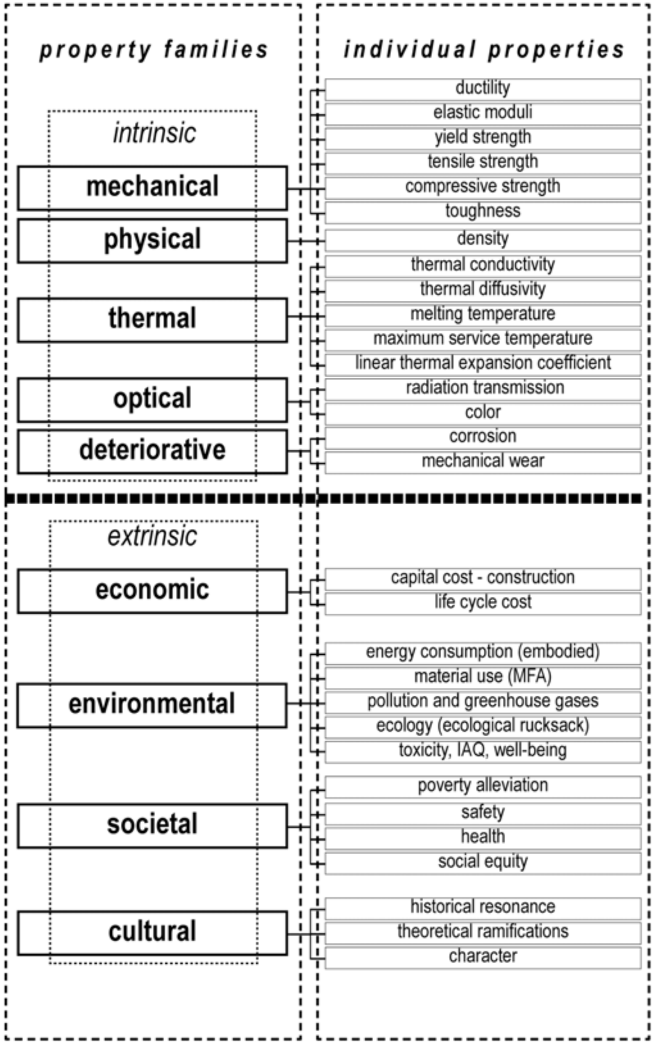
For **ceramics**, compressive strength is governed by crushing and is much larger than the tensile strength . Typically

Composites which contain fibres (including natural composites like wood) are a little weaker (up to 30%) in compression than tension because the fibres buckle.

For **continuous fibre, polymer composites,** where no data was available, the compressive strength was calculated using the Maximum Stress Failure Criteria (see [44]).

Wood, often, is used to support compressive loads: railway sleepers, pallets, frames of buildings, packaging for heavy objects are examples. The compressive strength is important in such applications.

Three strength properties of woods are widely reported (Forest Product Laboratory [27]:the compressive crushing-strength, s_c, the modulus of rupture (or bending-strength) s_{MOR}, and the shear-strength parallel to the grain, $t_{||}$. We define these first, before going on to the elastic limit, tensile strength and endurance limit which were frequently estimated from them to make the database.



Material properties -> families:

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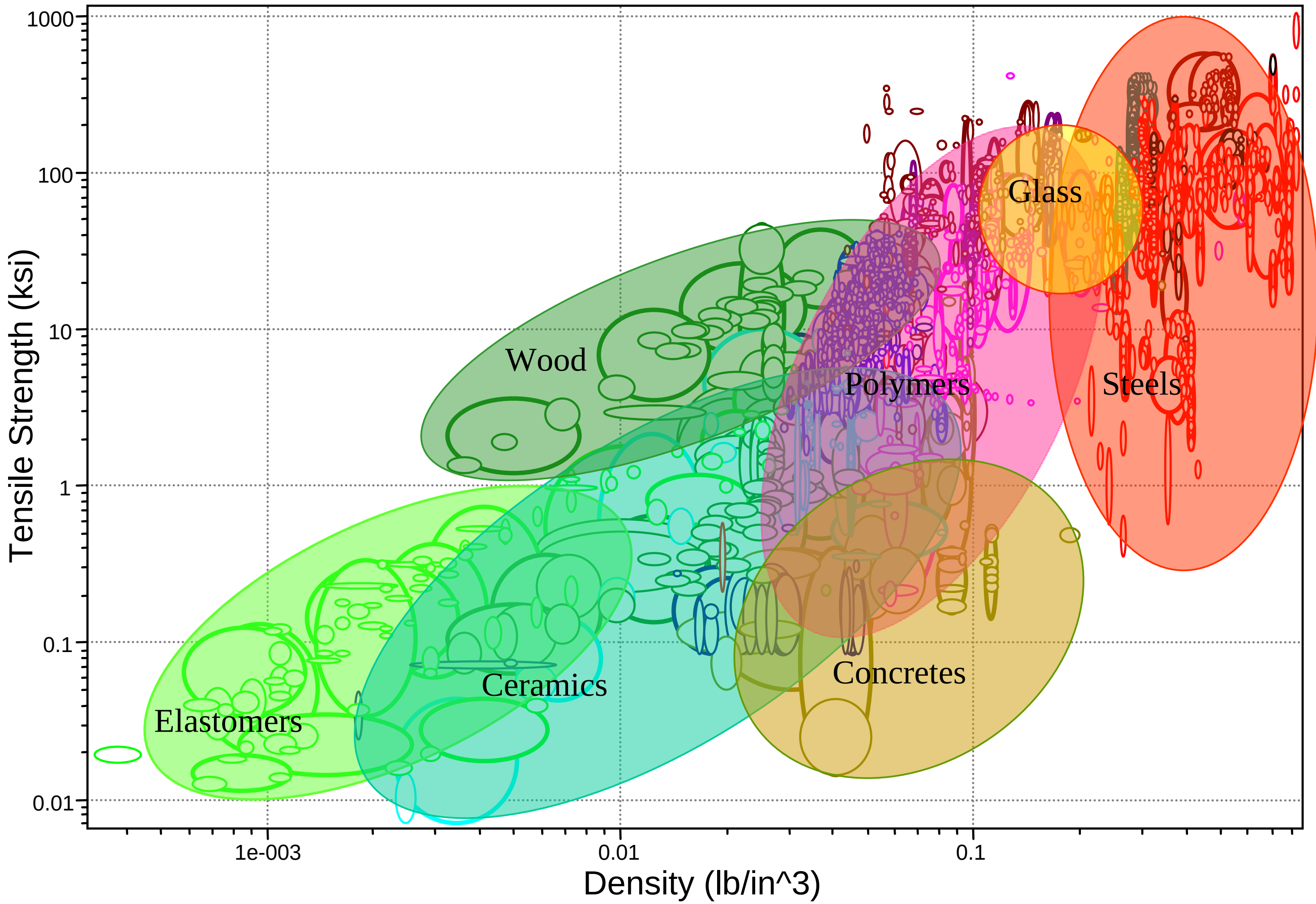

Material families:

- Metals
- Polymers
- Ceramics
- Natural
- Composites

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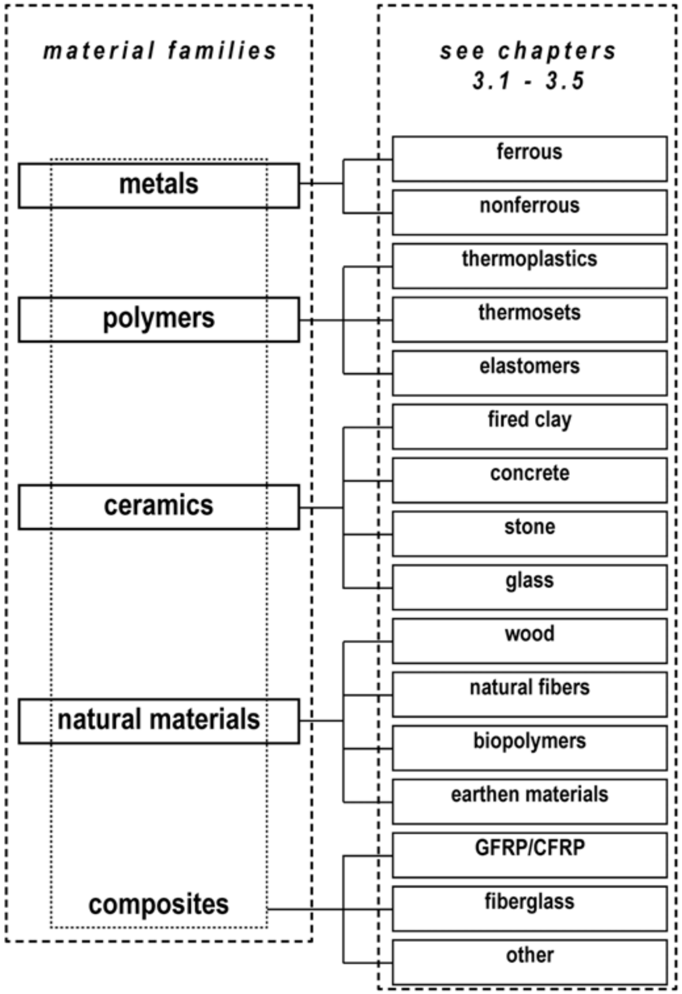

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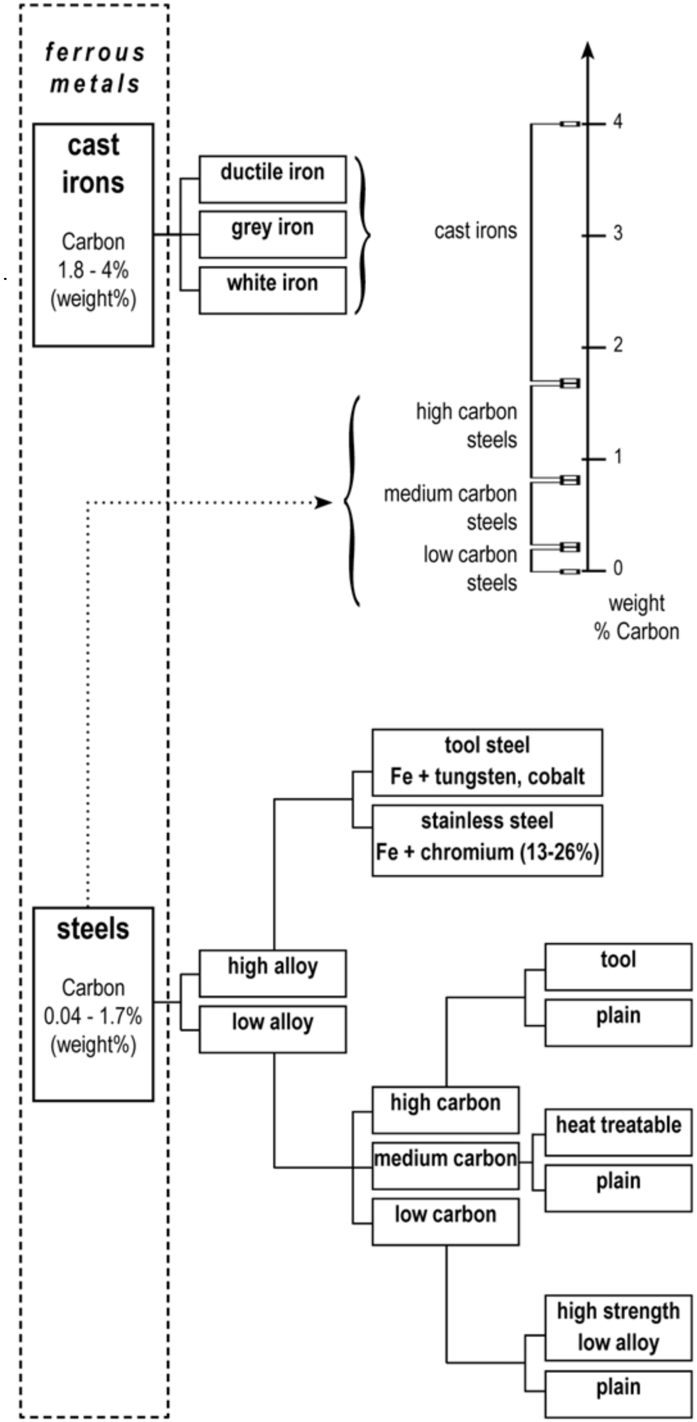
Material families:

- Metals
    - ferrous



Approximate dates of discovery for the seven metals of antiquity

gold	6000BC
copper	4200BC
silver	4000BC
lead	3500BC
tin	1750BC
iron, smelted	1500BC
mercury	750BC

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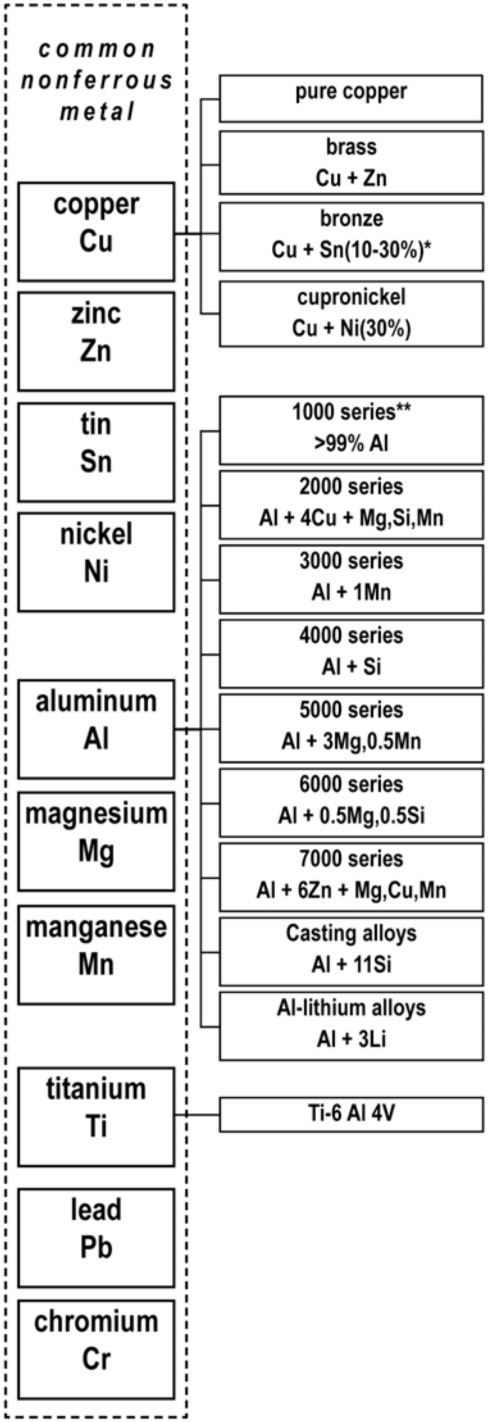
PROPERTIES

SELECTION

Material families:

- Metals
  - nonferrous



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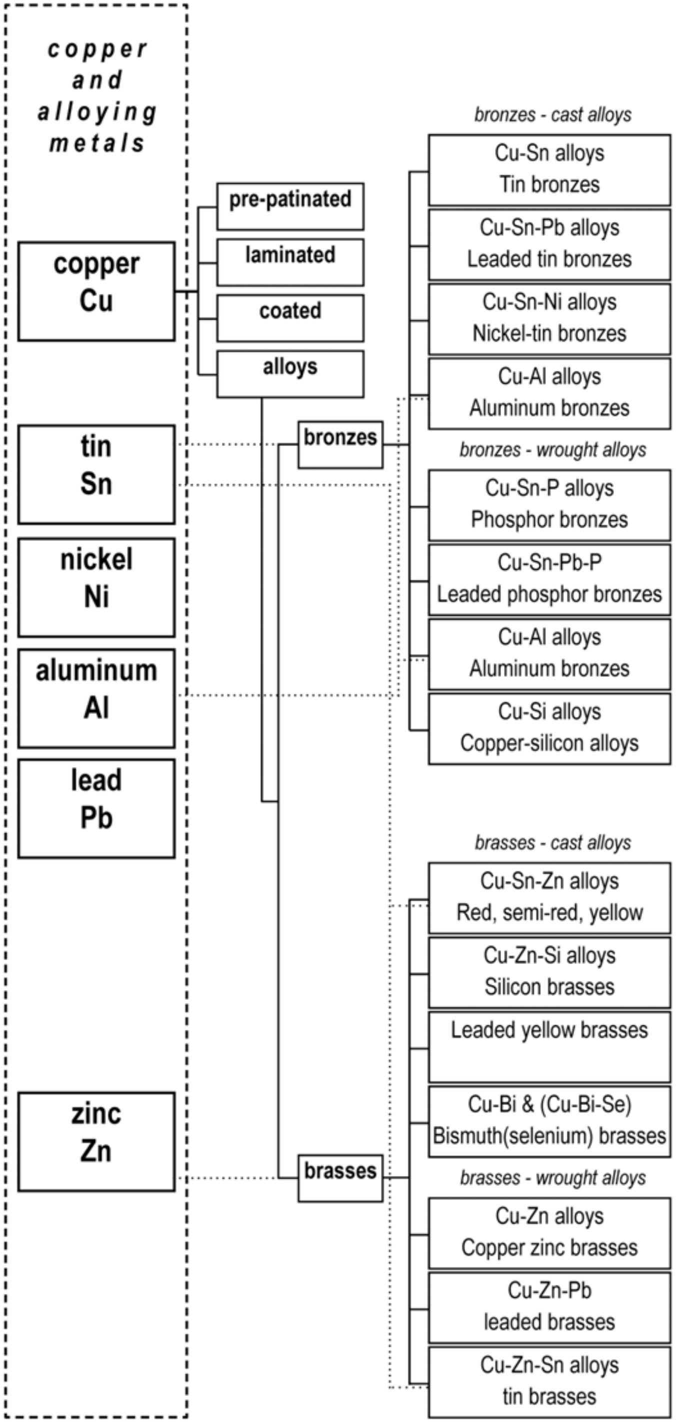
Material families:
- Metals
    - alloying metals



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Material families:

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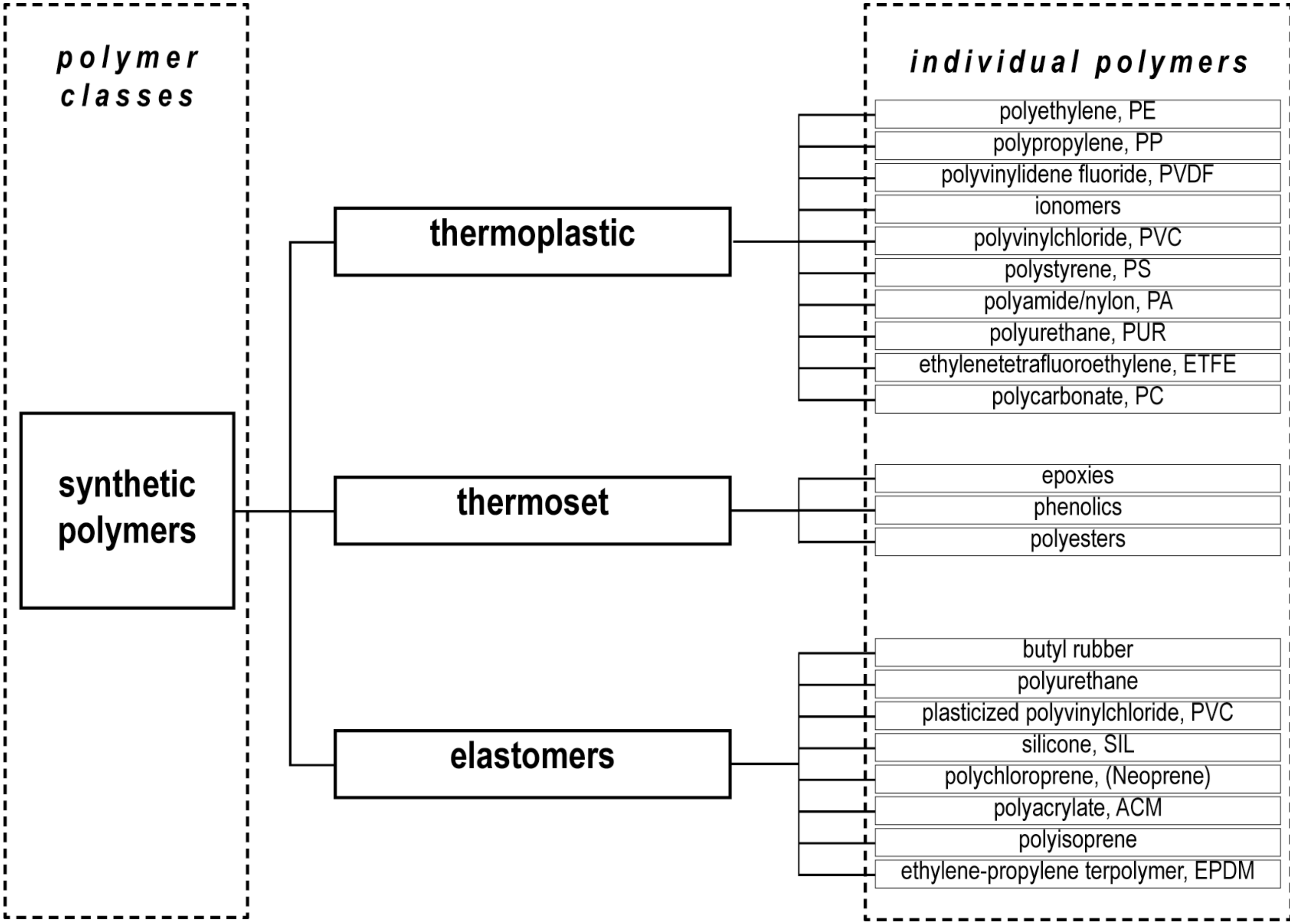

Material families:

- Ceramics

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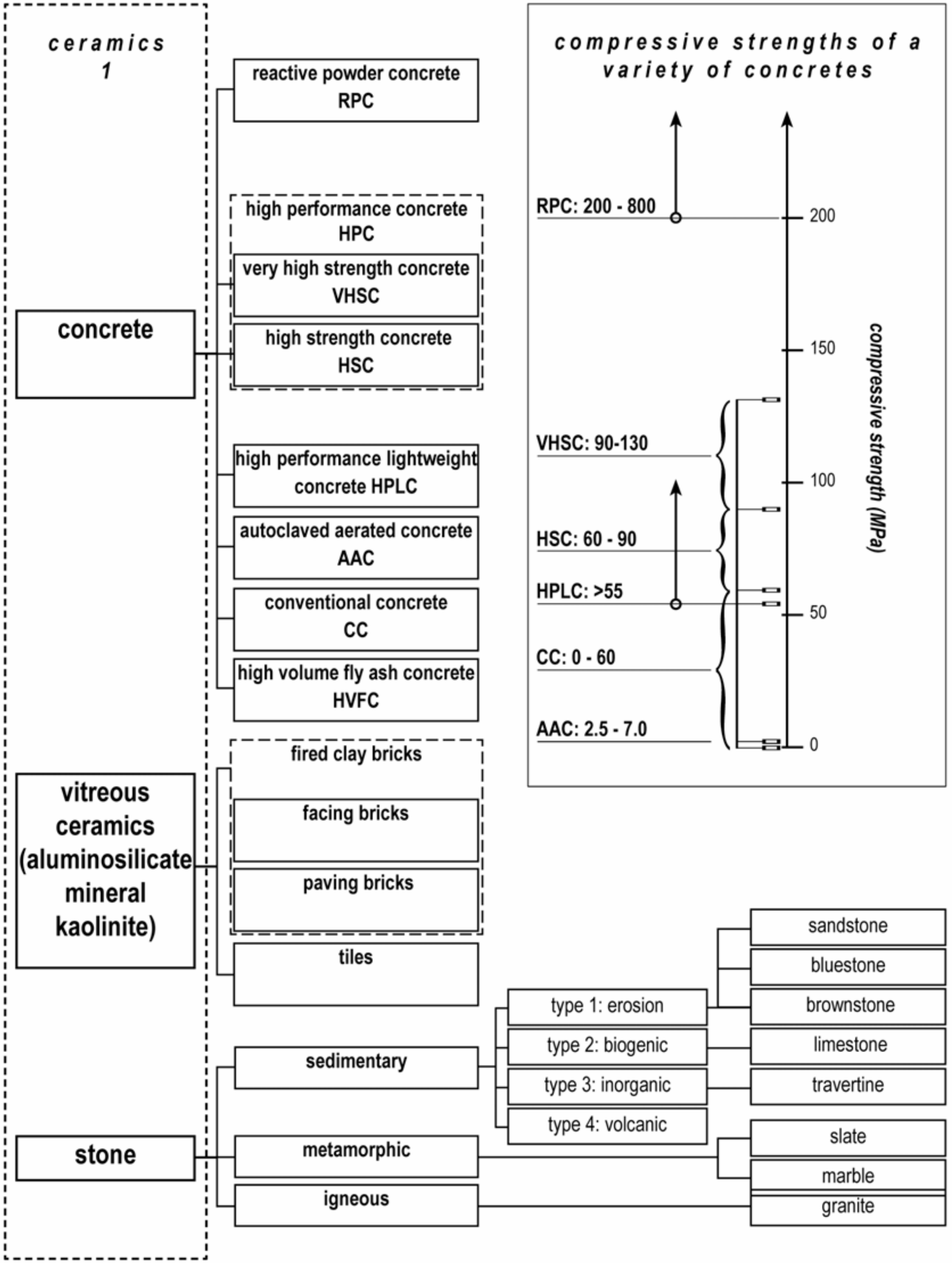
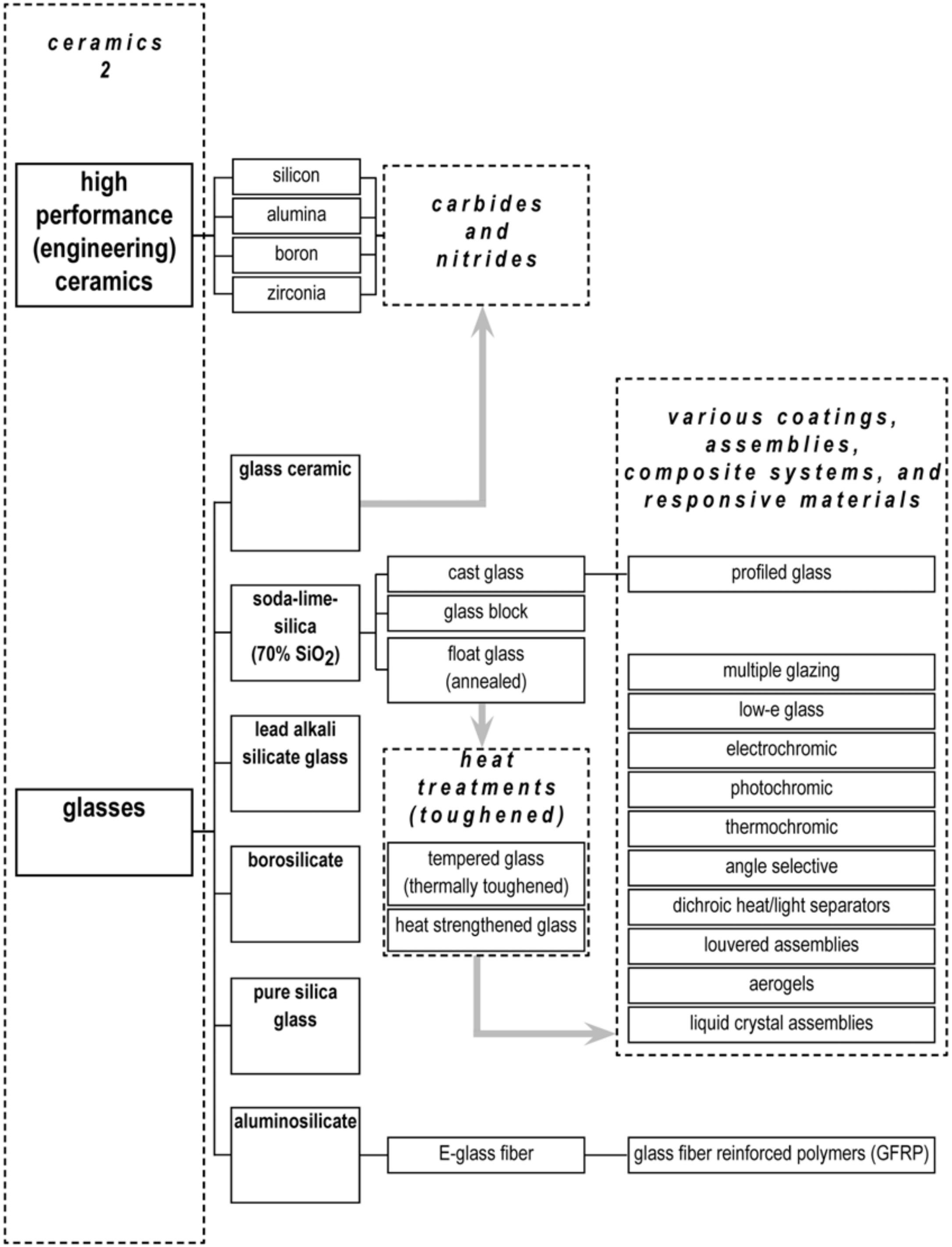


Material families:
- Ceramics



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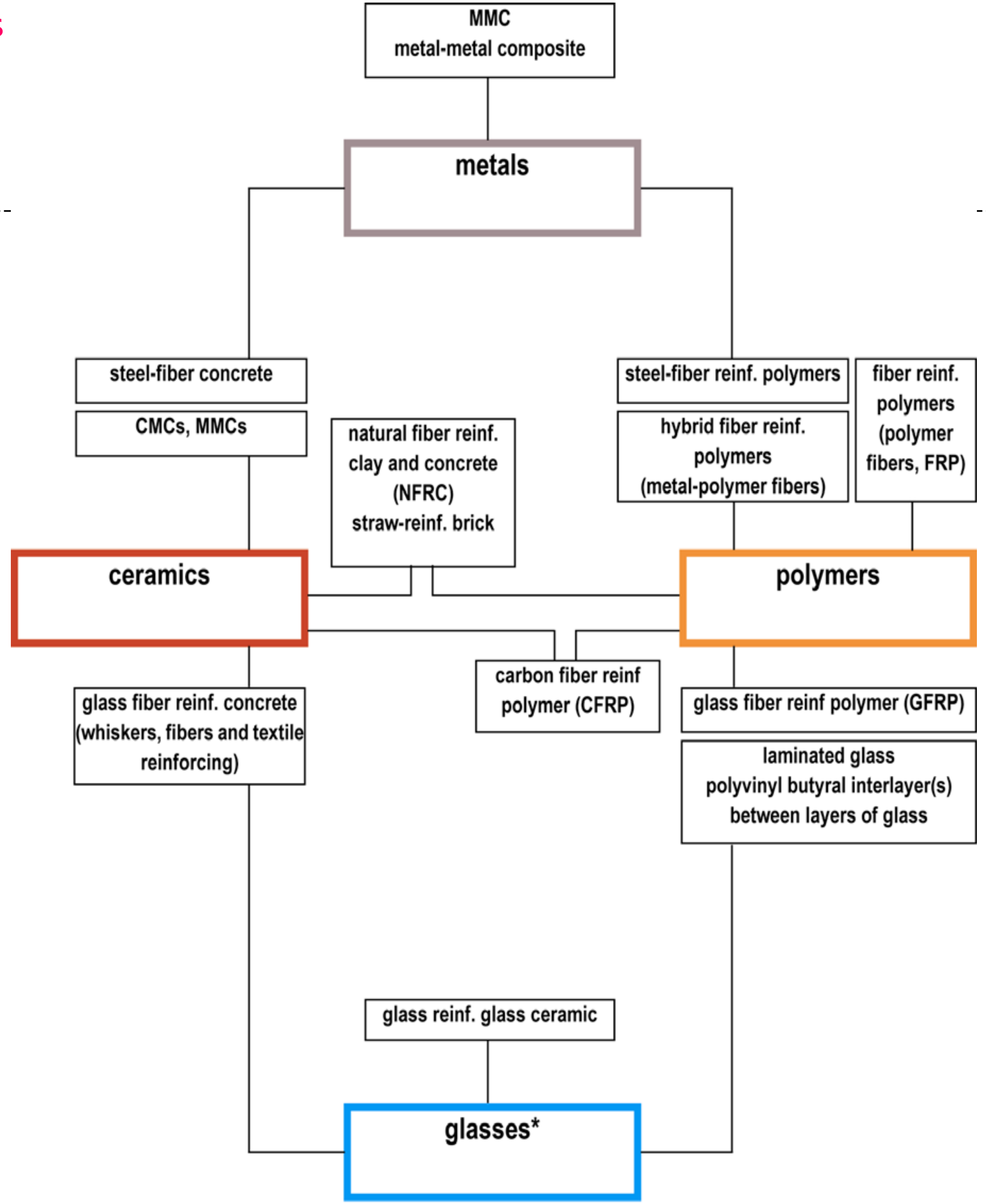
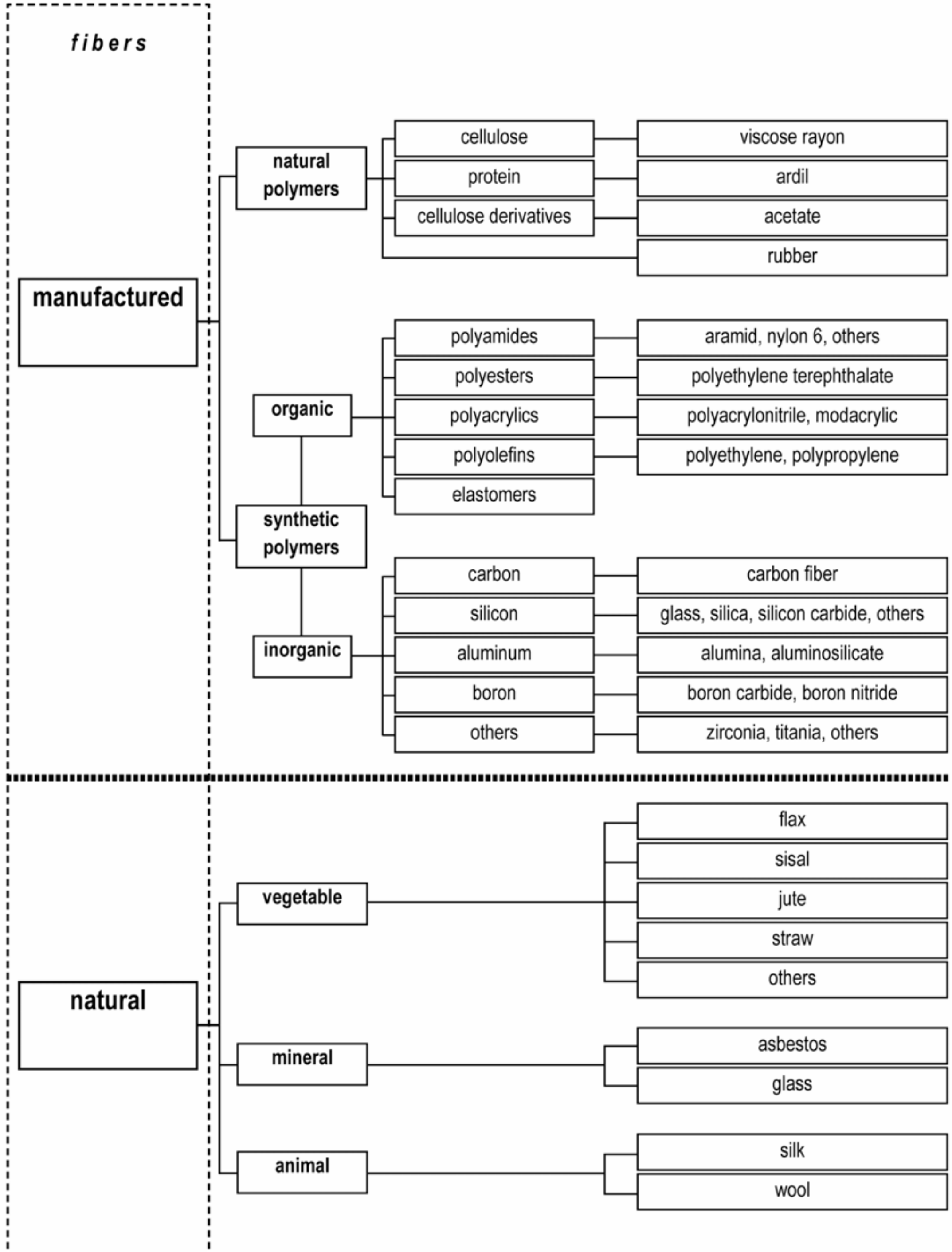


Material families:

- Composites



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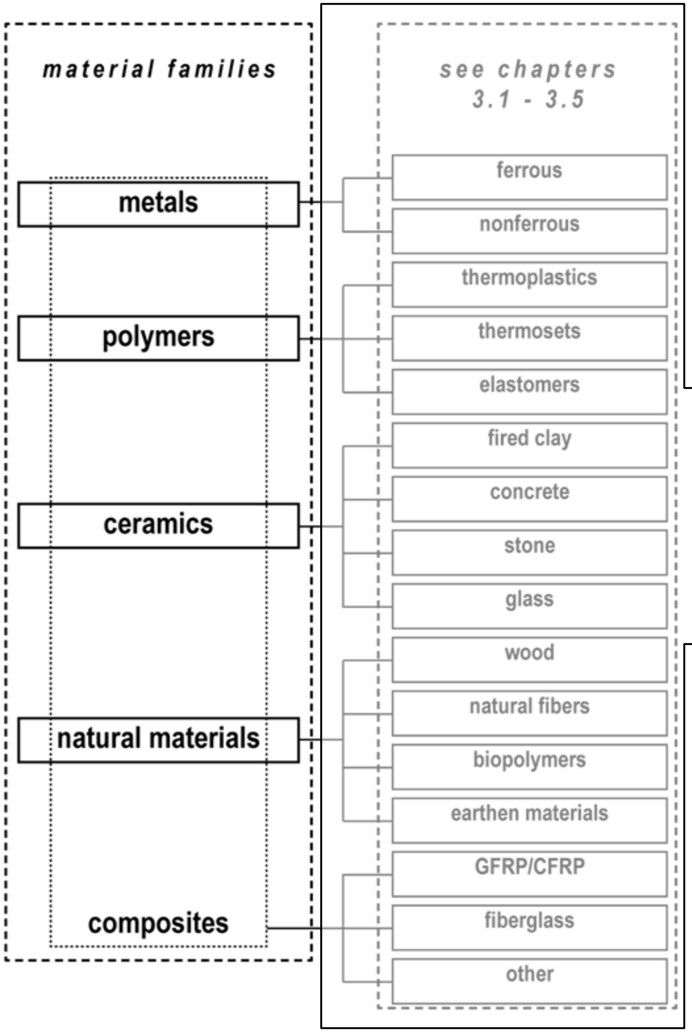

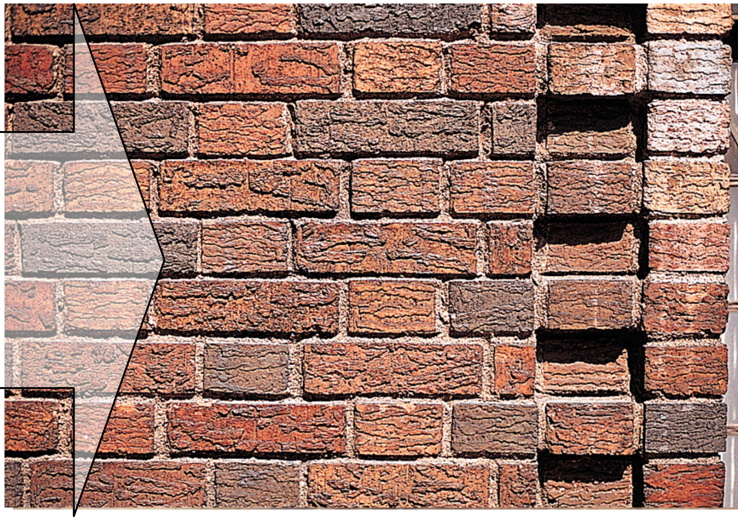

- Analogs for design
    - biomimicry

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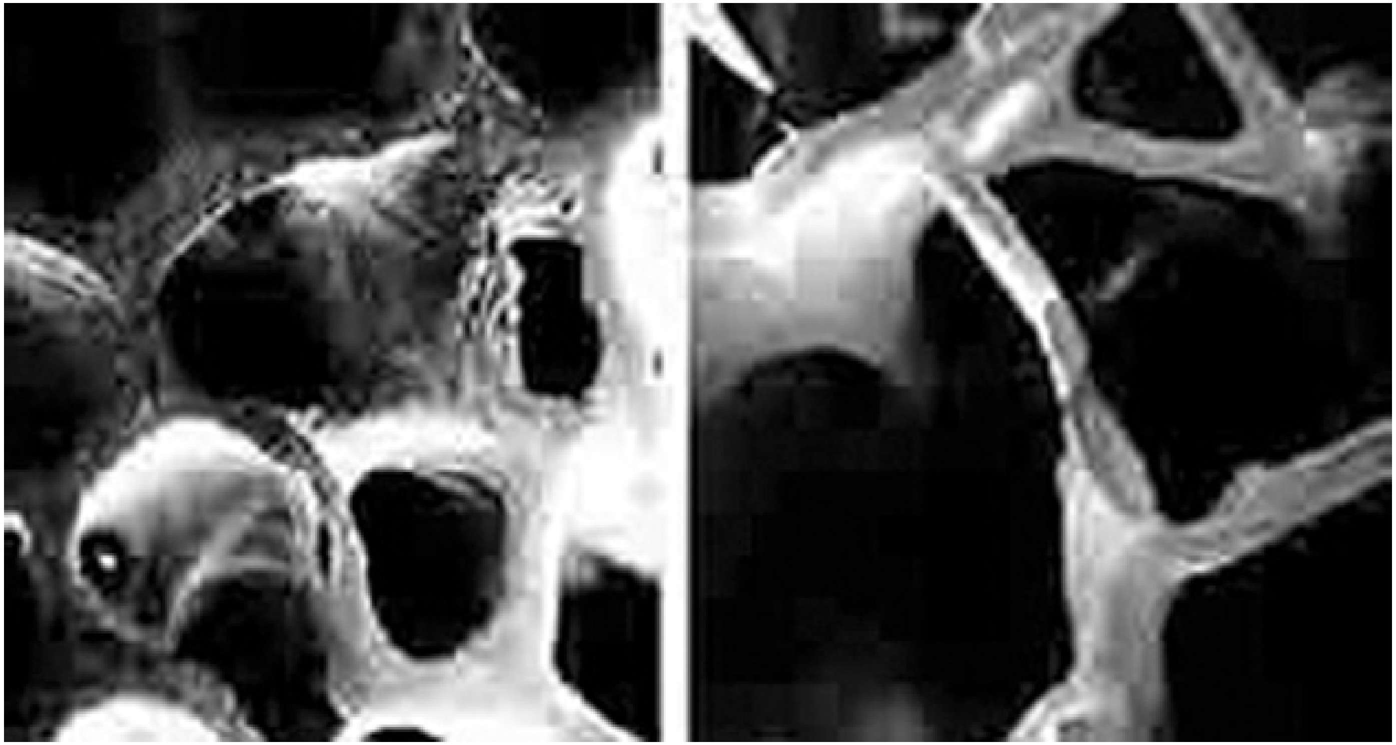

- Analogs for design
    - biomimicry
    - other complex systems (vehicles)

References

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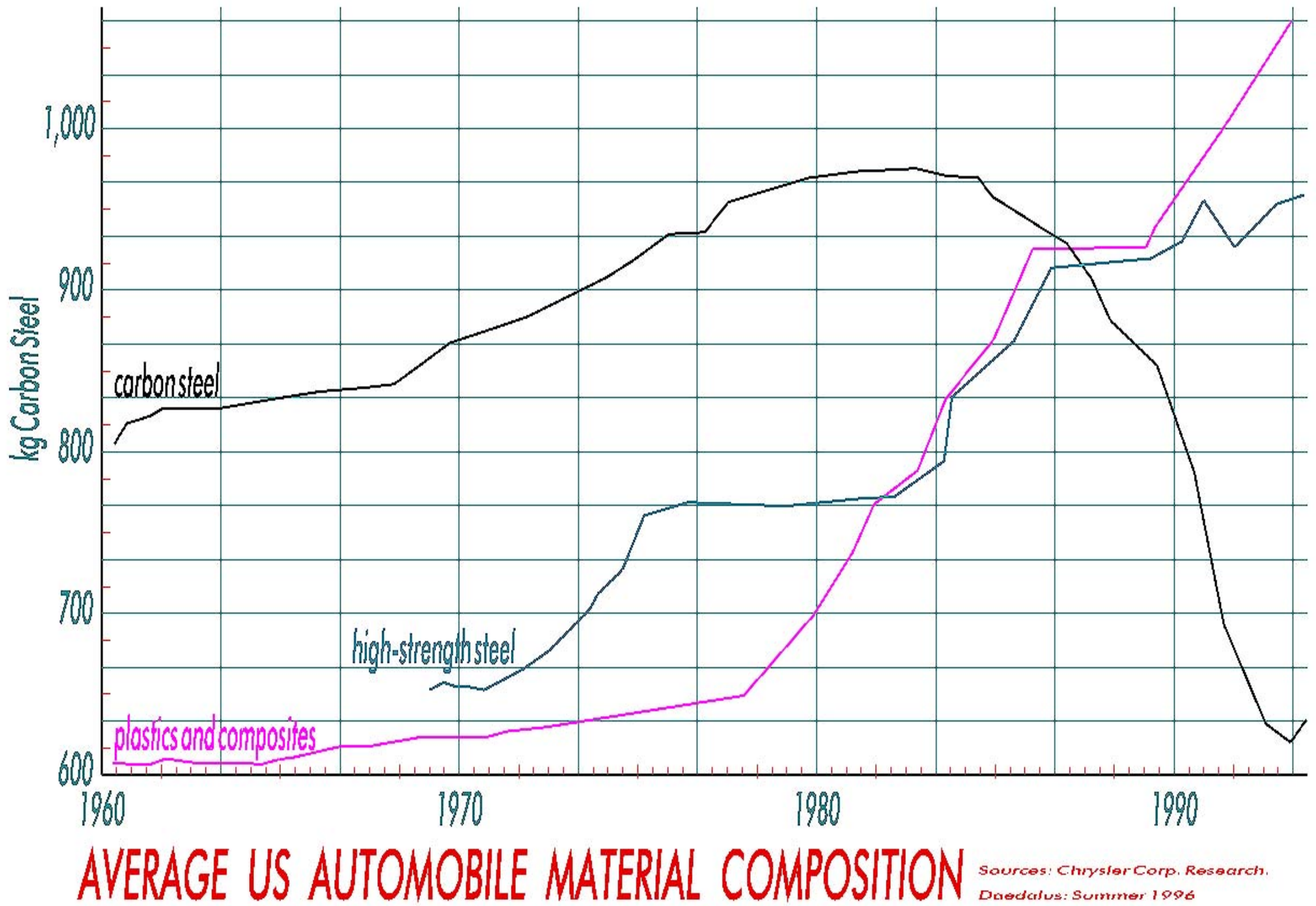

- Next steps
    - Tutorial
    - Material family assignments
    - Software development template

References

See CES Manual
(to be distributed)