School of Civil Engineering

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Sustainability in the built environment: A typology system for supporting construction components reuse

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Rationale

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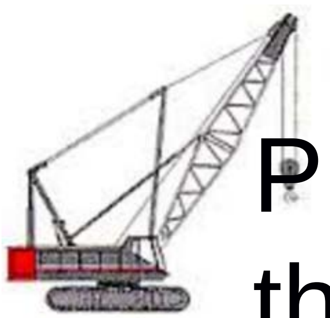
Promotion of sustainability through a shift from material wastage to material conservation is becoming a key driver in the construction sector.



Construction sector consumes more than half of total global raw resources and generates the greatest and most voluminous waste stream globally.

E.g. In 2010, around 29Gt of construction minerals entered the global economy accounting for 44% of total raw materials entering the economy.[1]

In the UK, from the 202.8 million tonnes of total solid waste generated in 2014, around 59.4% were generated by the construction, demolition and excavation activities.[2]

Up to 70% of construction and demolition waste (CDW) is recycled in lower grade applications, leading to dissipation of construction materials and components technical value, e.g. their bending moment, nominal loading capacity, expected residual capacity.[2]

1. UNEP, 2016. Global Material Flows and Resource Productivity. An Assessment Study of the UNEP International Resource Panel. , in: Schandl, H., Fischer-Kowalski, M., West, J., Giljum, S., Dittrich, M., Eisenmenger, N., Geschke, A., Lieber, M., Wieland, H.P., Schaffartzik, A., Krausmann, F., Gierlinger, S., Hosking, K., Lenzen, M., Tanikawa, H., Miatto, A., Fishman, T. (Eds.). United Nations Environment Programme, Paris, France.
2. Defra, 2016. UK Statistics on Waste. Department for Environment, Food & Rural Affairs and Government Statistical Service, Gov.UK.

Rethinking construction practices

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Deconstruction
Reclamation of components from existing structures.

Adaptive reuse
Reuse of the basic structure and/or fabric of the building.

Design for deconstruction
Whole life-cycle consideration at planning stage.

Design for reuse
Reuse of components mined from existing structures in new ones.

Design for manufacture and assembly
Design and manufacture of construction products off-site.

destruction.

New business models

Innovation

Creation of value

Need of lifecycle component information

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but….

still not being mainstreamed due to short-term economic and organisational factors, as well as technical constraints associated with the ***identification*, *recovery* and *handling* of construction components due to lack of information!**

Need for a typology system that supports the reuse of construction components and enables lifecycle information capture.

Use of smart technologies such as radio frequency identification (RFID) integrated with building information modelling (BIM), has been advocated to be a feasible and viable route of promoting sustainability in the built environment.[3]

The subset of 'upstream' and the additional 'downstream' properties required to promote reuse of components, remains an important knowledge gap that needs to be filled.

3. Iacovidou, E., Purnell, P. (2016). Smart technologies: Enablers of construction components reuse? , 4th International Conference on Sustainable Solid Waste Management, Limassol, Cyprus.

Reusability potential: Typology must haves

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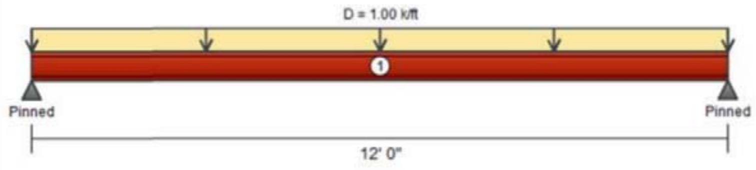
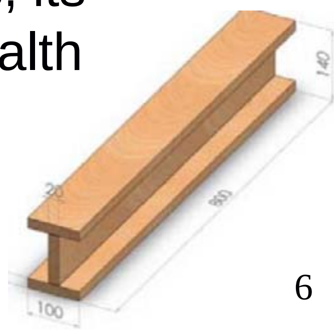
A measure of the ability of a component to retain its functionality after the end of its primary life.

May depend on:

- Essential and desirable properties and characteristics of the component;
- Nature of the original use, performance over time and exposure conditions, and the match thereto for the proposed new structural form, loading, exposure;
- Multi-dimensional value associated with the environmental and/or social "costs" of production, use and reclamation processes, its refurbishment for reuse (e.g. cleaning, painting, testing), health effects, and the associated likelihood of damage or contamination.





Level I Classifications		Level II Classifications
1	**Action**	The physico-mechanical role of the component in its previous deployment.
2	**Material**	The material from which the component is made and strength grade for the structural materials.
3	**Deployment**	The structural form or class in which the component was previously used
4	**Exposure**	The environmental conditions to which the component has been subjected, associated with quantifications (e.g. weather records, detail of chemical environments, Eurocode EN1992 exposure classes) where appropriate.
5	**Loading**	The loading history of the component
6	**Recovery**	The methods used to recover the component
7	**Residual**	The structural and functional properties of the component remaining.
8	**Connections**	The capacity of the component to be connected to other structural and/or functional components and artefacts
9	**Availability**	Details of when and where a component is likely to be available, and in what quantity
10	**Generation**	The number of times the component has already been reused, and whether the proposed new use would represent upcycling, recycling or down-cycling/cascading.

4. Iacovidou, E., Purnell, P., 2016a. Mining the physical infrastructure: Opportunities, barriers and interventions in promoting structural components reuse. Science of The Total Environment 557–558, 791-807.

Construction workshop stakeholders results

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- Proposed typology is a great starting point but needs to become more meaningful to the stakeholders involved in the construction supply chain.
- Classifications at level I should be restrained only to:
  - **Nature;**
  - **Performance;**
  - **Value-availability.**

- Development of a process map – what classifications for which products.
- Making typology operational: must be user specific!
- Vocabulary needs to be refined – common language between all stakeholders involved will improve communication and uptake.
- Training and support - governmental support required as well as acceptability of reuse by the clients.

Typology refinement - Key considerations

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- **What are the key actors in the construction supply chain?**

Government and regulators – those who transpose EU Legislation and waste policy measures in assisting the construction sector to consider its impact on the environment and to improve waste management practices.

Clients – those (or someone who advises them) who seek or accept the services of another for carrying out of a project for them; or carry out a project themselves.

Designers and Engineers – those who either prepare or modify a design and are responsible for optimising the reuse of materials and/or reduce waste from construction projects.

Construction Product Manufacturers – any person who makes a construction product through a process involving, raw materials, components or assembly.

Suppliers (distribution/retail) – those who supply construction materials/ components to a construction project.

Contractors (main and specialist) – those who carry out or manage construction work.

Demolition (Deconstruction) – those who deliberately pull down, destroy or take apart a structure, or a substantial part of a structure, including dismantling for re-use.

Waste management industry (resource management industry) – those who offer a service to transport, treat and dispose of waste, including reuse, recycling, energy recovery and landfill.

- Are the attributes specific and comprehensible enough to allow each actor to assess reusability?
- Do the elements at each level of the typology include all the attributes needed to adequately describe all characteristics that one would need to know/ use to assess reusability potential?
- Decomposition of attributes to too many layers must be avoided so that typology does not become less reliable and comprehensible.

Stakeholders in CSC

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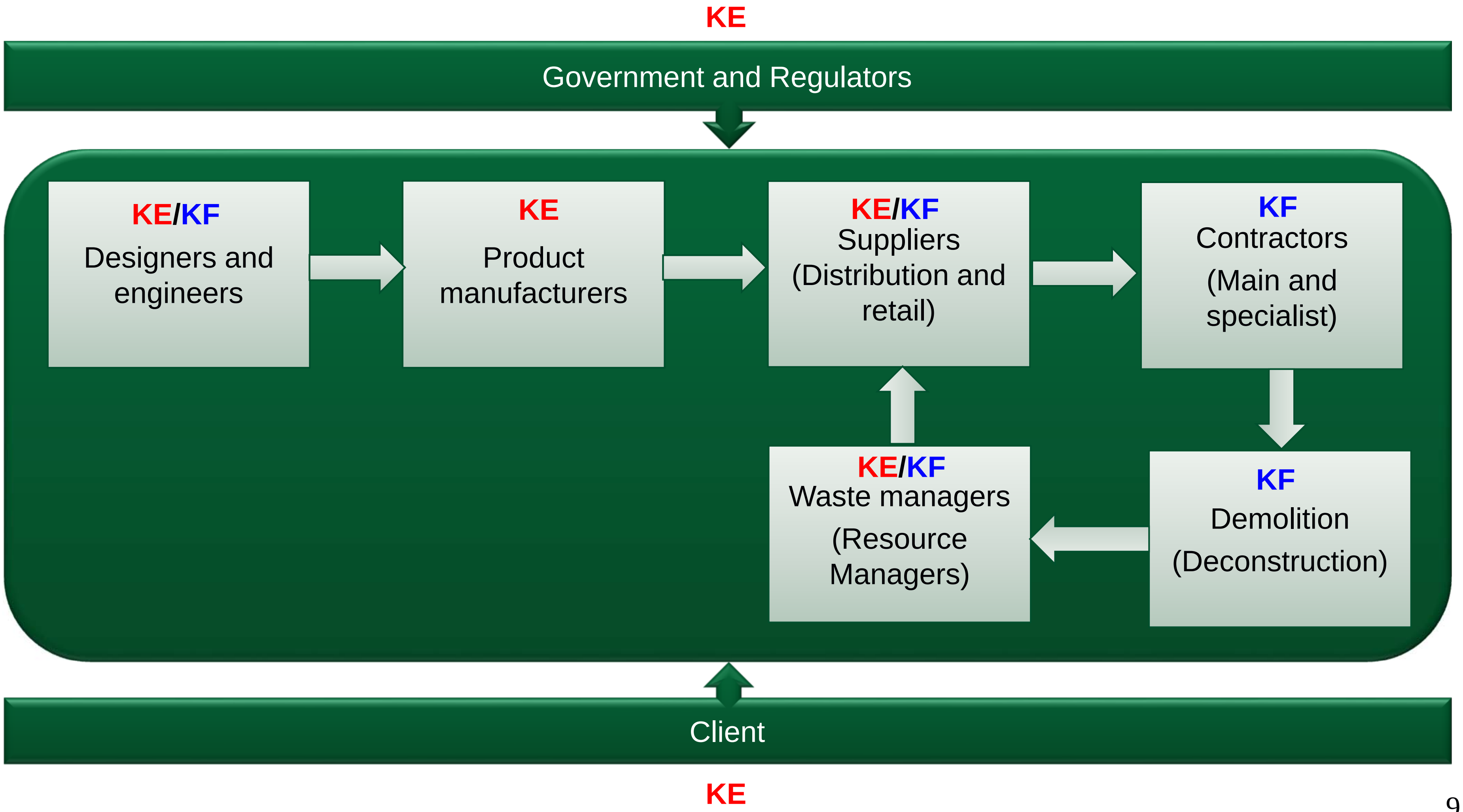
Key enablers: KE ↔ **Key facilitators: KF**



Typology refinement - Key considerations

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- What are the key actors in the construction supply chain?

- **Are the attributes specific and comprehensible enough to allow each actor to assess reusability?**

Depends on each actor – if the person making the assessment is a technical expert and users are likely to be relying on his/her judgement, then some very technical attributes can in principle be esoteric, i.e. in Level III (and perhaps IV).

- Do the elements at each level of the typolog needed to adequately describe all character to know/ use to assess reusability potential?

E.g. For engineers and contractors very specialise/technical dimensions are very important for the reusability assessment, whereas for the client this is too much detail, as reusability could be based around performance, and aesthetic (nature) aspects.
For retailers the typology must be value, performance and nature based.

- Decomposition of attributes to too mar typology does not become less reliabl

http://asbp.org.uk/case-studies/chobham-manor-marketing-suite
https://recyclecoach.com/blog/item?id=88

Tree of hierarchy of typology attributes

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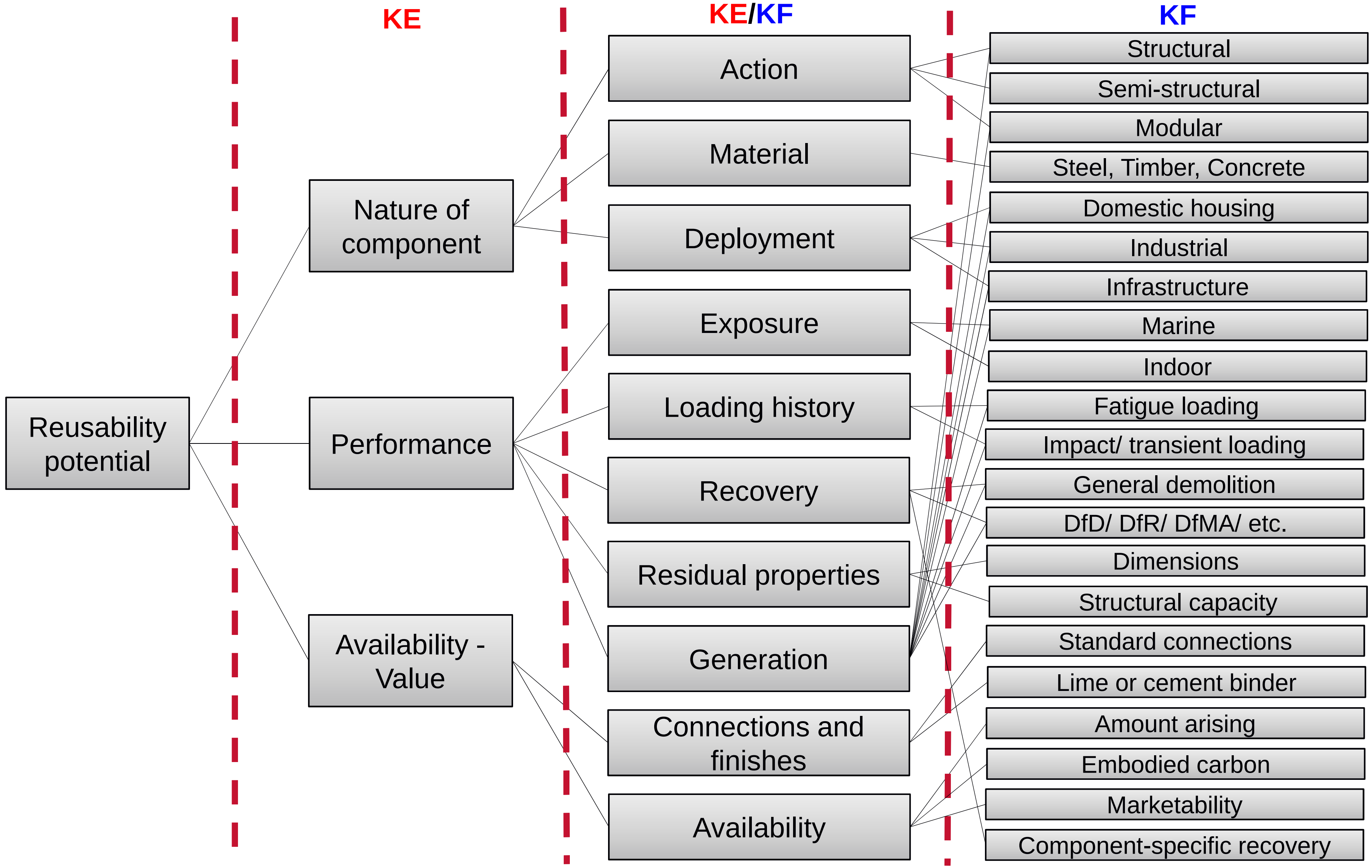

Typology refinement - Key considerations

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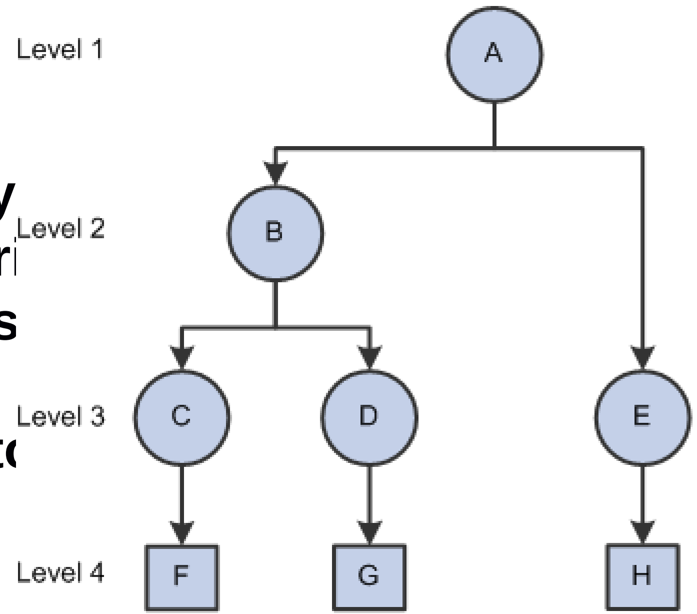
- What are the key actors in the construction supply chain?
  - **Is the decomposition of attributes to too many layers a useful feature of the typology?**
- Are the attributes specific and comprehensible enough to allow each actor to assess reusability?
- **Do the elements at each level of the ty attributes needed to adequately descri one would need to know/ use to asses**
- **Is the decomposition of attributes to t feature of the typology?**

Hierarchy of classifications is needed to make it a useful tool to all stakeholders involved in construction supply chain, from starting from simple classifications to very specialised technical dimensions, but this should be done in such a way so that **typology does not become less reliable and comprehensible**



To sum up…

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Typology for reuse is considered by stakeholders to be useful in promoting sustainability.

Simplicity combined with completeness is key: Ensure that all attributes required for assessing reusability and sustainability of reuse are accounted.

Once this typology means something to all stakeholders this can then become a useful tool:

- aiding communication between the stakeholders, and
- enabling a vigorous transformation of the currently unsustainable practices into more effective and resourceful ones;
- drive innovation.

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Thank you for listening!

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The information flow

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A component's life story evolves from design, to use and reuse.

Transformation of its characteristics and functionality.

- ***Nominal information (static, essential):*** characterises the component in its **as-installed state**, the **action** of the component (i.e. its structural and/or functional role as installed), the **material** from which it is made **and grade** thereof, the **installation method** and **connection type**, the **type of structure** in which it was deployed, **environmental impact** (e.g. embodied carbon, energy or water), inferred **residual capacity information** (i.e. how the component was expected to degrade with time in service) and information on the previous **reuse history** (if any).

- ***Service history information (dynamic, desirable):*** evolves in response to the **physical** (stresses, strains, accidental damage), **and environmental** (temperature, humidity, chemical exposure etc.) **loads** the component endures during its service lifetime, and other **residual properties** (e.g. evidence of corrosion, records from monitoring programs such as acoustic emissions).

Typology refinement - Key considerations

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