Responsible Use of Materials –
The Structural Engineers' Path to Climate Change Mitigation

1) The Starting Point

In the wake of the publication of the European legal framework for propelling sustainble investment – *EU Regulation 2020/852 On the Establishment of a Framework to Facilitate Sustainable Investment* – in June 2020, the discussion of the consequences derived therefrom gained momentum on each and every level of societal, economical and politcal activities.

Due to the sheer dimensions of building- and civil-engineering-structures, the thoughtful and responsible use of the resources and the assessment of the structures' impact on the society and the environment was and is a pivotal issue of the construction industry's mindset. Hence, the basic principles laid out in the mentioned EU Regulation, i.e.:

- the sustainable use and protection of water and marine resources
- the transition to a circular economy
- pollution prevention and control
- the protection and restoration of biodiversity and ecosystems

have always been the fundamentals of the education and practice of structural engineers.

Thus, all structural engineers, especially the consulting engineers, are predestined to assume a crucial position in the construction industry in moderating the actual discussion on possible means for climate change mitigation and climate change adaption, the remaining two of the six central topics of the EU-Regulation 2020/852.

2) The Actual Position of Structural Engineers

Against the background of the ongoing revolution of software tools for structural design and current and future developments using big-data-processing, the recent evolution of the construction industry is characterised by a renunciation from the historic principle that good design is based on well established construction rules, both with respect to robust, resilient and adaptable structures and with respect to the structure´s environmental impact. Or to put it in Louis Sullivan´s famous words from 1896, written down in "*The Tall Office Building Artistically Considered*":

"*Whether it be the sweeping eagle in his flight, or the open apple-blossom, the toiling work-horse, the blithe swan, the branching oak, the winding stream at its base, the drifting clouds, over all the coursing sun, form ever follows function, and this is the law. Where function does not change form does not change.*"

This decline in engineering prowess, often hidden under glamourous multi-dimentional computer simulations and renderings, led to the situation that in the principal design process, usually driven by the client and the designer/architect, and the inevitable loops of economic optimisation efforts the voice of the structural engineers remains unheard and, consequently the structural engineers´experience is reduced to an item which can be bought cheapest. A well-designed structure outpaces virtual structural-models, relying on number crunching and huge amounts of computational power, technically and economically by far – a forgotten topic.

This results, with respect to a responsible use of resources, in a critical shift along the decision-time-axis. The structural engineers' involvement, which is vital for the choice of materials, dimensions and construction techniques – in other words: the amount of material used per unit –, is deliberately delayed to a point where the engineers' influence on the critical decisions regarding to the above mentioned, six major EU-Regulation goals, is marginalised.

Instead of exploiting the structural engineers' experience in desig and development of high-performance structures under responsible use of resources, the structural designer's input on the project is postponed to a point where all the crucial decisions have been made and only an insignificant potential of material-savings, often accompanied by a significant reduction of the structure´s robustness, resilience or future adaptivity, is left.

3) How to Create Leverage

To begin with, a clarification of terms is imperative: For the context under disscussion, the expression **Sustainability** isn´t the appropriate one, as it gives to much space for interpretration and hence lacks the necessary precision. The elementary task of everybody involved in shaping, building and enhancing the built environment is to do this responsibly. So, creating leverage for structural engineers when addressing Climate Change Mitigation means: Identifying the areas where leverage lies and use the so created leverarm with **Responsibilty.**

However, the actual European regulatory framework which encompasses the structural engineers´ area of influence, i.e. the Structural Eurocodes, is written with the explicit intention to minimise the engineer´s responsibility and hence limiting the manoeuvrability to an extend that is in contradiction with the above mentioned principles of good practice. So, the structural engineers can only fulfil their societal responsibility when they can shake off the yoke of nanny standardisation of the last 20 years.

Leverage to come in line with the EU Regulation requirements can only be created when the following is achieved:

- Involvement of the structural engineer at the earliest possible design stage, i.e. when the design process is about to lift off, to take advantage from the engineers experience and to give the engineer the chance to influence the design. Otherwise the impact on the so-called sustainable approach is lost.
- Rejuvenating the basic design principle that good design is based on well established construction rules
- Accepting that modern software tools are only tools and not the solution

– Allocating the responsibility to the structural engineer by condensing the mandatory regulatory framework down to the absolute minimum, i.e. definition of the generally accepted safety levels and the therewith corresponding material and structural properties

So, creating leverage for structural engineers to contribute successfully to the Climate Change Mitigation transition of the construction industry needs a paradigm change for the entire civil-engineering-community: Getting rid of superfluous regulations and accepting the responsibility for designing robust, resilient and long-living structures and shaping the built-environment accordingly – brain work based upon knowledge and experience and not being merely an extension of enormous computational power .

4) Consequences

Having said this, a successful integration of the six central EU Climate Change Mitigation requests into the everyday work of structural engineers requires:

– Looking at the broad picture, i.e. identification and evaluation of all parameters which have an influence on the structure-environment interaction, instead of concentration on single issues as the problem at hand is characterised by multi-dimensionality and multi-dimensional problems can only be tackled successfully by addressing the total, complex sensitivity of the problem, or, speaking in mathematical terms, when the total derivative of the multi-dimensional function is analysed instead of looking at the derivatives of the single influence parameters.
– This can not be achieved by merly polishing the actual standards with respect to safety factors and other secondary parameters, commonly known as quick wins, as this single-minded approach neglects all other aspects of the structure-environment interaction.
– This can not be achieved by defining a new, recently proposed limit state, the *Limit State of Climate Compatibility*, as it is impossible to judge and assess complex, multi-dimensional issues like engineering ideas, good design and responsible use of materials with simple, standardised limit state functions.
– Looking back into engineering history shows that restricting the effort to quick wins, which can be realised in short term and are therefore often the first and easiest choice, will backfire in the long term with economic and environmental consequences far beyond the gains the quick wins will ever provide.
– The only way to comply with the societys' right of transforming the construction industry according to the EU regulation goals is to understand that every participant has to take his burden but that all the burdens are linked to each other and therefore the only way forward is integrated teamwork from the very beginning otherwise all efforts will lead to a dead end. Precicely as Richard P. Feynman has stated it in the wake of NASA´s Challenger disaster in 1986:

  "For successful technology, reality must take precedence over public relations, for nature cannot be fooled."