Design and Assessment of Structures as a Concerted Planning Process

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Summary

The consideration of all aspects of sustainability leads to an integrated design of structures that does not meet only the traditional requirements for mechanical resistance and stability as well as safety in case of fire but that meets also the more general requirements with regard to hygiene, health and environment, safety in use, protection against noise, energy efficiency and sustainable use of natural resources.

As various requirements may lead to conflicting directions for design, a first conclusion is that concerted actions are necessary to develop consistent concepts for an integrated design process of construction works which are suitable for structural optimisation in general view.

A sustainable development for construction will not simply respond to new needs by adding new constructions to the existing construction stock or demolish old buildings and simply substitute them by new ones: it will analyse existing construction to identify their possibilities for meeting sustainability goals.

In parallel to the development of the engineering services and construction market the future generation of structural design codes and product standards will highlight new and advanced concepts for the design and assessment of civil engineering works.

Keywords: Integrated design process; assessment of existing structures; sustainability; limit state design; safety; serviceability; durability; design working life; quality management; design codes of practice.

1. Introduction

This contribution is an approach to the subject of sustainability from the point of view of experience in structural engineering practice. The review on state of the current structural design concepts is the basis for discussion and observations of the design practice between architects and engineers, which is strongly developing in direction of an integrated planning process.

The design codes and product standards are expected to be a support for the involved parties in the design and construction process. They should represent a tool and help for the mutual understanding. The general trends of promoting sustainability mean also a challenge for the development of a future generation of design codes in practice opening the door for a more general view of the structural design.

2. Current structural design concepts

2.1 Bases of structural design

The structure and structural member should be designed, executed and maintained in such a way that they meet the fundamental requirements of structural safety, serviceability, robustness, and fire protection.

https://doi.org/10.2749/222137809796067461

The recent generation of operational codes for practice [1] recognise the possibility of reliability differentiation and provide guidance for obtaining different levels of reliability. Reliability differentiation comprises the measures intended for the socio-economic optimisation of the sources to be used to build construction works, taking into account all the expected consequences of failures.

2.2 Limit state design

Limit states are states beyond which the structure no longer fulfils the relevant design criteria. Based on the use of structural and load models, the relevant design values for actions, material and product properties, and geometrical data are used. This is achieved by the partial factor method. Two types of limit states are considered: ultimate limit states and serviceability limit states [2].

The design concepts based on limit state design and the application of the semi-probabilistic method with partial factors are widely used in many countries [3]. The features of the general appreciation of the fundamental requirements and design methods are to lead to a common understanding in the profession of structural engineering and the mutual recognition of design culture.

3. Development of design and construction practice

3.1 Integrated design process

The acceleration of modern processes suggests that the only constant in life is change. Broken down to the issue of the design and construction process of buildings, bridges and other construction works we have to recognise that a building project is characterised as a integral system, which embraces a number of different subsystems. The conceptual design of a building has to consider all different aspects of the following subsystems:

- main structure (primary system) including architecture, structure, and envelope or facade.
- techniques, services (secondary system) including HVAC services, electrical and mechanical services, acoustics and building physics, fire protection, building automation, and others.
- environs, including urban planning, environmental planning, traffic planning, supplies, waste planning, and others.

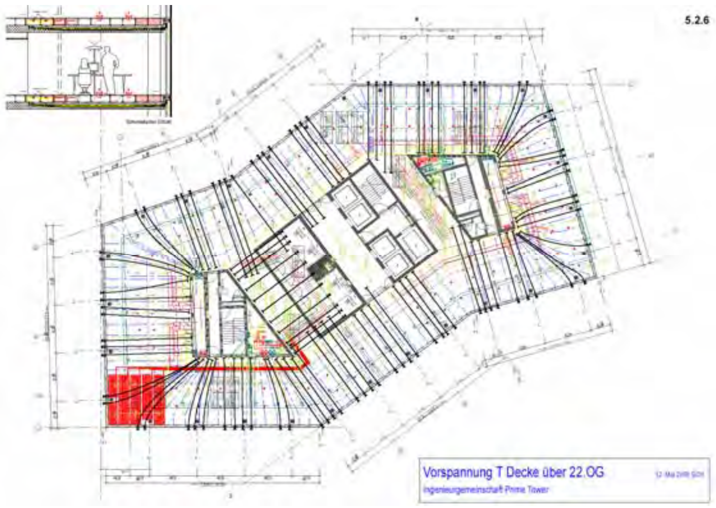

Fig. 2: Prime Tower Zurich Switzerland is an example of a complex building system

Requirements of different interest may lead to conflicting directions with regard to the overall design. The main conclusions are that the number of subsystems to be considered in design and construction of buildings is generally increasing and that the subsystems have to be coordinated rather than to be optimised separately. The subsystems have to be subordinated to the overall concept.

The current practice of the linear structural design procedure is changed into an interactive dialogue of all involved parties.

Similar considerations have to be respected in the design and construction of bridges. The network of the integral system and the subsystem is of the same nature as for buildings. However the subsystems and the involved parties in bridge design are different from those in building design.

3.2 New materials

Fibre reinforced polymers (FRP) have been used in the construction sector since the mid-1980s. In the beginning FRP have been used mostly for the strengthening of existing buildings and bridges. Increasingly since the past decade, a number of pilot projects for new structures have been developed.

Of all parts of a building, the facade probably has the greatest potential in the near future for undergoing decisive further development and improvement [4]. Modern facades are therefore one of the most important key elements to achieve energy efficiency and sustainability in the building sector. The recent architectural trends (figure 4) and technological developments have brought changes in the use of glass in buildings.

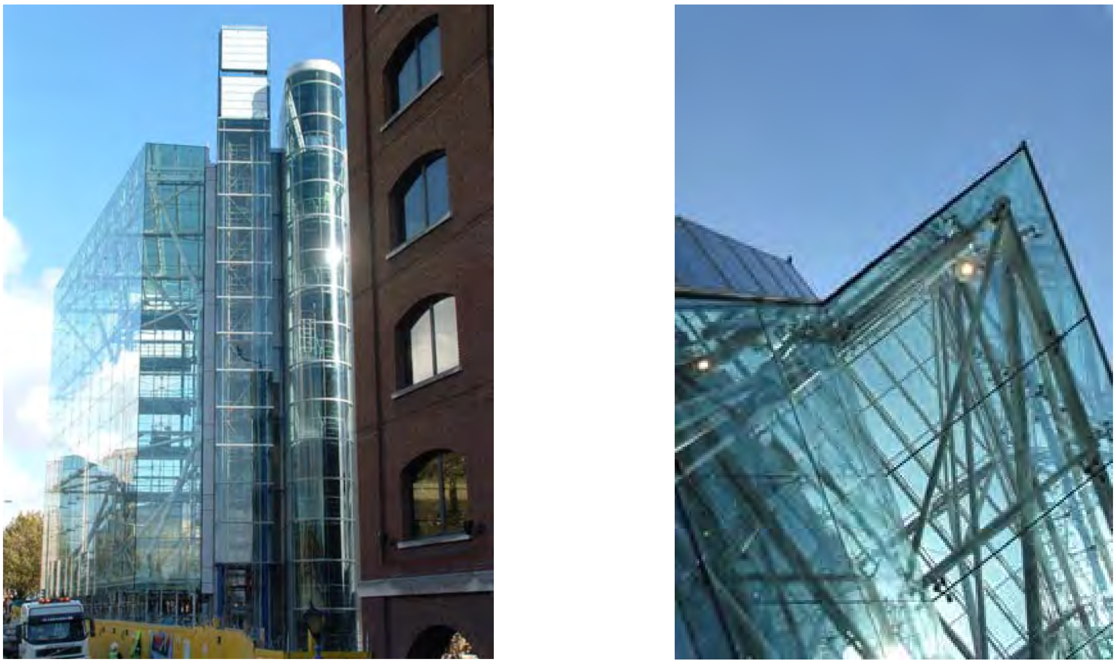

Fig. 4: Glass façade, St. Katharine Estate London is an example of a loadbearing glass structure

3.3 Recycling materials

Recycling reduces waste going to disposal, consumption of natural resources and improves energy efficiency. It therefore plays an essential role in the move towards sustainable consumption and production - not only in terms of energy but also in terms of all resources we produce. The potential is also significant to improve efficiency and capacity, by encouraging innovation and introducing more effective processes and technologies. This would save costs, energy, and natural resources and help to be less dependent on raw materials.

4. Assessment and retrofitting of existing structures

A sustainable development for construction will not simply respond to new needs by adding new buildings to the existing building stock or demolish old buildings and simply substitute them by new ones: It will analyse existing structures to identify their possibilities for meeting sustainability goals.

Owners of existing structures, real estate agents and other partners interested in the technical performance of the structure are interested to profit from a successful assessment or retrofitting in realising a higher value on the real estate or rent market.

The experience demonstrates that in many cases the assessment and retrofitting of existing structures are not initiated by structural aspects. In fact more general requirements and considerations with regard to economical and ecological considerations are the main growth drivers. Hence the considerations with regard to the integrated design process also apply for the planning process of the assessment and retrofitting existing structures.

However the approach for the assessment of existing structures is in many aspects substantially different from that for designing new structures, although the principles and fundamental requirements are the same. Whereas the design is taking into account uncertainties in the anticipated use of a structure, the assessment considers the history of a structure and the future use equally. Especially the updating of information and data is one of the major tasks.

5. Conclusions

In parallel to the development of the engineering services and construction market the future generation of structural design codes and product standards will highlight new and advanced concepts for the design and assessment of civil engineering works. Codes and standards based on consensus and the involvement of stakeholders have the potential to play a leading part in promoting sustainable development across all its three spheres: economic growth, environmental integrity and social equity.

It would mean the development of a coordinated system that allows architects and engineers to optimise the design in view of best efficiency to meet the full set of requirements. It is the persistent and fruitful dialog between the architect, engineer, and all other involved parties in an integrated design process that enlightens the art of construction.

6. References

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PL, 2009.06.30