FIELDS OF EXPERTISE
TU Graz research
2023-2/#30

Figure 1: Extreme slender concrete structures for architectural reasons but also to achieve record-spans of bridges.
Source: Schlicke

Dirk Schlicke

Dirk Schlicke is head of the Institute of Structural Concrete.

Source: Sissi Furgler Fotografie

Dirk Schlicke

Resource-Responsible Construction with Concrete

Concrete is an incredibly powerful building material that can be tailored to the specific requirements of an application with enormous versatility.

Its properties range from almost unlimited availability and enormously cost-effective production to almost boundless freedom in shaping, achieving compressive strengths equal to structural steel, water and even gas tightness as well as extreme durability for particularly harsh environments. Looking at our built environment, starting with the sewage network, sewage treatment plants, bridges, tunnels, locks, towers, dams, protective structures, the foundations of houses and buildings and the buildings themselves etc., it can be said without exaggeration that concrete is an essential part of our civilization – and in many cases without alternative.

At the same time, however, building with concrete also has significant Global Warming Potential (GWP) due to the process-related release of CO_2 in the manufacturing of the most important component of concrete – cement. The current environmental crisis therefore urges construction of more sustainable structures, which requires a radical change in how we design and build. More than ever, innovative solutions are being developed to reduce the GWP of concrete, both on the part of materials

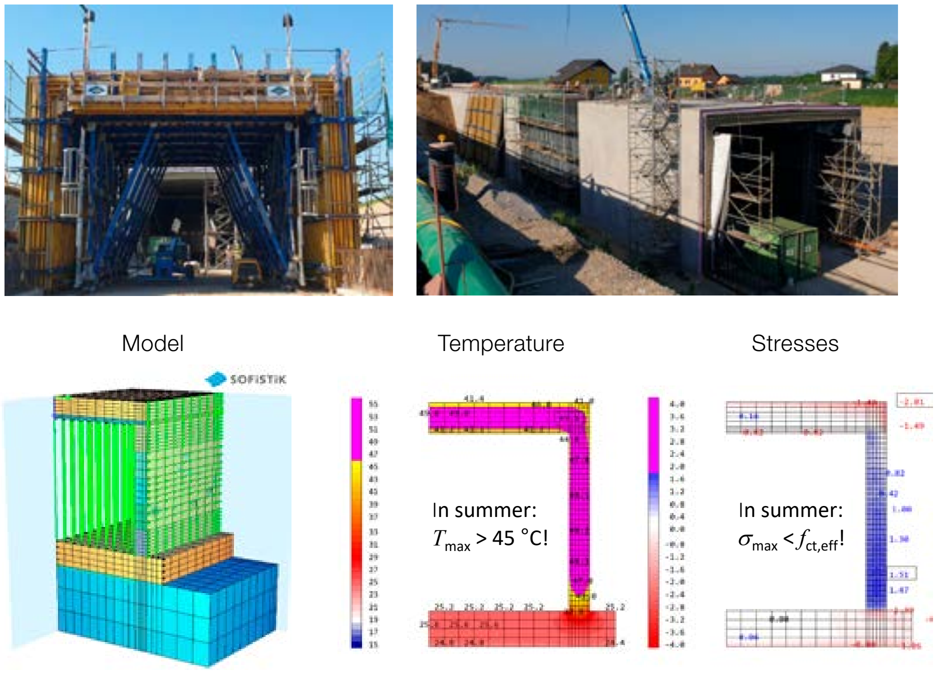


Figure 2: Assessment of concrete behaviour due to hardening by thermomechanical simulations for Koralmbahn.
Source: Schlicke

technology on the developments of concretes with reduced CO_2-emission as well as with regard to concrete mass-optimized construction methods. However, the implementation of these innovations requires the provision of design parameters for building with CO_2-reduced concretes and nothing less than a revolutionization of the planning process in structural design. This is where the IBB's research on resource-responsible construction with concrete comes in.

Structural design as such is a complex and dynamic process involving various stakeholders with different interests. Today's planning practice is characterized by the tension between cost efficiency and normative requirements as well as empirical values in the context of legal framework conditions. It is not uncommon to accept compromises in the mechanical consistency of a solution in order to avoid costly discussions within the framework of a planning process trimmed to record time, at the end of which the resulting material and >

Figure 3: Concrete in tunneling, here Semmering Base Tunnel.
Source: Schlicke

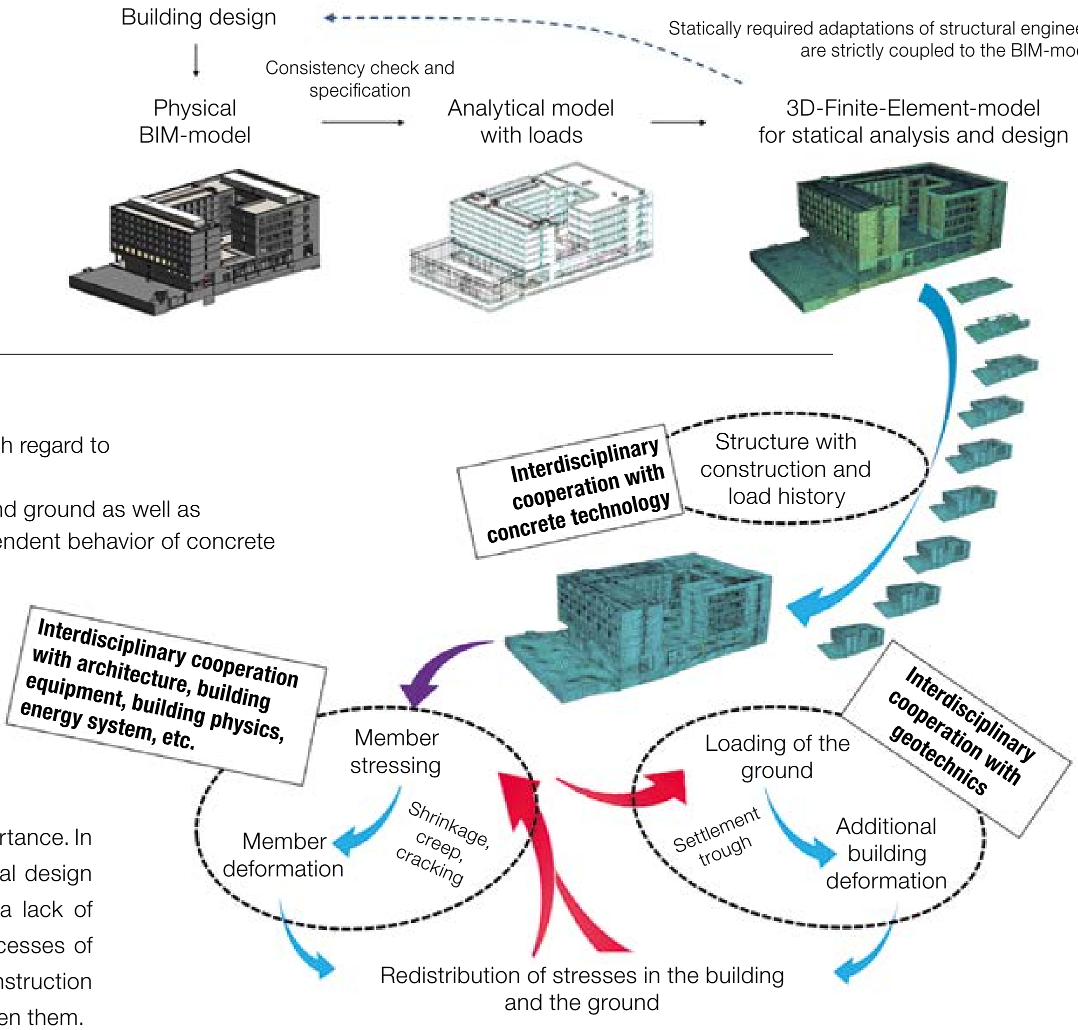


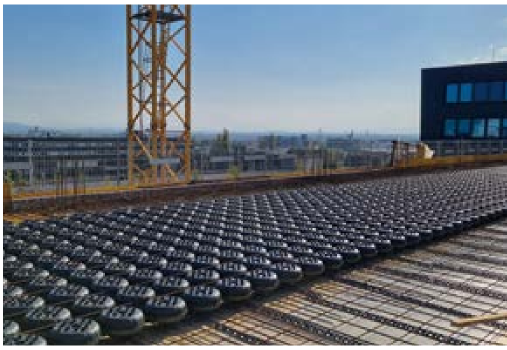
Figure 4: Schematic illustration of integral and interdisciplinary planning.
Source: Schlicke

energy input is of secondary importance. In addition to the concrete structural design aspects, there is currently also a lack of coordination of the planning processes of the various sectors involved in construction and insufficient interaction between them.

With the help of interdisciplinary cooperation between structural design, geotechnical engineering and materials technology as well as architecture, building physics and energy systems across all planning phases, the aim is to pave the way for innovations in materials technology as well as in components and construction methods to be put into practice. With regard to the transfer of material-technological innovations into the practice of structural design, the work of the IBB is focused on the development of thermo-hygro-mechanical simulation tools and their application in parameter studies for the derivation of key figures for the practice-oriented design of innovative construction methods, such as the aforementioned use of CO_2-optimized concrete, but also timber-concrete composite construction methods are in focus here. To this end, a large öBV industry project and various cooperation projects with Holzbauforschungs gmbH in Graz are currently being worked on at IBB.

Figure 5: Reinforcement cage of 3.8 m thick ground slab.
Source: Schlicke

Figure 6: Flat building slabs with hollow bodies.
Source: with permission of foermli GmbH



With regard to the transfer of component- and construction method-related innovations into the practice of structural design, the work of the IBB lies in the development of rules for consistent structural analysis and design in holistic 3D models. In contrast to conventional structural design, in which the structural analysis and design of components takes place in decoupled substitute models, holistic 3D models are used here, which in the best case are also in feedback with Building Information Modeling models from the architectural design. In these holistic 3D models, notable optimizations of the concrete masses in the range of 5 to 10 % have already been achieved by mechanically more consistent considerations in combination with better possibilities in the interdisciplinary cooperation between structural design and geotechnics. These aspects are currently being tested at IBB in cooperation with IBG.

In addition, these holistic 3D models can be derived or created by the structural engineers in the early planning phases so that the possibility of a follow-up assessment for the application of innovative construction methods, such as flat building slabs with hollow bodies or infill girder grid foundation slabs, is created. Thus, the innovative construction method with all its further effects on the vertical and horizontal bracing system as well as the foundation will be made quantifiable. Finally, the question of what synergies can result from an interdisciplinary cooperation between structural design and energy system in early as well as late planning phases will be investigated. These aspects are currently being tested at iWT and iBB in the context of the QualitySysVillab real laboratory using the example of a real development project in Villach with a claim to sustainable neighborhood development.

Overall, resource-responsible concrete is easier said than done. The mandatory interdisciplinarity and agility in structural design requires a fundamental rethink and an open-minded redesign of the framework conditions of construction planning processes, including greater involvement of structural design in early planning phases. However, education and training also play a role here. In addition to the mechanical fundamentals and normative requirements for the structural analysis and design of structures, new planning methods with holistic 3D models, deformation-based approaches and non-linear calculation methods must be taught in a well-founded manner. It is also important to apply these new methods not only from a structural engineering perspective, but also in an interdisciplinary and agile manner.