Zukunft Bau

KURZBERICHT

Titel

Behavior of precast concrete sandwich walls under mechanical and thermal stress

Anlass/ Ausgangslage

So far, building facades made of precast concrete sandwich panels are mainly realized by utilizing reinforced concrete members with a facing shell thickness of about 70 to 100 mm. By applying corrosion-resistant textile reinforcement it is possible to reduce the thickness of the outer shell significantly. With respect to this perspective and the need for research, the aim of the research project is to both numerically and experimentally derive realistic temperature values and gradients for an appropriate design approach.

Gegenstand des Forschungsvorhabens

The research project was developed out of the intention to derive realistic temperature values for innovative constructions made of facing shells with corrosion-resistant textile reinforcement and to extend the state-of-the-art load approach according to DIBt 1995/5 [1] to such applications. In the course of the project, this necessity could not only be ascertained for the mentioned innovative systems, but also for the commonly used reinforced concrete systems with facing shell thicknesses between 70 and 100 mm (see Figure 1).

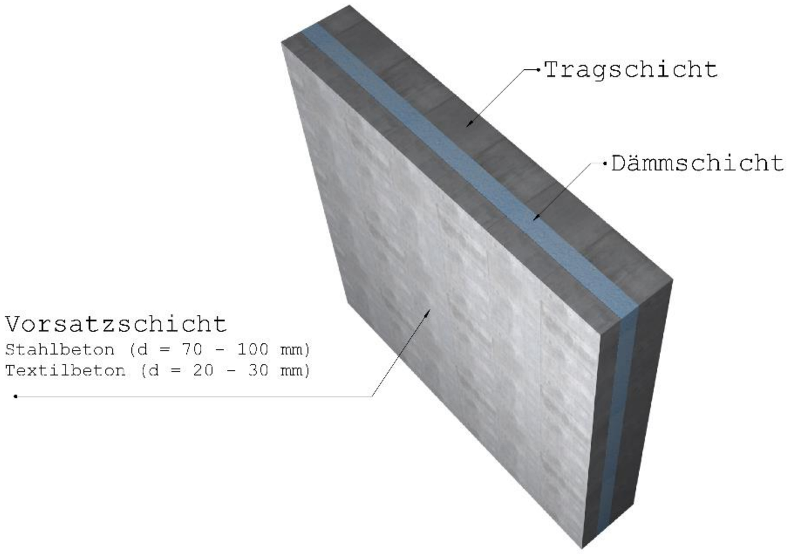

Figure 1: Components of a precast sandwich wall (3D model)

The main reason for that lies in the fact that the load approach according to DIBt 1995/5 [1] has no cross-sectional dependence. The climatic change with more extreme weather conditions is also to be mentioned as justification.

With the support of companies from the precast concrete industry, the fundamentals of the project could be formed by a large-scale in-situ experiment under natural conditions. Through this 365-day long-term test numerous measurements were obtained, which reflect the conditions of a 30 mm textile-reinforced, as well as an 80 mm steel-reinforced facing shell of sandwich walls. Figure 2 shows the developed and manufactured test setup.

Figure 2: Test setup with facing shells VS1-VS4 (south-west orientation)

Among other things, this experiment showed that the complex physical processes of the climate and the resulting impacts within the facing shells can be simulated realistically by numerical simulations. With the resulting link between reality and numeric, numerous virtual images of the test setup were created and the entire temperature spectrum of a wide range of boundary conditions was determined. Thus, with the measured effects (for example solar global radiation, wind, etc.), the thickness, surface color and the used material could be numerically parameterized and evaluated with regard to the resulting thermal distribution. Among other things, this calculation process made it possible to prove that the load approach according to DIBt 1995/5 [1] is only valid for 60 mm reinforced concrete facing shells under normal climatic conditions. Other facing shells with identical dark colors (α = 0.90 - 0.95) showed strongly deviating surface and layer temperatures for the selected summer day (see Figure 3).
The need for a cross-section-dependent load approach could thus be clearly demonstrated.

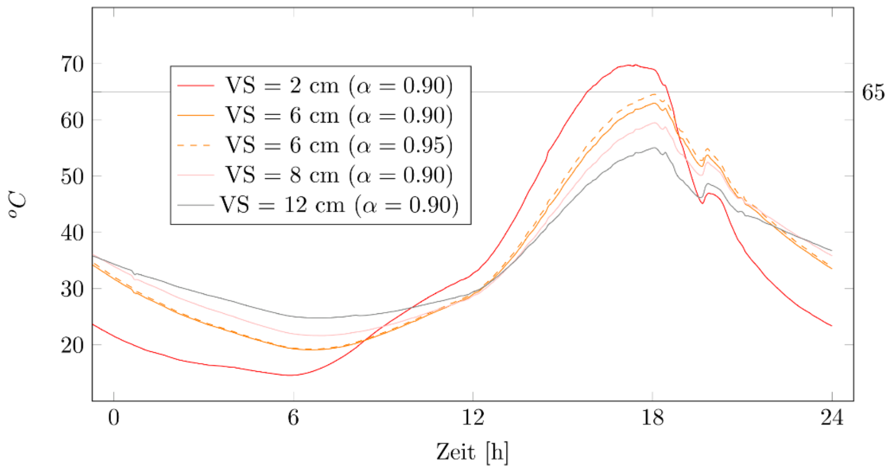

Figure 3: Surface temperatures as a function of thickness – α = 0,90/0,95 (06.07.2017)

In addition to the numerical computations based on the in-situ experiment, numerous simulations with general data of the Deutschen Wetterdienstes (DWD) were carried out. Based on the so-called test reference years, parameter studies were implemented by means of a specially developed software, which virtually varies the facing shells in its geographical orientation as well as its thickness and coloration (see Figure 4). Among other things, this requires calculation processes that convert the solar radiation values of a horizontal plane on arbitrarily inclined walls. Thus, a total of 1620 calculations were carried out for 15 regions of Germany in a summer half-year (01. April to 30. September). The simulations using test reference years showed a good agreement with the measurement and simulation data of the natural experiment and are therefore basically suitable for the derivation of generally valid design approaches for engineering practice.

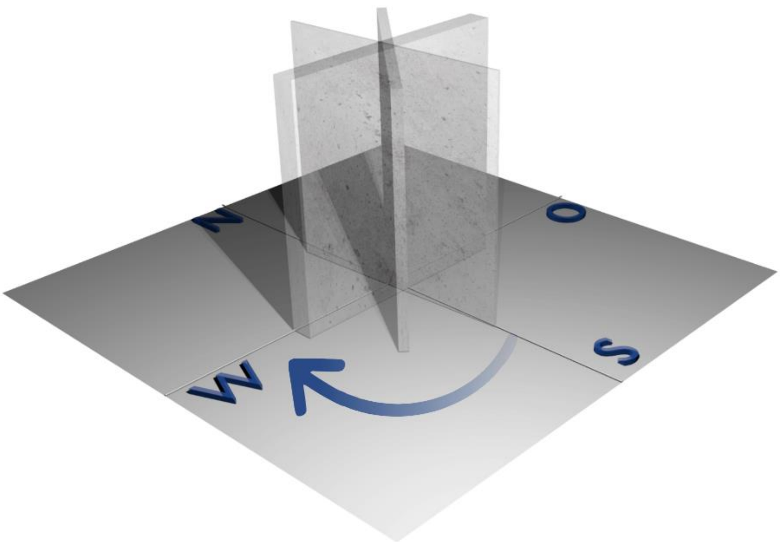

Abbildung 4: Virtual rotation of the wall with changes in thickness and coloration (software concept)

In order to not to base all studies on different sandwich wall structures on purely numerical foundations, a multifunctional climatic chamber for sandwich facades with 1 x 1 m facing shells was designed and realized at the Chair of Concrete Structures of the Technical University of Munich. A 3D model of the climate chamber can be seen in Figure 5.

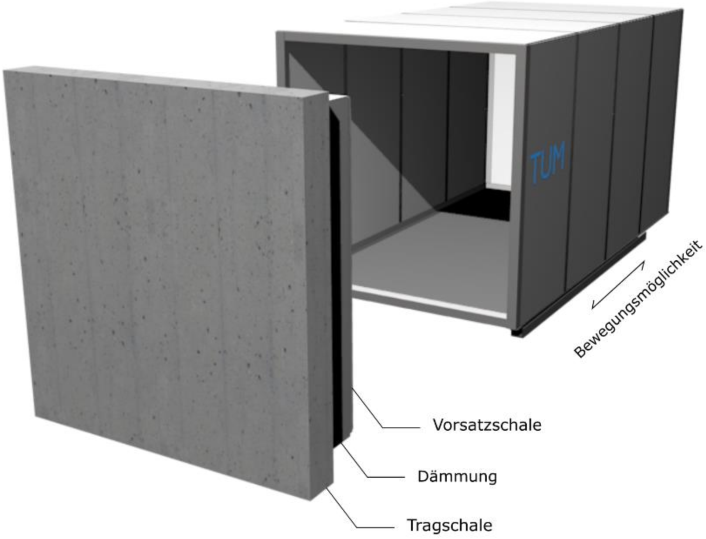

Abbildung 5: 3D visualization of laboratory test setup

Both the control and software technology was developed especially for the requirements of a precast sandwich wall construction. The wall itself forms a closed space with the climatic chamber, in which numerous climatic conditions can be applied to the outer shell from the inside. The experiments carried out showed a very good agreement with the reality both for the simulation of usual summer days as well as for extreme conditions under rain. With the help of this test setup further large-scale test series are planned for the future, which analyze different cross-sectional thicknesses as well as different materials under normal and severe weather conditions.

[1] Deutsches Institut für Bautechnik (DIBt). Grundsätze zur Ermittlung der Temperaturbeanspruchung mehrschichtiger Wandtafeln mit Betondeckschicht. Mai 1995.

Fazit

This research project is an essential foundation for the development of cross-section-dependent design approaches for precast sandwich walls. With the help of this and the research planned for the future it is possible to establish the new innovative systems of the textile-reinforced facing shells on the market and simplify the application for planning engineers. At the same time, the results make it possible to optimize existing structures with regard to their efficiency and service life. We hope to make a major contribution for achieving this goal.

Eckdaten

Kurztitel: Behavior of precast concrete sandwich walls

Forscher / Projektleitung: Lehrstuhl für Massivbau (Technische Universität München)
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BILDER/ ABBILDUNGEN:

Bildnachweis jeweils:

Figure 1: Sandwichwandaufbau.png
Components of a precast sandwich wall (3D model)

Figure 2: Naturversuch.png
Test setup with facing shells VS1-VS4 (orientation south-west)

Figure 3: Temperaturverlauf.png
Surface temperatures as a function of thickness – α = 0,90/0,95 (06.07.2017)

Figure 4: Softwarekonzept.png
Virtual rotation of the wall and changes in thickness and coloration (software concept)

Figure 5: Laborversuch.png
3D visualization of laboratory test setup