Experimental and numerical investigations on the structural behavior of metallic gratings

Metallic gratings are a common lightweight construction solution for industrial floors covering the machinery spaces below, as well as for steel platforms and stairs or aesthetical elements in facades. In Germany, the design of these gratings is regulated in *RAL-GZ 638*, which covers the determination of the load-bearing capacity under concentrated loads of simply supported gratings simplified as effective rectangular beam cross-sections. Currently, the design is limited to the material structural steel and has rather conservative as well as partly unsafe assumptions which have not been sufficiently investigated in the past.

With regard to these formulas and assumptions, the Industrial Association of Gratings in Germany aims to establish a new and revised standard to ensure a safe, but also sustainable calculation and verification of gratings. Up to now, only the elastic load-bearing capacity of gratings is taken into account in the design formulae and the plastic behavior has been neglected entirely. Due to the use of metallic materials of all kinds, such as stainless steel or aluminium in addition to the traditional structural steel, the standard could be extended for these as well. Furthermore, the number of load-bearing bars, which are considered in the effective beam section, is determined under the centre of the concentrated load acting on the grating. However, as demonstrated in the framework of the research project, the safer assumption is the outer edge of the load application area, which corresponds to the bar at the free edge of the grating due to the governing load position (see Figure 1).

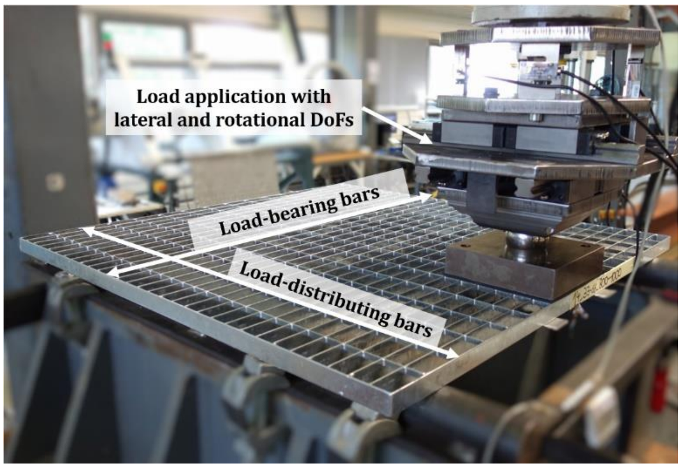

Figure 1: Test setup for a simply supported grating specimen including the load application system

Following a large number of experimental tests on grating plates and additional smaller tests to determine reference and material properties, finite element models were calibrated and an extensive parametric study was carried out. Based on the collected data, it was possible to derive formulae for the effective beam cross-section and the elastic as well as the plastic load-bearing capacity (see Figure 2). For slender load-bearing bars with a high distance between load-distributing bars, stability failure was observed in the experimental and numerical tests. New formulas were developed for the assessment of the slenderness of these gratings and to give the possibility to verify the desired grating with either the elastic or the plastic load-bearing capacity, depending on which limit value is fulfilled.

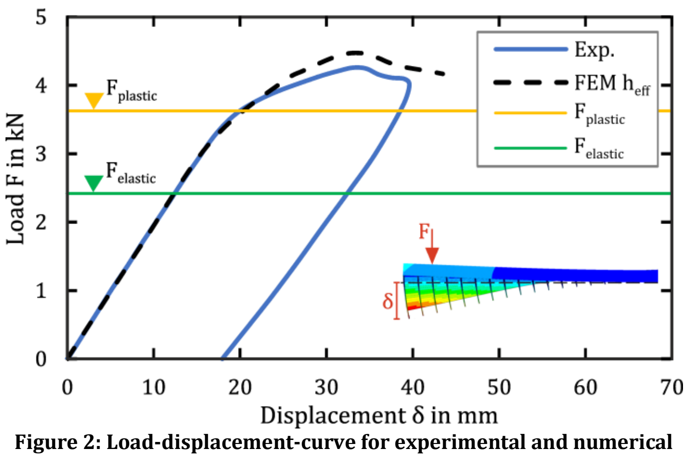

Figure 2: Load-displacement-curve for experimental and numerical investigation with load-bearing capacities

In addition, the influence of imperfections was investigated which, due to the geometry and the manufacturing process, only occur with gratings. These imperfections are mainly caused by the load-distributing bars which are pressed into a slot that is punched into the load-bearing bar at the desired location. Due to the gaps and the lack of welding, these slots reduce the load transfer in these areas and thus cause a reduction in the load-bearing capacity and stiffness of the load-bearing bars and of the whole grating. As a result, an effective height of the load-bearing bars has to be determined using a formula derived from the experimental and numerical results.

Considering the previously mentioned parameters, the plastic load-bearing capacity marks the transition point between the elastic and plastic stiffness in each grating configuration (see Figure 2). This transition point is considered as a good design value, as an even higher design load would result in a significant increase of the occurring displacement.

In conclusion, a new design guideline is proposed for an advanced verification of gratings fabricated from different metallic materials. This design concept takes into account the plastic capacities of the metallic materials and provides a solution to the stability of gratings that is not included in the current regulation. While the consideration of a derived effective height of the load-bearing bars due to imperfections and the safer assumption regarding the number of load-bearing bars in the effective beam cross-section lead to a lower elastic load-bearing capacity, the plastic capacities as well as the determination of a slenderness ensure a safer and more sustainable verification of gratings with higher load-bearing capacities compared to the current regulations.