Zukunft Bau – Short Report

Title

Development and Test of indicators for the determination of the maximum allowable test load during load testing of building constructions with low announcement of failure II

Concern of the research

The experimental evaluation of the load bearing safety of existing structures is regulated in the guideline of the DAfStb. The guideline is the basis for the planning, examination and evaluation of loading tests. By now the use of this method is limited because only structures can be investigated for which a failure with ductile behavior can be secured. With this research project the method will be extended, so also the evaluation of brittle failure modes can securely be done.

Subject of research

Aim of the research project is the development of special indicators, which are able to already show very small structural changes and therefor allow the detection of the maximum test load even for small indications of failure. Therewith it is also possible to exclude an intolerable damage or even a failure during load testing securely.

In this project the failure mechanisms of typical reinforced concrete elements in building structures have been analyzed and classified according to their announcement character. In pre-tests the application of different measuring techniques has been tested to determine their usability for the development of maximum test load indicators. The results have been published, and will be published, several times.

According to this analysis many of the existing constructions are found as weakly reinforced slab or beam structures. If the main failure cause is bending failure, an appropriate announcement of failure is given. But in many cases sufficient shear reinforcement is missing.

In these cases the carrying capacity may be determined by the development of a critical shear crack. The shear compression failure is a brittle type of failure and has only little announcement before failure. For pre-stressed concrete structure the danger of a brittle failure is smaller, but a loading test could also cause unallowable damages (cracking, plastic deformations of the pre-tensioning tendons), which have to be excluded.

If a loading test has to be done for such constructions, the qualitative and time-dependent analysis of the damage and failure mechanisms is very important. Therefore it is crucial to define measurable events, which could be used as indicators during load testing. These events are commonly connected to cracking, special characteristics of the crack development or crack widths.

To be able to detect this critical crack development at a very low level, even beneath the level of an irreversible damage, the photogrammetric image evaluation was used. Therewith it was possible to visualize and localize the cracking processes on a very low level. To be able to qualify this measuring technique for the in-situ use during loading tests, three main goals had to be reached. The invariance of the photogrammetric deformation measurement caused by relative displacements had to be secured. Additionally practical signalization concepts had to be developed and tested. Finally the resolution of the crack development had to be determined with a high resolution in time and space.

For cracks developing inside concrete elements the crack development was tracked with acoustic emission analysis. Because the evaluation has to be in real time the parametric ae-analysis was chosen.

To verify the theoretical investigations, several laboratory experiments have been done. Reinforced concrete beams with and without shear reinforcement were experimentally investigated and the found indicators were specified.

During an in-situ loading test the results were successfully tested under practical construction side conditions.

Conclusion

The aims of the research project were reached. Indicators for the evaluation of the load bearing condition of reinforced and pre-stressed concrete elements were developed, which allow the detection of a beginning failure and therefor the secure experimental evaluation. On the other hand the chosen measuring techniques were specifically adapted for the given task of the in-situ application during loading tests and the evaluation of beginning damages of the structure. The online application of the photogrammetric image analysis allows the detection of beginning crack development and the localization on an early stage.

Facts

Short title:	Indicators for the maximum test load during load testing
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Total costs:	339.750,00 €
Percentage of funding:	38,44% or 130.600,00 €
Project time:	01.12.2011 – 30.11.2013

Pictures

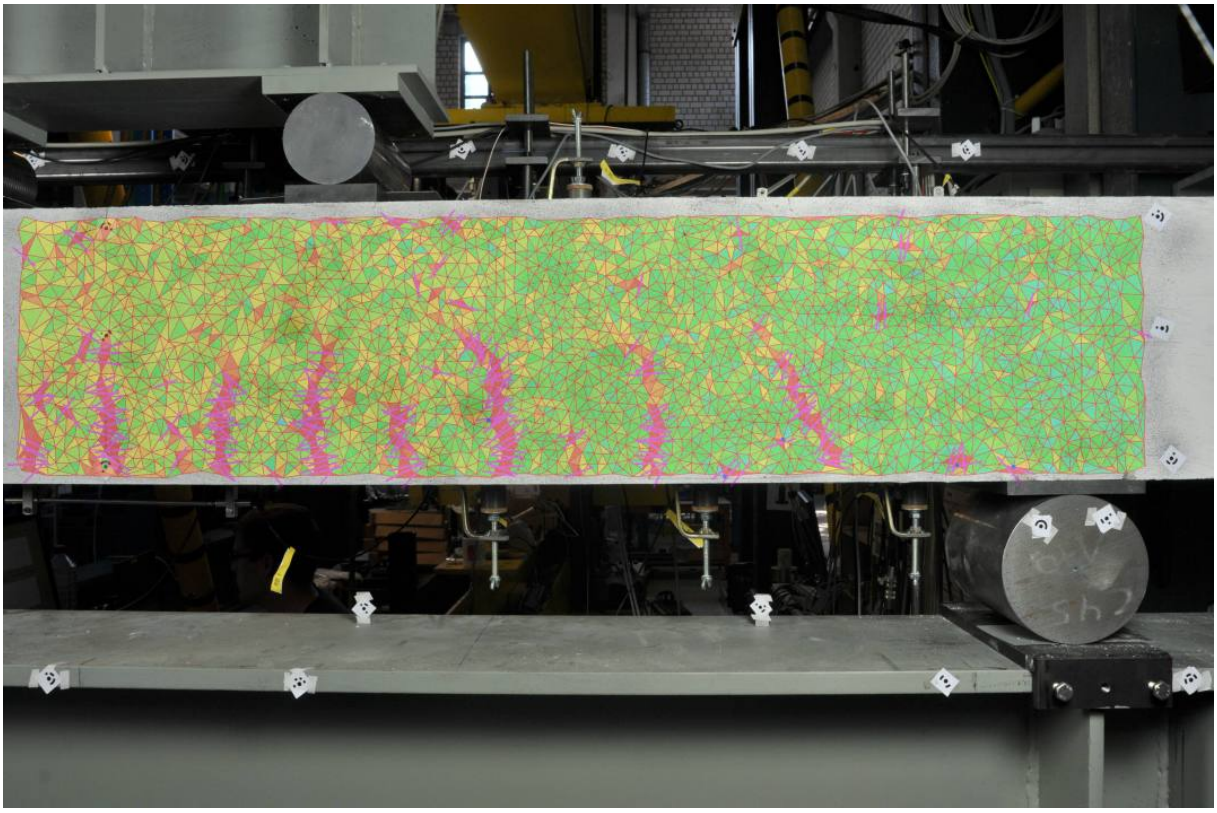

Figure 1: messbild3.jpg
Figure text: photogrammetric image evaluation for crack detection

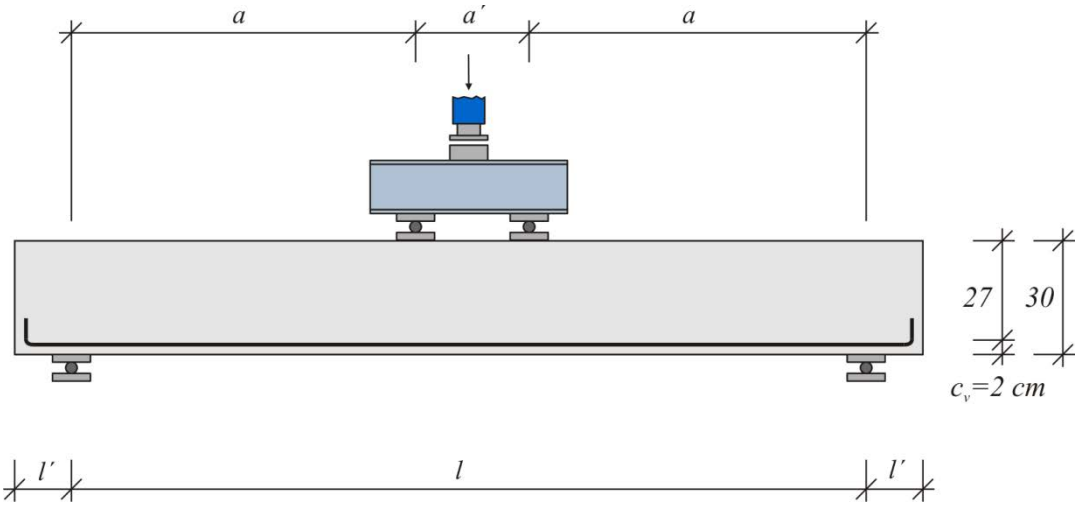

Figure 2: belastung.png
Figure text: experimental setup for shear test of concrete beams

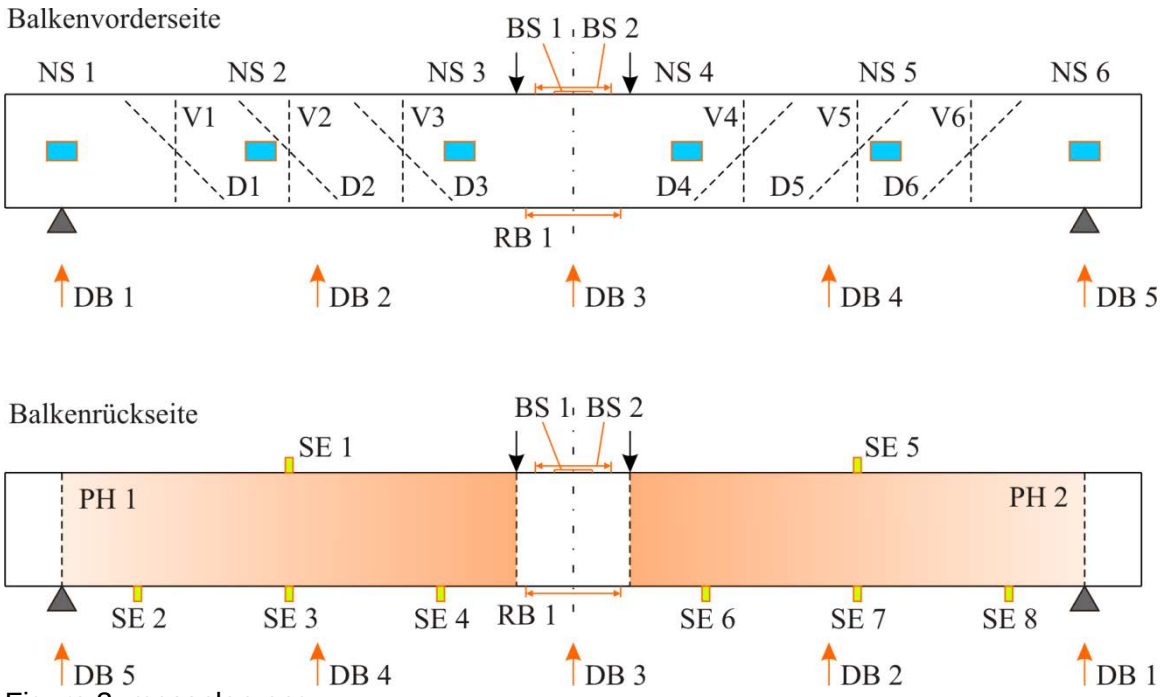

Figure 3: messplan.png
Figure text: applicated measuring techniques in shear tests

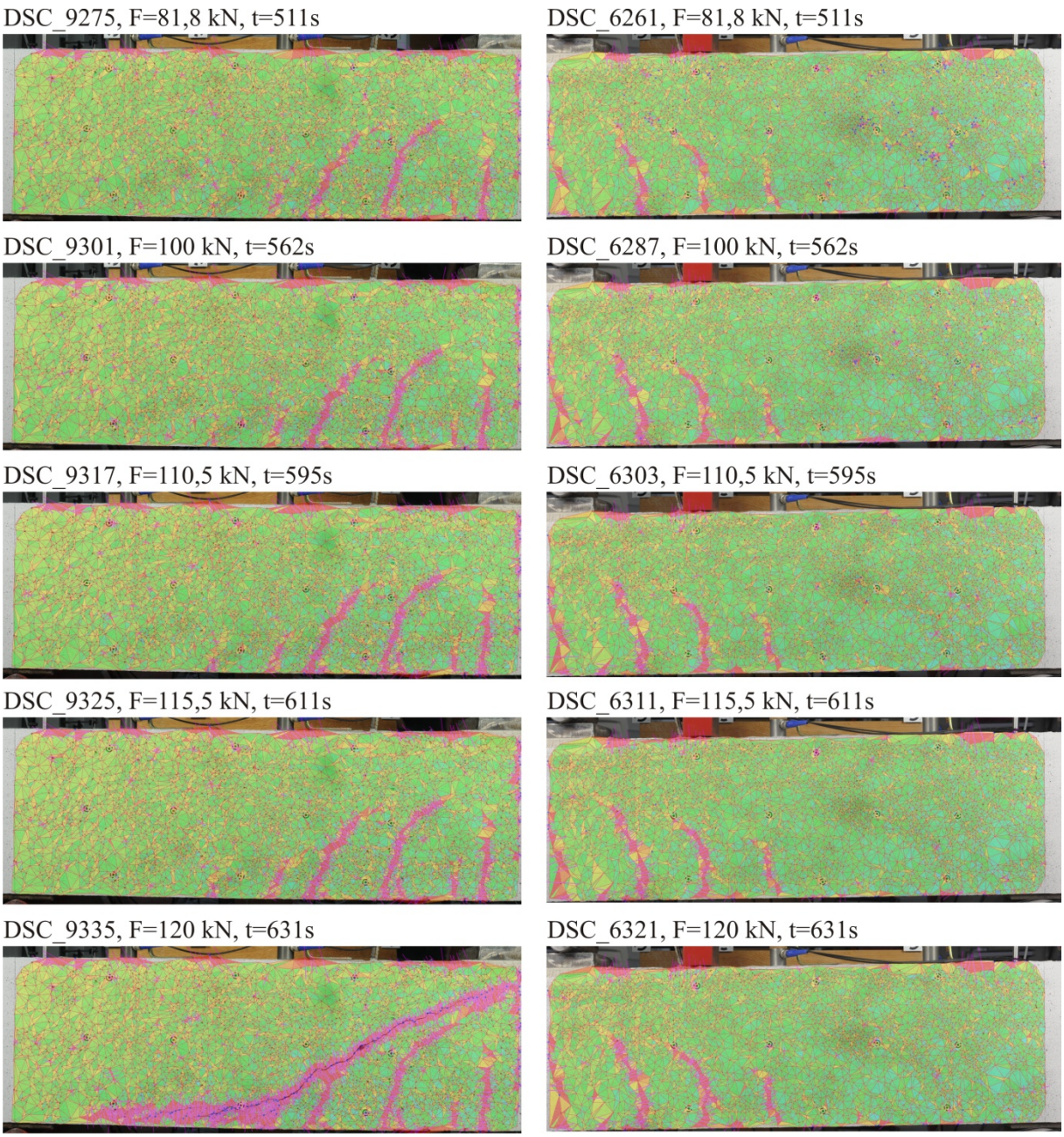

Figure 4: photo1.png

Figure text: Results of the photogrammetric evaluation of an pre-stressed concrete beam with shear failure

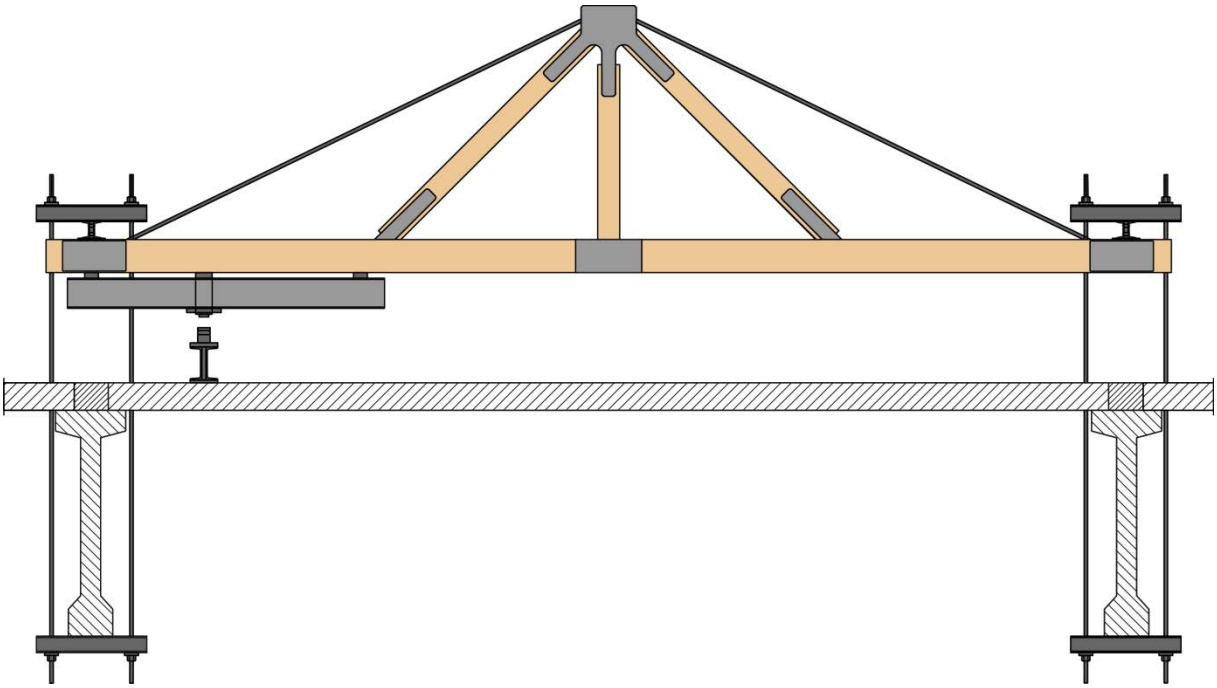

Figure 5: belastungsrahmen.png
Figure text: experimental setup for the in-situ loading test

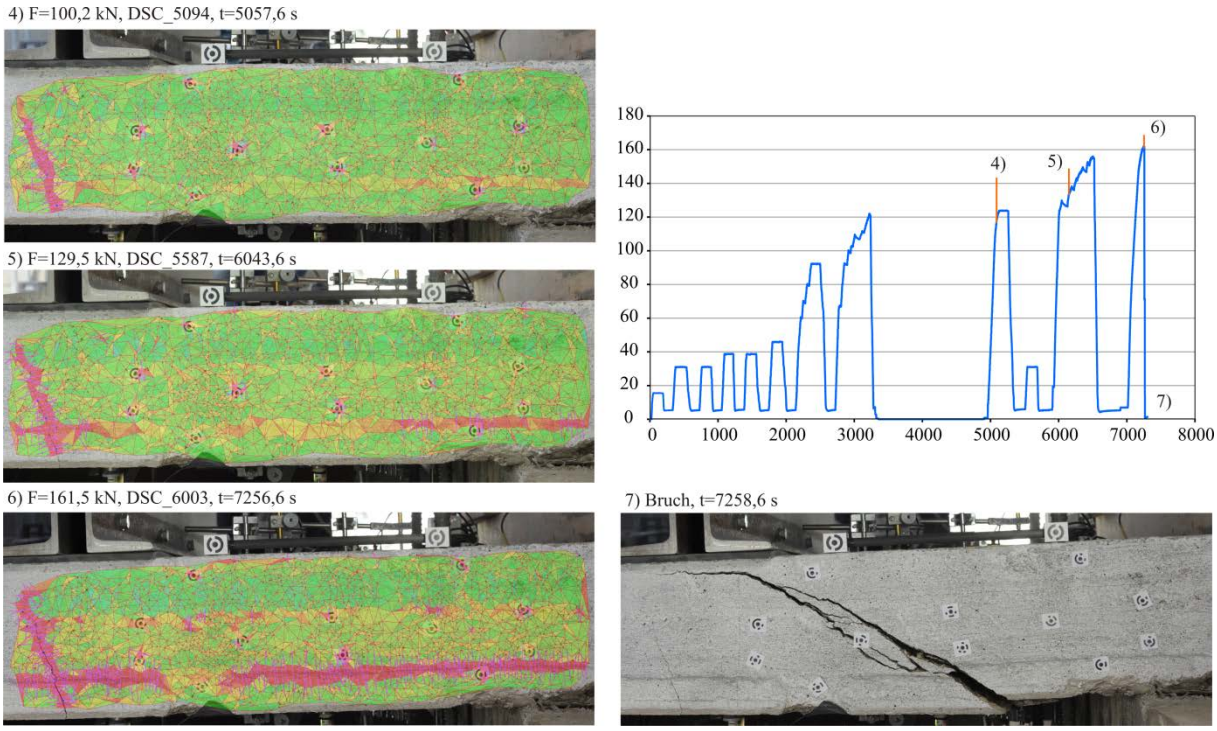

Figure 6: bruch.png
Figure text: Results of the photogrammetric evaluation of the crack development during the in-situ loading test