Digitale Zwillinge zum Schutz kritischer Infrastruktur

AP 1.2 – intelligent buildings in bridge engineering

Optimisation of numerical model for historic steel bridge

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Railroad underpass during dismantling 2020

Test facility at UniBw Munich

Motivation / Goals

- The condition of Germany's transportation infrastructure is very poor; 45% of railroad bridges were built before 1945.
- Closures, slow routes and temporary support constructions lead to numerous restrictions in rail operations.
- The bridge type under investigation is still in operation in many cases. Findings can be projected to other bridges
- Development of a validated calculation model by investigating the failure mechanisms taking into account the redistribution effects on a real-scale test bridge.

Test Facility

Object of investigation:

- Gau Algesheim railroad underpass was built in 1903.
- The riveted trough bridge consist of composed girders and is made of cast iron.
- The bridge with a span of 4.8 m has only been open to traffic with restrictions since 2016.
- Dismantling took place in 2020 with subsequent construction of the bridge test facility on the University of the Bundeswehr Campus in Munich.

Static test:

- Determination of the overall stiffness by static load tests and measurement of the deflection in the center of the bridge.

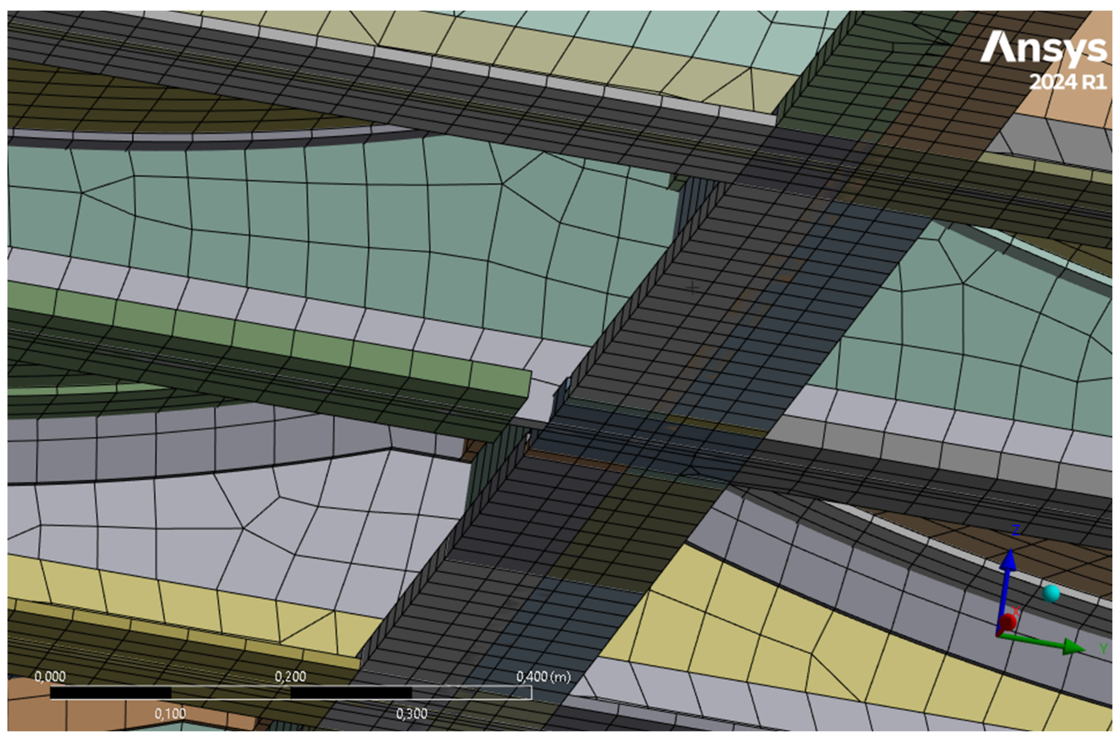
Dynamic test:

- The bridge with a span of 4.8 m has only been open to traffic with restrictions since 2016.
- Ballasting with concrete blocks / steel Slabs for medium stress level and reduction of natural frequency.
- Excitation with infinitely variable unbalanced vibration exciter at the natural frequency of the bridge including ballast simulating a crossing train.
- Realistic load with deflection of Δe_z=3,3 mm in the middle of the bridge which is equal to a crossing heavy cargo train.
- Introduction of artificial damage (missing rivets, geometric notches, weld beads, partial cross-section failure) with increasing severity.

Fatigue crack caused by artificially induced damage

Numerical Simulations

- The numerical model which is typically used for calculation (beam model with flexible joints) is less stiff than the bridge in our experiment.
- Shell model behaves more rigidly than experiment.
- Detailed numerical models of applied damages were set up to investigate failure mechanisms.



FE-Model of bridge with crack

Results

- No fatigue damage caused by realistic loading after 5 x10^6 load cycles.
- No brittle failure due to artificially introduced damage. Failure of partial cross-section led to progressive fatigue crack.
- Validation of the numerical models based on the results of static and dynamic tests to increase accuracy of calculations.
- Transfer of the results to other bridges of this type in operation is possible.

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