



Design of Sports Facilities for Structural Dynamics

Verification of serviceability
due to spectator induced vibrations

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Rhythmical actions of spectator on grandstands in sports facilities (multi-use stadiums) can cause dynamic excitation of the structure. It is possible that the induced vibrations not only exceed the human perception threshold. Because of resonances the vibrations can also affect the well-being (serviceability limit), and in extreme cases, they will cause panic which endanger the audience (safety limit).

Examples in the past have shown that tuning the eigenfrequency of a single grandstand stair is not sufficient to assess the structural vulnerability to dynamic excitations. It is necessary to consider the substructure in order to verify that panic is eliminated and to assess the comfort for the spectators.

Year **Reference Projects (Extract)**

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| 2014 | Stadion am Millerntor, Northern Grandstand, Germany
Dynamic investigation of serviceability of the grandstand concerning person induced vibrations. |
| 2012 | Sports Institute of Ruhr-Universität Bochum, Germany
Dynamic investigation of a treadmill room in the university's new sports institute. |
| 2012 | Grandstand FSV Frankfurt, Germany
Assessment of the dynamical characteristics of a new grandstand for the stadium in Bornheimer Hang (FSV Frankfurt). |
| 2010 | Stadium Rot-Weiss Essen, Germany
Vibration investigation and assessment of serviceability for grandstands typically crowded with people. |
| 2009-
2012 | FC St. Pauli von 1910 e.V., Hamburg, Germany
Evaluation of structural dynamics and serviceability checks for the grandstand with focus on self-excited oscillation. |
| 2009 | Wersestadion RW Ahlen e.V., Germany
Evaluation of structural dynamics and serviceability checks for the grandstand with focus on self-excited oscillation. |



Year **Reference Projects (Extract)**

2009 **Tripple span ceiling of a sports hall, Dresden, Germany**
 Dynamic investigation of the roof construction field concerning the serviceability for a planned use as a sports field.

2009 **New Stadium 1. FC Ingolstadt 04, Germany**
 Evaluation of structural dynamics and serviceability checks for the grandstand with focus on self-excited oscillation.

2008 **VfL Osnabrück – Northern Grandstand**
 Serviceability investigation for the reconstruction of the northern grandstand. Optimisation of the structure.

2008 **Stadium Spartak Moscow, Russia**
 Dynamic investigation of the serviceability of the grandstands concerning person induced oscillation. Pre-analysis of the structure.

2007 **Stadium Alemannia Aachen, Germany**
 Investigation of the serviceability and structural pre-analysis of the grandstands.

2007 **TSG Arena Sinsheim, Germany**
 Dynamic investigation of the grandstand for engineering purposes and optimisation of the structure.

2003 **MSV Arena Duisburg, Germany**
 Dynamic structural design and optimisation of the arenas structure.

2002 **LTU Arena, multi-use facility, Düsseldorf, Germany**
 Measurements of vibrations, deflection and damping with different load cases.

2002 **AWD-Arena Hannover*, Germany**
 Vibration measurements for research and development (associated paper: Wirtschaftlichkeitsuntersuchungen zu Tribünenplatten unter dynamischer Beanspruchung, Sonderdruck zum Betontag 2007: Roeser, W.; Kuhlmann, D.).



Year **Reference Projects (Extract)**

2000 **Eisarena Dome, Düsseldorf*, Germany**
 Vibration and damping measurements, dynamic tests of precast concrete stairs

2000 **Ruhrstadion VFL Bochum – Eastern Grandstand**
 Vibration measurements during German Football League match and design of retrofitting measures.

1997 **Westfalenstadion Dortmund – Southern Grandstand****
 Vibration measurements of the southward grandstand. Reconstruction measures.

* during the time as scientific assistant at RWTH Aachen university

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