

Radar-Interferometric monitoring of ground settlements caused by tunnelling

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The safety of surface structures plays a decisive role in the whole process of designing intra-urban tunnelling-projects. Depending on the specificity of building, structures possess different sensitivities to settlements caused by shield tunnelling. To prevent or at least reduce damages of surface structures with alleged high sensitivity, usually various complex measures – e.g. compensation injections – are necessary. To investigate the interactions between tunnel driving and overlying buildings in a more detailed way, it is required to gain area-wide and precise settlement data with respect to the chronology of tunnel driving. Terrestrial methods would require enormous time and cost efforts.

In the framework of the Collaborative Research Center SFB 837 - founded by the German Research Foundation (DFG) – a Synthetic Aperture Radar technique (SAR) is applied. It uses data from the TerraSAR-X Satellite provided by the German Aerospace Center (DLR) to attain area wide and accurate measurements at the construction site of the shield-tunnelling project "Wehrhahnlinie" in the city of Düsseldorf, Germany. In an area along the 1 km intra-urban shield tunnelling axis, Persistent Scatterers (PS) with a resolution of 3 x 3 m will be evaluated. For each PS new settlement details provided every 11 days. By a satellite orbit altitude of 514 km the data achieve an accuracy down to millimetres. Combined to local terrestrial displacement data spaceborne radar measurements are verified. Preliminary results received from the 24 TerraSAR-X scenes – acquired between January 2011 and December 2011 – are presented.

For further structural analyses the methodology of two approaches are presented: On the one hand side the movement of surface structures due to settlements by tunnelling are visualized. On the other hand the results are used to categorize their typical intra-urban surface structures (masonry and reinforced concrete) with respect to vulnerability due to settlements induced by tunnelling. The vulnerability of each categories assessed by critical crack widths of structures or – in case of FE-based calculations – the equivalent plastic strains. One main issue of vulnerability is the building stiffness. It is planned to derive an equivalent building stiffness by comparing the displacements of the upper part of the buildings (SAR measurements) and foundations (terrestrial measurements). In order to do so, a representative scope of buildings at the tunnel building site in Düsseldorf is used.

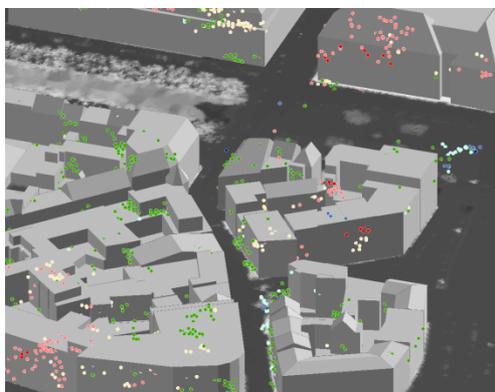


Fig. 1: 3D-Model of Düsseldorf and PS

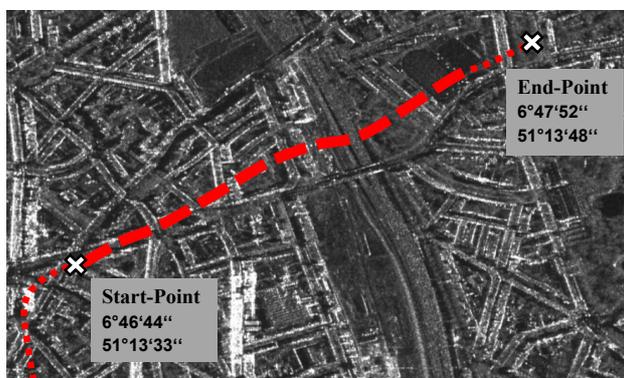


Fig. 2: Radar-Image and tunneling axis