THE NEW DGZFP GUIDELINE MONITORING OF CIVIL ENGINEERING STRUCTURES

DIE NEUE DGZFP-RICHTLINE DAUERÜBERWACHUNG VON INGENIEURBAUWERKEN

Frank Lehmann, Michael Schreiner, Sebastian Laumann

Materials Testing Institute (MPA), University of Stuttgart, Otto-Graf-Institute

SUMMARY

The upcoming year 2022 will see the publication of a new guideline on structural monitoring. The document has been worked on since 2017 by a subcommittee of the German Society for Non-Destructive Testing (DGZfP). We briefly present in this paper the considerations for its development, the context in which it was created and an overview of the content that can be expected by the readers.

ZUSAMMENFASSUNG

Im kommenden Jahr 2022 wird ein neues Merkblatt zur Dauerüberwachung von Ingenieurbauwerken veröffentlicht. Das Dokument wird seit 2017 von einem Unterausschuss der Deutschen Gesellschaft für Zerstörungsfreie Prüfung (DGZfP) erarbeitet. In diesem Beitrag berichten wir kurz über die Erwägungen, die zu dessen Entstehung geführt haben, über den Kontext, in dem es entwickelt wurde, und einen Überblick über die Inhalte, die die Leserinnen und Leser erwarten können.

1. RELEVANCE

Structural monitoring is a widespread decision-making tool during the construction and operation of civil engineering structures with high investment, societal or infrastructural value. The individual motivations for the use of such system are manifold and may, for instance, arise from the desire to safely predict or prolong the operation period of an existing structure, to accompany and evaluate construction works or to better understand certain structural behaviour. Yet, there is no universal recipe for how to achieve any of those goals. Even more so, the large variety of possible monitoring approaches makes it challenging to objectively select the optimal solution, while considering all known boundary conditions and probable limitations of the system and in the expectable informative content.

To ease the decision-making process for building owners and operators and to provide orientation for monitoring system providers, a guideline for monitoring of civil engineering structures has been developed by the German Society for Non-Destructive Testing (DGZfP) [1]. Its aim is also to reduce the fragmentation of the extent of system designs, technical content and answers promised as expectable and thus to put different monitoring systems for a project on common and honest ground.

2. GUIDELINE DEVELOPMENT BASIS

A prior DGZfP guideline on “automated monitoring in civil engineering” [2] had been in existence since October 2000. Although it incorporated a rather general consideration of different monitoring goals, its focus was mainly set on dynamic measurements and modal analysis. The document was kept relatively condensed with only 13 pages long plus appendix. It was withdrawn in November 2008 due to technical developments in the meantime.

In the past more than twenty years since the release of this first DGZfP guideline on monitoring, there have been many publications on various aspects of monitoring and quantum leap developments in the applied technology, especially with the spread of everyday mobile applications and the rise of IoT. The use of monitoring systems in civil engineering has increased tremendously and their application is recommended by various normative documents [3]. Based on these strong scientific and technological pillars, it was decided to merge the collected efforts in a new, application-oriented guideline on design, possibilities, limitations and prerequisites for a monitoring measure. The document was not created from empty

space though, but is embedded in a context of other recent and older guidelines and similar documents. All have bridges as the main use case, but the content can be translated equally well to other structures:

- The Sustainable Bridges Research Project delivered the "Monitoring Guidelines for Railway Bridges" [4] in 2007, that treats both the design of monitoring systems and gives details on sensors for many different applications in a common format. With this content orientation, the project deliverable is primarily aimed at monitoring planners.
- In 2012, the guideline "Monitoring of Bridges and other Engineering Structures" [5] was published by the Austrian FSV. The authors therein focus on the configuration of monitoring systems and regard different likely monitoring tasks from an end-user point of view. The study of the document is therefore intended mainly for building owners and operators who are considering whether structural monitoring would be beneficial.
- The DBV guideline "Bridge Monitoring" [6] from 2018 is an extensive publication on the application of monitoring systems in civil engineering. The authors' distinctive achievement is to outline in detail which construction services must be tendered for the implementation of a structural monitoring. They also regard the profitability of a monitoring measure. The guideline thus mainly addresses administrations and engineering offices that prepare tenders, as well as to be able to better assess whether structural monitoring is worthwhile in the respective case.
- In the United States, the Transport Research Board (TRB) published a circular on "Structural Monitoring" [7] in 2019. It stresses sensor technology and project implementation. In addition, it includes a small chapter on financial return from a monitoring project and a section with frequently asked questions (FAQ) about the implementation of monitoring technology. The circular examines how monitoring can be a decision-support in condition assessment and therefore clearly targets building operators.
- Another, yet clearly more detailed document with a similar scope and structure is the report of the American Concrete Institute "Concrete Structure Structural Health Monitoring Technologies" [8] that was only recently published in 2021. In the report, a multitude of sensors is presented, each in a consistent format, taking into consideration different aspects from physical

properties to deployment and limitations. Its focus on sensor technology and sensor selection suggests a main use by monitoring planners.

More and more monitoring service providers continuously enter the market and monitoring hardware is increasingly available for end-users without detailed knowledge of structural monitoring. On the one hand, this entails a high risk of incorrect or unsuitable application and, on the other hand, makes it difficult for clients to assess whether a proposed system meets their needs and is worth the financial expenditure. The primary target audiences for the new DGZfP guideline were therefore identified as both monitoring contractors, in order to support them in the development and operation of such systems, and their clients, i.e. usually the building owners or operators, to enable them to properly assess offers from a technical and effort point of view.

3. GUIDELINE CONTENT

The guideline is structured to reflect, wherever and as far as reasonably possible, the procedure for carrying out a monitoring measure. It can therefore be understood as step-by-step guide in order to cover all relevant aspects of the process. With currently around 80 pages, it provides many details on numerous topics, whereby care was taken not to overflow with technical vocabulary and to be comprehensible even without a deep understanding of monitoring systems.

A short introductory section explains the legal framework within which a monitoring measure lies, especially in the context of building inspection. The target group of the guideline is defined and the motivation for the development of the document is explained.

In the following, the objectives are described that can be achieved with the implementation of a monitoring measure, i.e. on the basis of which occasion the establishment of a monitoring could be useful. These are, for example, the benefits of monitoring during construction, the applications in the context of building and maintenance management, or the use for the expansion of knowledge on the behaviour of structures. The chapter is to serve as guideline whether monitoring might be a suitable solution for a given problem.

A great deal of attention is paid to the design of monitoring systems. This comprehensive chapter covers in detail all the considerations that have to go into developing a monitoring project, from fundamental considerations, to measurement

variables and locations, sensor selection, sensor connection and local data transmission, power supply, data storage and data evaluation, alarming and special considerations, if the monitoring is to serve safety-relevant duties, and many more.

In the next extensive chapter, typical tasks are considered for which the use of a monitoring system could come into question. This could for example be the enquiry for a certain time-dependent deflection, whether a visible crack in a surface is stationary or active, or regarding prestressing steel fractures. Each topic is considered according to purpose, sensors and measurement technology, data analysis, application and limits.

As monitoring measures tend to provide a lot of data, the necessary data management is discussed in a dedicated chapter. This does not only include data storage, but also how data quality can be ensured, the importance of extracting useful information from the bulk and data security and safety.

Distinguishing good and bad monitoring systems can be difficult at times, as the differences are mainly in the detail. Quality assurance thus plays an increasingly important role as the size of the project increases. Aspects relating to this are therefore explained in a further chapter, without having undue overlap with the DBV guideline [6].

The guideline concludes with a large number of best practice examples that cover the scope of possible measures well. Each application is detailed with the problem to be solved by monitoring, the system used and the results obtained.

4. CONCLUSIONS

With the publication of the new DGZfP guideline in the near future, its target group will be provided with a comprehensive document that offers a solid basis for the implementation of a monitoring measure, from planning to operation and data evaluation. It is hoped that the guideline will contribute to the adoption of high-quality monitoring systems that will provide users with the best possible results regarding their questions.

Once published, revisions will be forthcoming based on feedback. It is also planned to publish an English-language version of the guideline in recognition of the pursuit of standardization in the European region and beyond.

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REFERENCES

[1] *Merkblatt B 09 – Dauerüberwachung von Ingenieurbauwerken*. Deutsche Gesellschaft für Zerstörungsfreie Prüfung e.V. (DGZfP), Fachausschuss ZfPBau, Unterausschuss DvB, Berlin, 2022 (in preparation)

[2] *Merkblatt B9 – Merkblatt über die automatisierte Dauerüberwachung im Ingenieurbau*. Deutsche Gesellschaft für Zerstörungsfreie Prüfung e.V. (DGZfP), Fachausschuss für Zerstörungsfreie Prüfung im Bauwesen (AB), Unterausschuss Dynamische Untersuchungen, Berlin, 2000 (withdrawn)

[3] LEHMANN, F.A.: Non-destructive testing and monitoring as elements of building inspection. Otto Graf Journal, Materials Testing Institute (MPA), University of Stuttgart, Vol.19, pp. 119-130, 2020

[4] *Monitoring Guidelines for Railway Bridges*. Research project Sustainable Bridges - Assessment for Future Traffic Demands and Longer Lives, 6th Framework Programme of the European Commission, 2007

[5] *Merkblatt RVS 13.03.01 – Monitoring von Brücken und anderen Ingenieurbauwerken*. Österreichische Forschungsgesellschaft Straße – Schiene – Verkehr (FSV), Wien, 2012

[6] *Brückenmonitoring – Planung, Ausschreibung und Umsetzung (DBV-Merkblatt „Brückenmonitoring“)*. Deutscher Beton- und Bautechnik-Verein e.V. (DBV), Berlin, 2018

[7] *Structural Monitoring*. Transport Research Circular E-C246, Transport Research Board, Washington, D.C., 2019

[8] *Structural Health Monitoring Technologies for Concrete Structures – Report*. ACI PRC-444.2-21. American Concrete Insititute (ACI), Committee 444, Farmington Hills, MI., 2021. ISBN 978-1-64195-144-9