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Guidelines and Recommendations from COST TU 1406

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Abstract

Asset management depends on well-defined rules and standards for general application. Research results often represent the state of science in specific sections of specific cases. Standardization needs a downgrade of scientific work towards generally applicable specifications. This often leads to irritation in the scientific community fearing that their most interesting results are not specifically appreciated. This conflict makes standardization sometimes difficult.

COST action TU1406 is devoted to harmonizing the state of science and technology and to bring all involved disciplines into the process. The results produced are of value for a number of standards on ISO, CEN and National level. This represents another difficulty, namely, to find the right place in any of the organizations and to identify the most suitable technical committee and code.

This contribution reports on the experiences made with various committees and the results achieved. It soon became clear that specific parameters for bridge assessment cannot be standardized because they are too specific for a small sector. The way out is formulating the principles how to define them, to make a framework under which the detail results can be applied, and to define the interfaces to other necessary disciplines.

Sustainability as a headline was found to be suitable and TC59 of ISO was the committee of choice. Frameworks set in ISO55000 (asset management) and ISO31000 (risk management framework) are successfully addressed. A final draft of ISO 21929-2 is to be expected by early 2019.

Keywords: Standards, Asset Management, Risk Assessment, Sustainable Construction.

1. Introduction to Standards in Practice

Standards document a harmonized procedure agreed by all relevant stakeholders. The stakeholders involved in bridge management naturally follow different strategies. This restricts

the number of issues that can successfully be standardized to basic rules. This makes standards rather generic than very specific. Many standards relevant for our sector are therefore rather frameworks than cook books.

Bridge management is currently regulated on national level. This does not restrict the

application of Eurocodes or ISO standards but requires specific nationally determined parameters (NDPs). By the way the national practice can be fitted into the international frameworks. It is desirable to achieve approaches that produce comparable results in order to support the idea of equal quality on the European Transnational Corridors.

2. Application of Standards

The majority of our structures can be considered of being standard cases. For them standards are made and can be applied. Extraordinary cases are not covered. This opens opportunities for adjustment of standardized processes to specific cases.

In Eurocode this is specifically defined in EN 1990:2002 on page 7. The clause says,

“The Eurocode standards provide common structural design rules for everyday use for the design of whole structures and component products of both a traditional and an innovative nature. Unusual forms of construction or design conditions are not specifically covered, and additional expert consideration will be required by the designer in such cases.”

This clause is seldomly applied and very often standards are used or made obligatory in unfavourable situations. This can lead to designs which are not beneficial for the product.

3. Consideration of Responsibility

Designers ~~and~~ contractors and other employers' representatives are responsible for their work. It is commonly assumed that the strict satisfaction of specified standards protects them when things go wrong. This is not the case. Recent rulings in Europe have shown that standards are not “safe havens”. Standards represent the state of the art and practice. In special cases the state of science and technology has also to be considered. It can reasonably be assumed that designers and contractors working on special projects are aware of the latest development in their sector. As standards undergo a lengthy process to become valid (on average more than 10 years) science and

technology might have considerably progressed making previous rules and assumptions invalid.

Considering the above-mentioned facts, it becomes not only beneficial but rather necessary to get the necessary-required expertise on current know-how in order to be safe from being tried.

In the bridge community there are many structures that fall under these circumstances. This puts some additional burden on the bridge managers but often releases them from having to take approaches that do not fit.

4. The Framework of Standards for Bridge Management

Bridge management does not ~~know-have~~ one specific standard for relevant performance. Currently most European countries apply the rules that have been developed in the 1980s created after ~~the~~ prominent collapses (i.e. the Reichsbrücke in Vienna on 1 August 1976). They were made before the Eurocodes became ready for practice. The main basis has been the results of visual inspection which documented a subjective rating. This rating has been subsequently refined, and a specific structural condition has been connected to the values.

With the introduction of performance-based design approaches the procedure requires more information to become usefully applicable. With sustainability and resilience becoming desired performance criteria, the procedure had to include risk-based elements. From the previous simple determination of probability of occurrence, the consequences of performance have to be considered. This brings indicators on economy, environment and society into the procedures. The step from simple deterministic ways towards probabilistic approaches is inevitable. On the other hand, the older our structures get, the less the previous procedures produce credible results. ~~NThe~~ new tools allow dealing with structures built a long time ago under very different specifications to fit into nowadays-current frameworks.

As an example, how harmonization could benefit the interaction between the nations, a selected number of national rating codes are given in the

~~figure~~Figure 1 below. An extensive campaign in order to

Figure 1. Representative international rating scale and verbal description of related condition

collect more ratings applied in Europe is underway. This will be a good subject for future global standardization.

~~C~~The currently available valid standards on a global scale allow ~~to~~ implementing a management procedure divided into a generic and a project-specific domain. Figure 2 presented below

represents such a case elaborated for industries where structures also play a major role.

There is the intention to adopt it to ~~the~~very specific requirements of bridge management. Besides necessary activities, it also shows the relevant standards which present the frameworks for performance.

Figure 2. Typical framework for risk-based asset management

These relevant frameworks that can be used, are briefly mentioned below:

- ISO 55000 describes the basics of asset management. It shows an easily understandable basic framework which can easily be filled with national regulations.
- ISO 31000 represents the currently most appreciated risk management framework. The definition of risk, namely “risk is the effect of uncertainties on the objectives” can be considered a sensational progress in the basic philosophy. The demand to work on the uncertainties is obvious and opens doors to most useful probabilistic approaches. This standard also provides nice diagrams on a typical process in a very generic way. Furthermore, we can find good arguments for application in our cases.
- The Eurocodes EN1990 to EN1998 cover the indicators for safety and durability under consideration of relevant national standards like DIN 1076 in Germany. They are currently under further development in the direction of performance-based asset management.
- A standard for risk-based inspection has been developed in other industrial sectors. EN 16991:2018 (in force since May 2018) is the first comprehensive standard of this approach. It also contains the mathematical formulation of ageing (degradation) which has been developed and derived from a perfect set of bridge performance over a period of 45 years. This simple approach can be applied perfectly in our sector for the prediction of the development from current performance to expected performance in the future. The rules specified in this standard cover the subject of serviceability or sometimes called operability.
- The indicators on economy, environment and society are currently defined within the ISO organization. In TC59/SC17/WG5 the new code ISO 21929-2 on sustainability of civil construction works is developed. A list of specific parameters covering this field is prepared with the related specifications. This framework will allow to bring in these

indicators in an organized way and help assessment going beyond pure structural needs. The impact our structures have on environment and society is sometimes bigger than those from pure structural safety (ULS) or durability (DLS). The spectrum of assessment is considerably widened and the respective costs over a comprehensive life-cycle will show which solution is the optimum for a specific case. This supports decision making considerably, particularly bringing in other experts such as lawyers and economists as well as environmental engineers. A considerably better justification of intervention becomes feasible (Fig. 3).

- A major number of other standards are necessary to complete the procedure. They may comprise operational safety, impact on environment on the structure, security guidelines, quality specifications and project-specific definitions.
- Within all these frameworks the national bridge management strategy would function as a core element. It might happen that some outdated regulations will be overruled but this should normally be considered beneficial.

Figure 3. Spider diagram for risk and performance-based management

5. Incentives and Restrictions for Application of Standards

There is a number of arguments for applying standardized frameworks such as:

- Going from national to global markets, we require comparable approaches in order to be able to satisfy the foreign set of rules. In the European context it is also desirable to find equal quality standards all over the continent.
- Frameworks make works comparable and allow ranking of interventions. Doing that, international know-how can be directly applied and supports and sharpens one's own approach.
- In times of insufficient budgets, it will be easier to focus on projects that are highly ranked in the priority list. Decisions on future budget allocation become feasible.
- Standards provide the basis for juridically safe environments for operators and the related expert community. As explained above, standards alone do not satisfy this.
- Standardized procedures allow competition which will lead to more economic projects. Standardized products and procedures are more often applied and therefore lower budget for inherited risks will be considered.
- Standardized approaches will allow suppliers to develop economic products based on the potentially higher numbers of sales.
- Any standard can be excluded if it does not fit as explained above. Standards are for standard cases and specific cases have to be treated differently
- Every nation still has the power to issue nationally determined parameters (NDPs) to fit the framework for any specific application or case.
- Nationally determined parameters are necessary anyway for spatial-related hazards or loads such as seismicity, snow loads or wind regimes. Major attention shall also be put on the temperature effects on structures in each area.
- The mentioned standards do not restrict the use of any specific rule for visual inspections or the use of monitoring results in the assessment process. Advanced regulations such as the Austrian RVS 13.03.11 allow the case-specific determination of inspection intervals in case that uncertainties are reduced by monitoring results. This procedure is also supported by the new Eurocode EN 16991:2018 (Fig. 4).
- Once again standards are for standard cases only. For special cases engineering and expert knowledge shall be applied as quoted in EN1990 on page 7.

On the other hand, standards do not restrict owners beyond reasonable requirements. This can be expressed by:

Figure 4. Mathematical formulation of degradation as specified by EN 16991

6. Expected Future Development in this Domain

The European Commission and other global science funding agencies have supported a number of projects, particularly in the bridge domain. The most prominent ones are the following two:

- The Long-Term Bridge Performance Project (LTBP) in the United States started in 2012, has a scheduled duration of 10 years and a budget of 200 million USD. It is controlled and funded by the Federal Highway Agency (FHWA) with the objectives to better understand bridge performance and finally to achieve more robust bridges. FHWA operates the National Bridge Inventory (NBI) covering a total of about 620,000 bridges. This huge database is perfectly conditioned for the application of risk performance-based tools. Going from structural to element level a tool using the European development of the ageing curve has been already implemented and tested.
- The Strategic Innovation Program (SIP) in Japan has been launched by the Ministry of

Construction in order to ensure safe operation of bridges in Japan. The budget of 270 million USD has been used to improve inspection procedures, to develop robotic applications like drones and to modernize and improve applicable regulations for structural assessment. The final results are presented in December 2018.

It is interesting to see that both large projects take European development and make applications on a large scale. We are definitely missing such an initiative in Europe. Nevertheless, the projects developed here are still ahead of other foreign initiatives but are subject to losing ground steadily.

The development we see in the near future is concentrated on the following subjects:

- A comfortable open GIS surface and platform. This again allows comparable approaches, overlapping work at national borders and enables the application of the many, very useful tools developed in specific smaller European projects.
- Building Information Models (BIM) become more and more standard practice. Some bridge owners already demand any future

activity in this framework (refer to DB Deutsche Bahn). There is a standardization drive for BIM on ISO level where the Chinese Academy of Science is trying to establish a leading function. Nevertheless, the basis for BIM is still laid in Europe. A major advantage of applying such models would be that for future monitoring campaigns supporting the reduction of uncertainties the relevant structural models could be easily extracted. This is highly desirable.

- On the economy side there is no alternative to life-cycle approaches. Relevant standards of the 16000 series but also for environment and economics the 13000 and 14000 series provide helpful tools for our cases.
- Risk-based procedures are not yet common practice. However, with the first application in EN 16991 the charm of these approaches will quickly be recognized, and further development is expected.
- Sustainability-driven application considering the so-called soft factors economy, environment and society as specified in ISO 21929-2 will help to bridge the gap to applications in difficult environments.
- There should be room for subjective driven information (we could also call it the wisdom of the structures but specifically the wisdom of the bridge managers). Flexible consideration shall not be forgotten to be developed. In times of typical brain drain in owners' organizations this will be a most needed tool within our assessment procedures. We have to keep them streamlined but flexible enough to cover intuition. A key could be a wise approach towards the so-called "unknown unknowns" where proposals for treatment already exist as results from past European projects.

It shall not be forgotten that standards will finally lead to a downsizing of technologies to wide applications. When we exclude the extraordinary projects, we will be able to accept this fact. There is a demand for procedures to identify the extraordinary projects and an adaptation of the procedure towards these structures. This research

and development demand has already been communicated to the European Commission.

Nevertheless, the new frameworks will allow us to communicate our results to non-engineers such as politicians, operators and managers of respective enterprises. The impact on the quality of decision making shall not be underestimated.

7. Conclusions

With the introduction of performance-based design approaches the procedure requires more information to become usefully applicable. With sustainability and resilience becoming desired performance criteria, the procedure had to include risk-based elements. From the previous simple determination of probability of occurrence, the consequences of performance have to be considered. This brings indicators on economy, environment and society into the procedures. The step from simple deterministic ways towards probabilistic approaches is inevitable. On the other hand, the older our structures get, the less the previous procedures produce credible results. The new tools allow dealing with structures built a long time ago under very different specifications to fit into ~~nowadays'~~current frameworks.

8. References

- [1] ISO 55000 Asset Management
- [2] ISO 31000 Risk Management Framework
- [3] EN 16991:2018 Risk-based Inspection
- [4] ISO 21292-2 Sustainability Assessment of Civil Engineering Works