

Sustainability criteria

The sustainability of structures encompasses a number of sub-criteria related to the different phases of service life of structures - from design through execution, operation, maintenance, repair and upgrading, to demolition and replacement with a new structure. In the assessment of historic bridges, the following criteria are predominantly taken into account:

- societal: criteria related to the safety of bridge users, time lost on detour routes, and preservation of the heritage values of the bridge;
- technical and economic: criteria evaluating the technical possibilities of ensuring sufficient reliability and durability of the existing bridge based on the specific requirements for the transport of people and goods and taking into account associated economic requirements;
- ecological: criteria which target the re-use of materials, generally based on the carbon footprint theory (CO₂ production related to the production and transport of construction materials, but also to the use of detours in the event of temporary closure of the bridge, etc.).

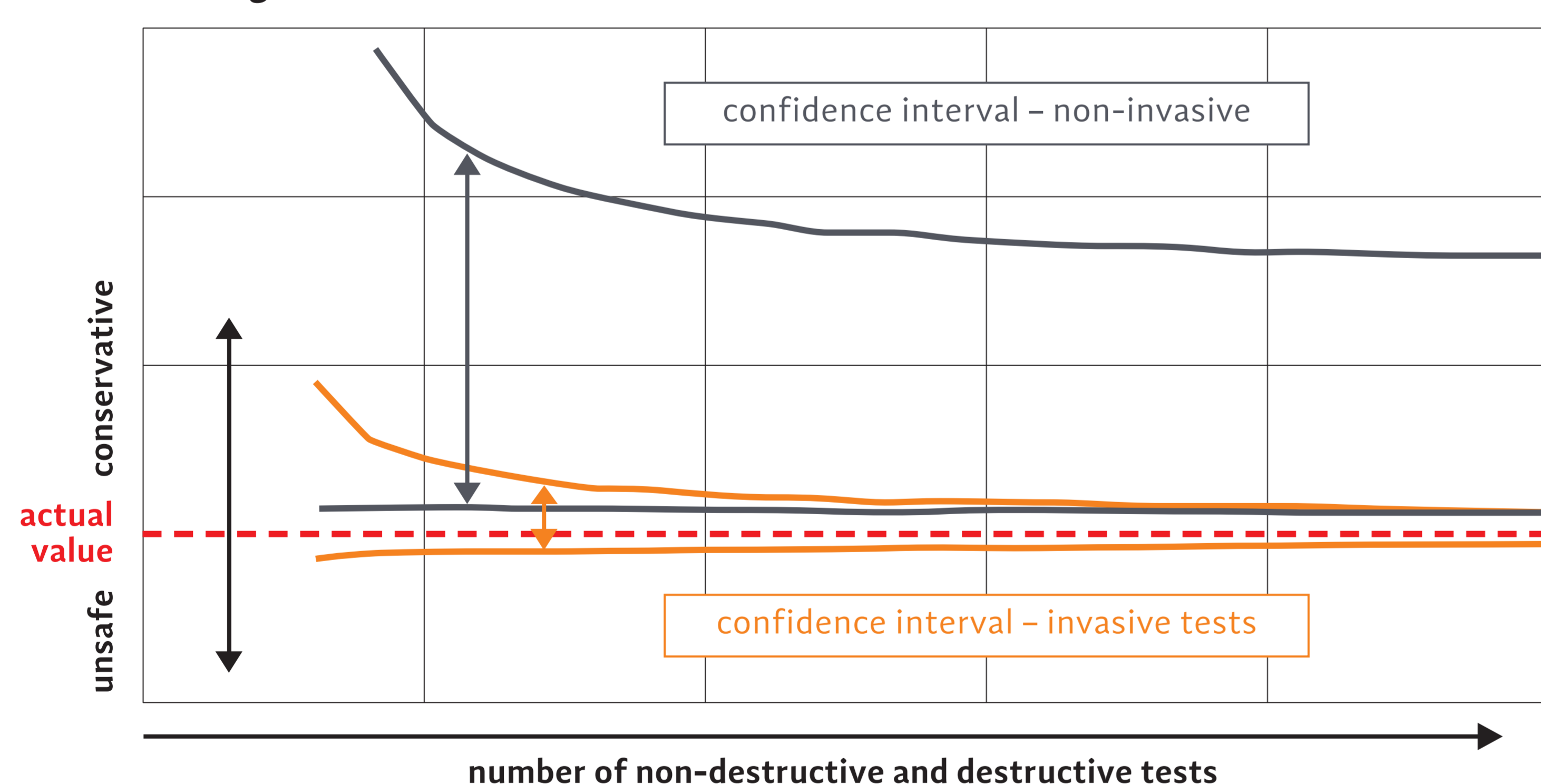
It is often necessary to decide whether to repair or upgrade an existing bridge or replace it with a new one. An assessment should always be made regarding whether and how traffic should be reduced if the existing structure is retained, what its service life will be, and what environmental impacts are expected when it is repaired and maintained in the future.

Methods and methodologies

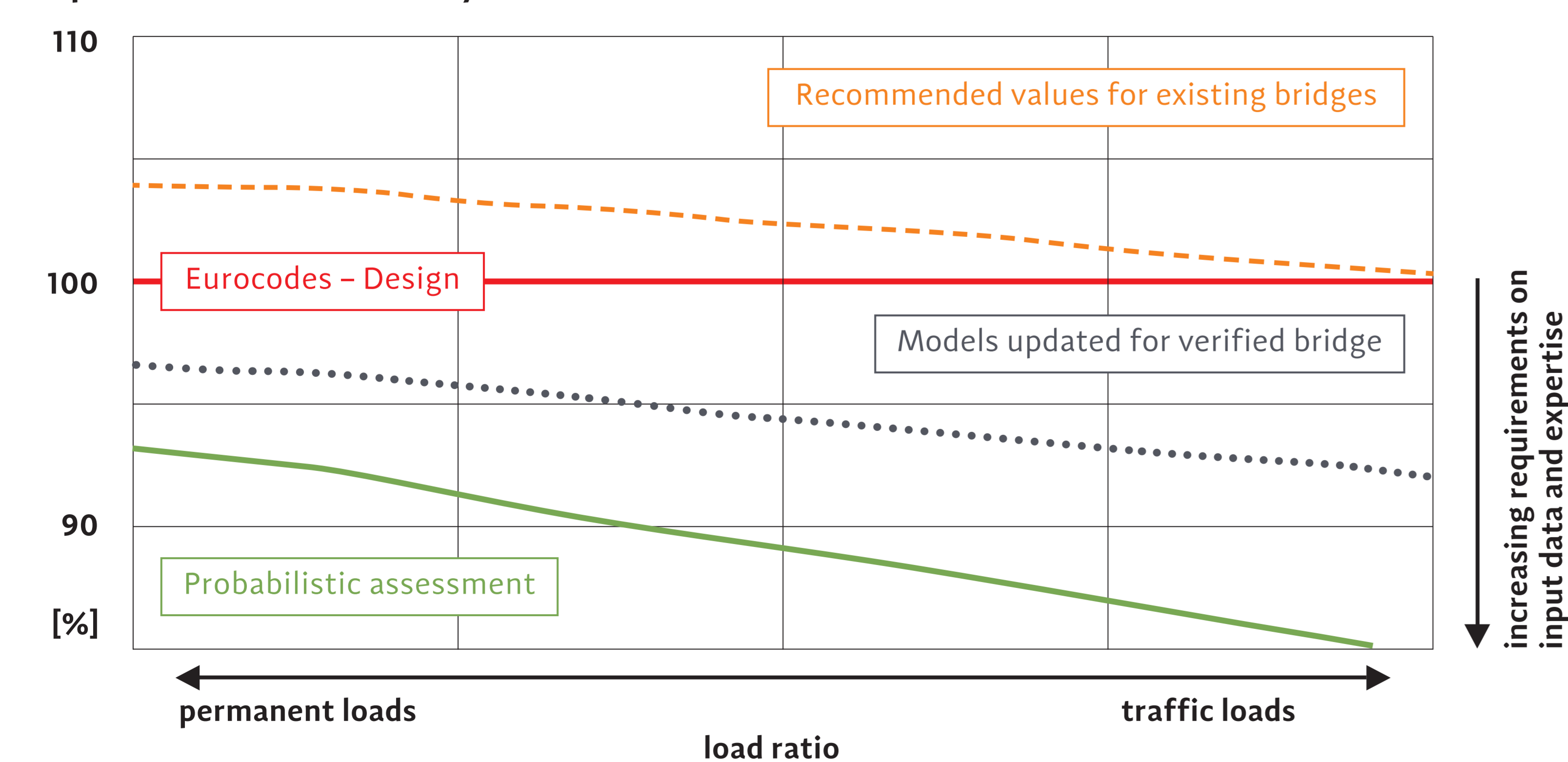
the loss of cultural and heritage values is carefully considered for each alternative. The decision should be made in an effort to minimize quantitative losses while minimizing the impact on cultural and heritage value. The project aims to ensure the sustainability of historic steel bridges by improving the following methods and methodologies:

1. Methodology for decision-making about surveys of steel bridges considering the relationship between measurement uncertainties and survey invasiveness and optimising a number of destructive tests depending on the result of non-destructive tests. Non-invasive methods are associated with large measurement uncertainties that can lead to underestimating the load-bearing capacity of the structure and therefore to unnecessary or inadequate upgrades. The survey methods thus need to be selected with regard to the required accuracy of the assessment. In particular, the assessment must be accurate in situations where the capacity of the structure is close to the limits provided by the requirements of the standards. Typically, an adaptive strategy is adopted in the assessment: non-invasive methods are applied first and then, if necessary, a more detailed assessment is carried out using more invasive procedures.

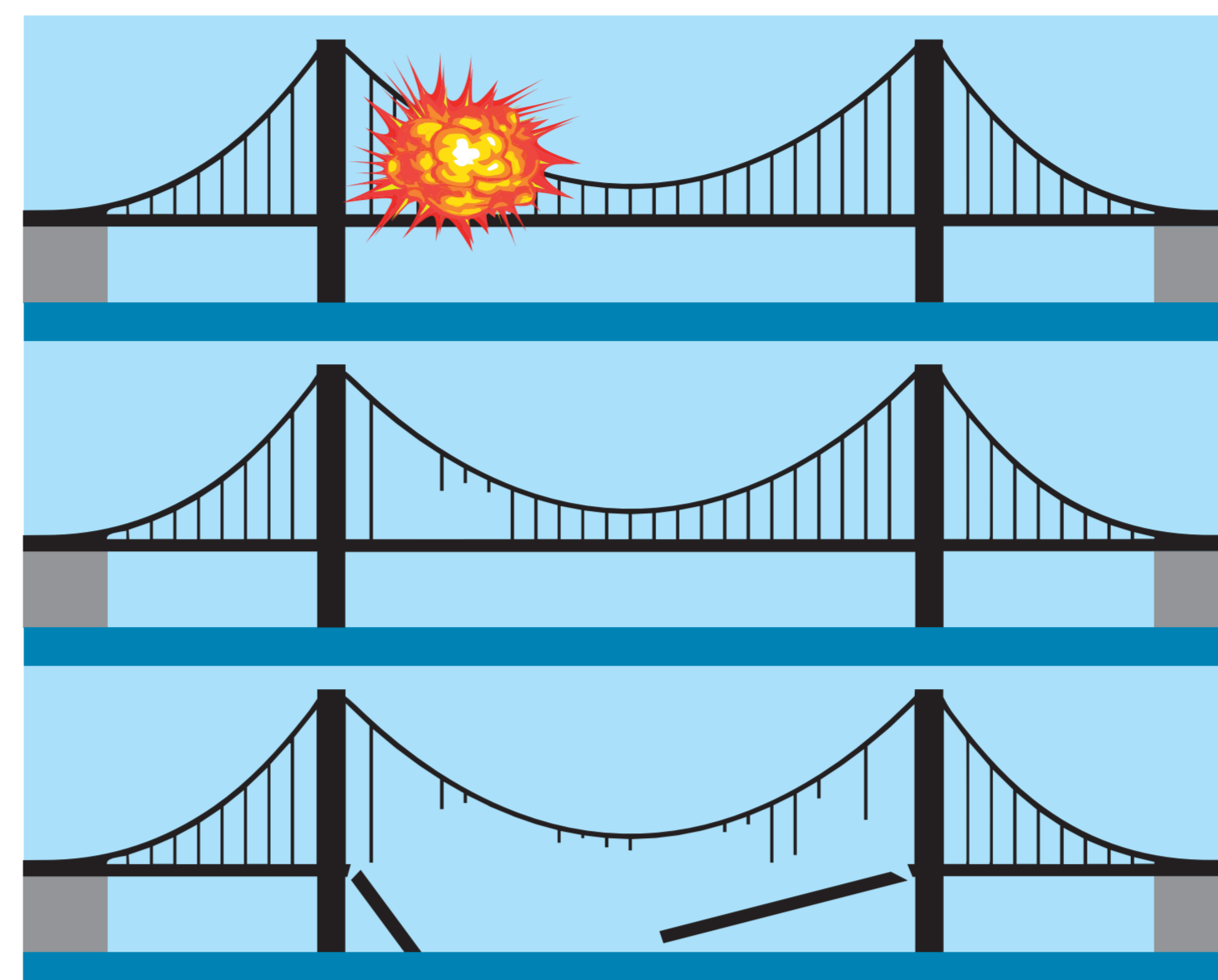
Error in strength estimate



Requirements for reliability verification



Comparison of reliability verification requirements (expressed e.g. in terms of load-bearing capacity) using different advanced methods



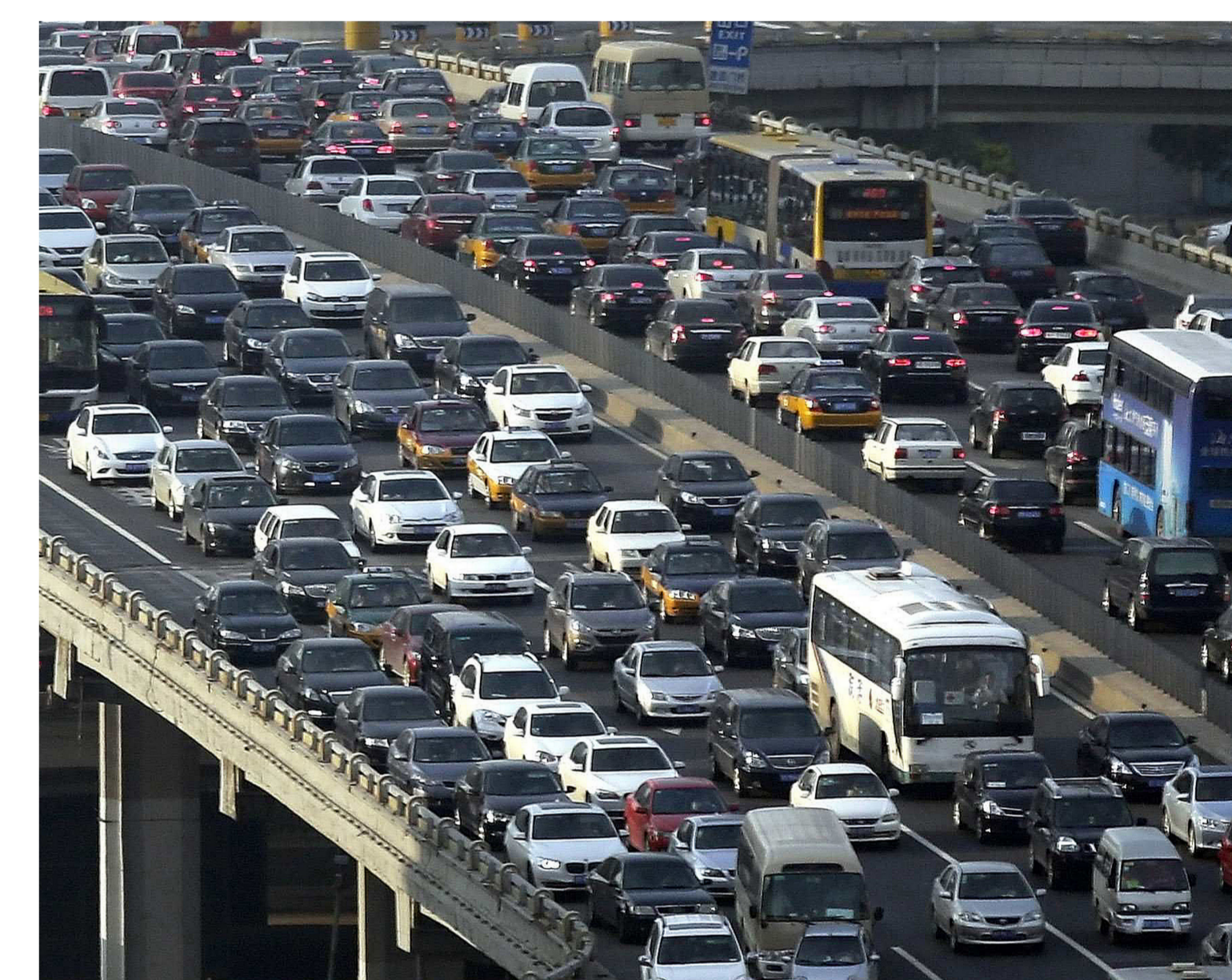
Social criteria (Is users' safety ensured?)



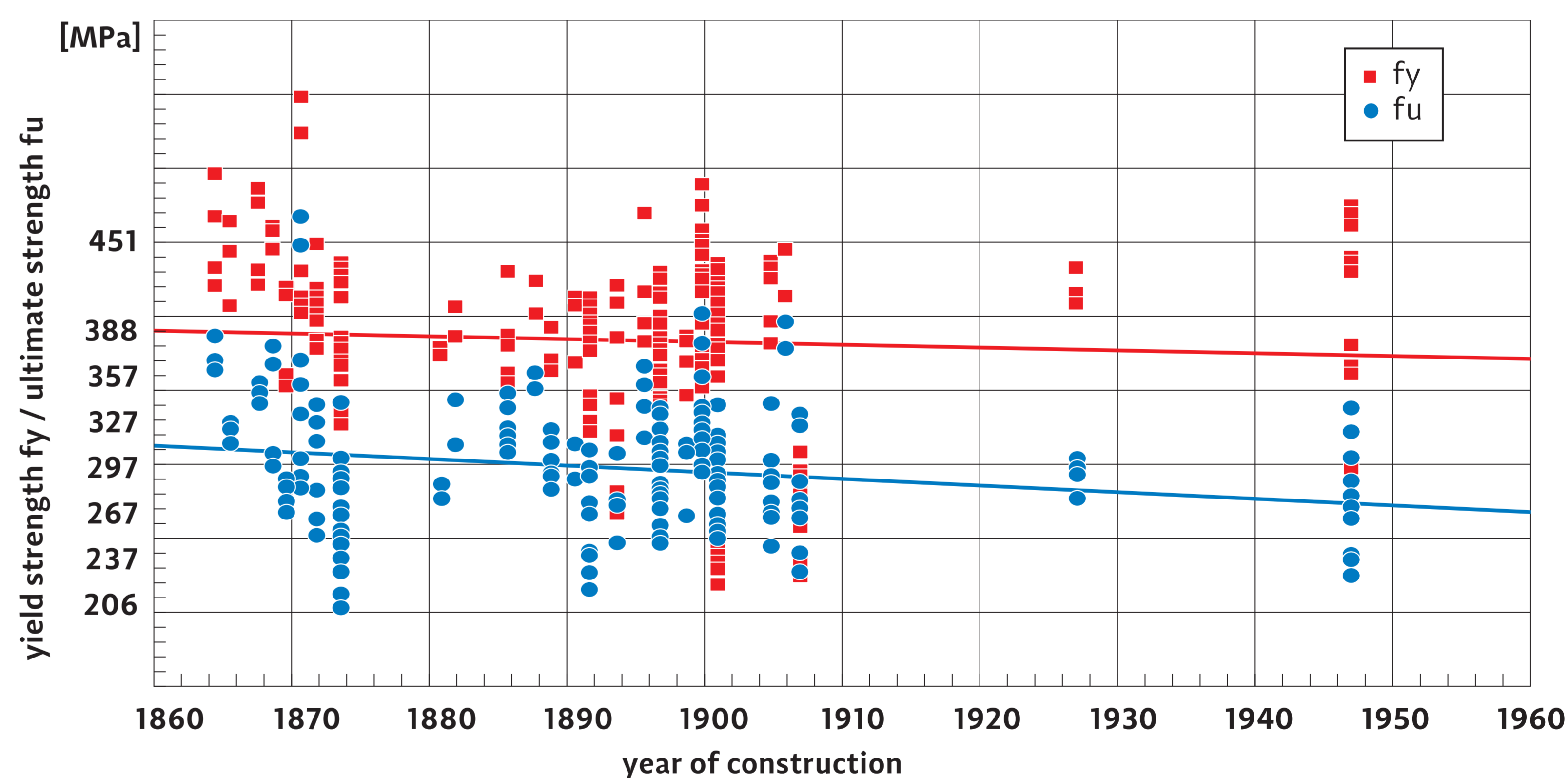
Loss of cultural and heritage values (Is it necessary to replace the historic structure?)



Technical and economic criteria (Can we save the historic structure with the available means?)



Ecological criteria (What are the impacts of detour routes, what is the material consumption?)



Variability of yield strength and ultimate strength depending on year of construction

2. Methods for assessing reliability and service life of bridges – detailed analysis of the uncertainties of the methods for reliability verification of steel bridges shows that, compared to the conservative procedures according to the standards, the load capacity requirements (while maintaining the same level of reliability) can be reduced by approximately:

- 5–10% when using updated models for load capacity and loads taking into account measurements and information on the specific bridge,
- 10–15% using probabilistic methods.

3. The basis of the methodology of heritage value assessment of buildings and bridges is provided in relevant methodologies. When assessing heritage structures, it is necessary in accordance with ČSN 730038 to take into account the technical possibilities of the survey, reliability criteria (including the safety of users) and compliance with the principles for preserving the cultural and heritage value of these objects. The methodology provides key information on the invasiveness of surveys and the potential impacts on the heritage value of a particular bridge.

4. The methodology for assessing the ecological impacts takes into account the consequences of the non-functioning of the bridge, including increased emissions and noise on the detour routes as well as increasing road traffic by shifting cargoes from railway traffic. The sustainability methodology allows the use of additional information obtained from monitoring, load testing and study tests to validate the calculation models and provides guidelines for the maintenance and strengthening of heritage bridges.