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Defects in railway bridges and procedures for maintenance



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Foreword

An International Railway Solution (IRS) is a document drawn up by consensus and applied on a voluntary basis which aims to facilitate and harmonise railway operation.

IRSs are gradually replacing UIC leaflets.

Members of the International Union of Railways (UIC) participate in the creation of IRSs, of which they benefit in full. Furthermore, marketing to railway stakeholders contributes to the sharing and harmonisation of good practices, in accordance with UIC's primary goal.

While IRSs do not have the force of law, they are created and published in a professional manner and with technical approval on the basis of UIC procedures, and have full technical legitimacy in the railway sector.

The "General application" section constitutes the heart of the IRS and contains the working group's expertise applicable in the broadest manner. The addition of a "Specific application" aims to cover factors specific to a region, a type of service, etc.

Some provisions shall be implemented in all cases to ensure correct application and maintain the system's cohesiveness. Certain operational circumstances require that specific provisions be systematically applied by all users of the document.

For the purposes of understanding, the user acknowledges that the expression of:

- obligation indicates requirements to be respected in order to comply with the expertise expressed in the document (usually "shall");
- recommendation indicates options that are favourable but not essential (usually "should");
- permission indicates options that are recognised but without consequence (usually "may");
- capacity indicates possibilities from a technical standpoint and not permissions or probabilities (usually "can").

Obligation, recommendation and capacity can be expressed in the negative to indicate prohibiting, non-recommendation and incapacity.

If applicable, notably for the purposes of compliance with a UIC approval, passages that are recommended or mandatory for the cohesiveness of the system will be accompanied by the letters "R" and "MCS" respectively.

This IRS reflects the following UIC working group expertise:

Drone4Rail group, for the "Harmonized methodology for drone / UAV use for bridge inspections", directed by the PoSE (Pannel of Structural Experts).

It integrates in full or in part the following UIC leaflets:

- *UIC Leaflet 778-4*

It complements the following standards:

- none

The following IRSs constitute a complementary series:

- none

Executive summary

The present IRS provides guidelines and recommendations covering procedures for the maintenance and strengthening of railway bridges. It includes inspection arrangements and methods, descriptions of defects, monitoring and assessment methods and maintenance, repair, strengthening and renewal procedures.

The purpose is to update the 2011 edition of *UIC Leaflet 778-4* and implement results from a UIC Drone4Rail Project (2019-2022) "Harmonized methodology for drone / UAS use for bridge inspections" which investigated the Unmanned Aircraft System (UAS) application in the field of periodic bridge inspections.

It integrates in full or in part the following UIC leaflets:

- *UIC Leaflet 778-4*

It aims to complement the following standards:

- none

Field of application

This IRS describes guidelines and recommendations concerning different procedures for inspecting the different typologies of railway bridges. Methods, descriptions of defects and monitoring and assessment procedures are included in the document.

The general purpose of maintenance and strengthening of railway bridges, objective of this IRS, is generally to ensure the long-term performance of the structure. The safety of the structures can be increased through regular inspections and, if necessary, maintenance measures. Without continuous monitoring, there is a natural residual risk of undetected damage.

Reference documents

The following documents are cited in this IRS or strongly support its requirements and recommendations:

1. International Railway Solution (IRS)

International Union of Railways (UIC)

- [1] *IRS 70778-2: Recommendations for determining the carrying capacity and fatigue risks of existing metallic railway bridges*
- [2] *IRS 70778-3: Recommendations for the inspection, assessment and maintenance of masonry arch bridges*

2. UIC Leaflets

International Union of Railways (UIC)

- [3] *UIC Leaflet 778-1: Recommendations for the consideration of fatigue in the design of steel railway bridges, especially with orthotropic decks, 3rd edition, 11.2011*

3. European Standards

European Committee for Standardization (CEN)

- [4] *EN 1337-1:2000: Structural bearings - General design rules, 2000*
- [5] *EN 13306:2017: Maintenance terminology, 2017*

Joint Research Center (JRC)

- [6] *ECCS-JRC Joint report: Recommendations for the assessment of existing steel structures (2008), EUR 23252 EN*
<http://eurocodes.jrc.ec.europa.eu/doc/background/EUR23252EN.pdf>, 2008

4. Miscellaneous

European Union: Experts group "Sustainable Bridges"

- [7] *SB-GUIDE (2007): Overall Project Guide: "Sustainable Bridges - Assessment for Future Traffic Demands and Longer Lives" - a project within EU FP7. 28 pp. Available from: www.sustainablebridges.net [cited 30.11.2008]*
- [8] *SB-ICA (2007): Guideline for Inspection and Condition Analysis of Railway Bridges. Prepared by Sustainable Bridges - a project within EU FP6. 259 pp. Available from: www.sustainablebridges.net [cited 30.11.2008]*
- [9] *SB-LRA (2007): Guideline for Load and Resistance Assessment of Railway Bridges. Prepared by Sustainable Bridges - a project within EU FP6, 428 pp. Available from: www.sustainablebridges.net [cited 30.11.2008]*

- [10] *SB-MON (2007): Guideline for Monitoring of Railway Bridges. Prepared by Sustainable Bridges - a project within EU FP6. 93 pp. Background documents for: Steel railway bridges, SB-5.2-S1, 53 pp; Structural Damping of Railway Bridges, SB-5.2-S2, 29 pp; Corrosion Monitoring Systems for Reinforced Concrete Bridges, SB-5.2-S3, 23 pp; Estimating Reliability of Monitoring systems for Bridges, SB-5.2-S4, 20 pp. Available from: www.sustainablebridges.net [cited 30.11.2008]*
- [11] *SB-STR (2007): Guide for use of Repair and Strengthening methods for Railway Bridges. Prepared by Sustainable Bridges - a project within EU FP6. 63 pp. Available from: www.sustainablebridges.net [cited 30.11.2008]*

Abbreviations and Symbols

AE	Acoustic Emission
CFRP	Carbonfibre Reinforced Polymers
EU	European Union
IE	Impact Echo
IRS	International Railway Solution
NDT	Non-Destructive Testing
PoD	Probability of Detection
SAFT	Synthetic Aperture Focusing Technique
UAS	Unmanned Aircraft System
UAV	Unmanned Aerial Vehicle
UIC	International Union of Railways
US	Ultrasonic

Defects in railway bridges and procedures for maintenance

General Application

1 – Inspection of railway bridges and detection of defects

1.1 – General

Regular inspection is a way of constantly monitoring the day-to-day condition of structures, by noting defects as they occur and identifying the cause of any damage discovered. The structure's actual condition must be compared with the applicable benchmark.

If only minor defects have been identified during an inspection, these observations can serve as a basis for specifying and organising the necessary maintenance work.

However, in case of more extensive damage the structure must be repaired and restored to a satisfactory condition, and the cause of the damage should be investigated into and put to rights (see Fig. 1 - page 10, Fig. 2 - page 10 and Fig. 3 - page 11).

The structure must always be in a suitable condition to meet the operational requirements of rail traffic and the safety requirements applicable to the line category.

If operational parameters for the line are changed (for example heavier axle loads or higher speeds), any decision as to whether the structure needs to be strengthened or completely renewed rests upon its actual condition at the time.

Engineers must adopt the engineering solution which will cause the least disturbance to rail traffic, while making sure the overall economic feasibility of engineering work is not overlooked.

Those responsible for the project and bridge designers should give preference to structures which allow easy inspection, maintenance, repair and renewal throughout their service life.

The present IRS shall refer to reports drafted as part of the EU project "Sustainable Bridges - Assessment for Future Traffic Demands and Longer Lives" (see Bibliography - page 48). The reports are available at the following address: <http://www.sustainablebridges.net>.

For masonry arch bridges, additional information is given in IRS 70778-3 [2] "Recommendations for the inspection, assessment and maintenance of masonry arch bridges".

EN 13306 (2017) [5] is a standard which provides maintenance terminology.

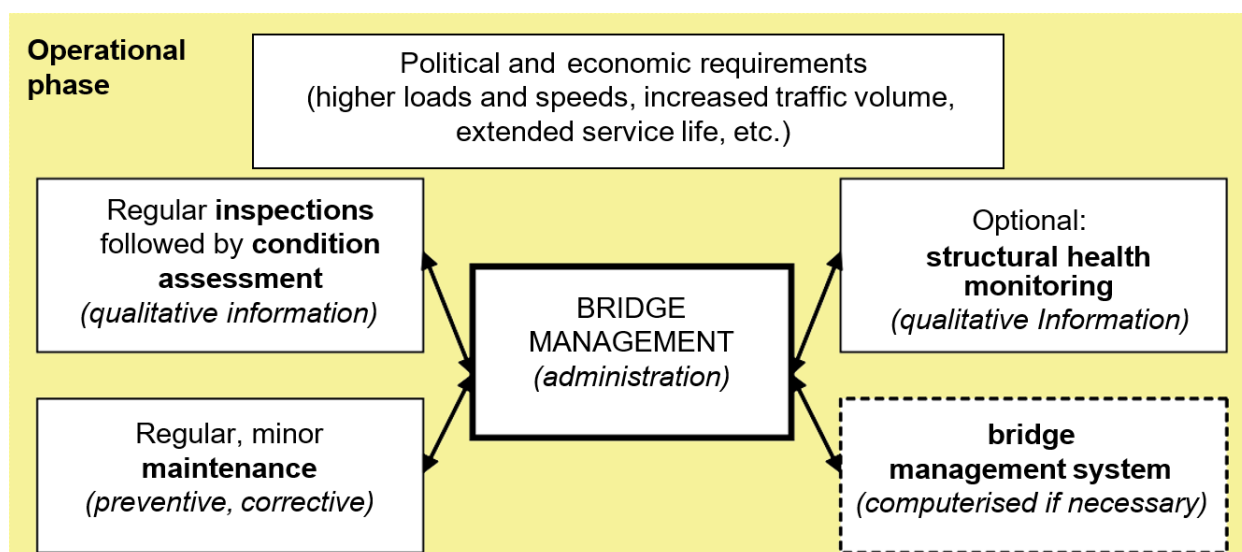


Fig. 1 - Regular operation and maintenance of bridges. Source: SB-guide (2007)

If any doubts arise as to the safety, serviceability or durability of the bridge, action can be taken according to Fig. 2 and Fig. 3 below.

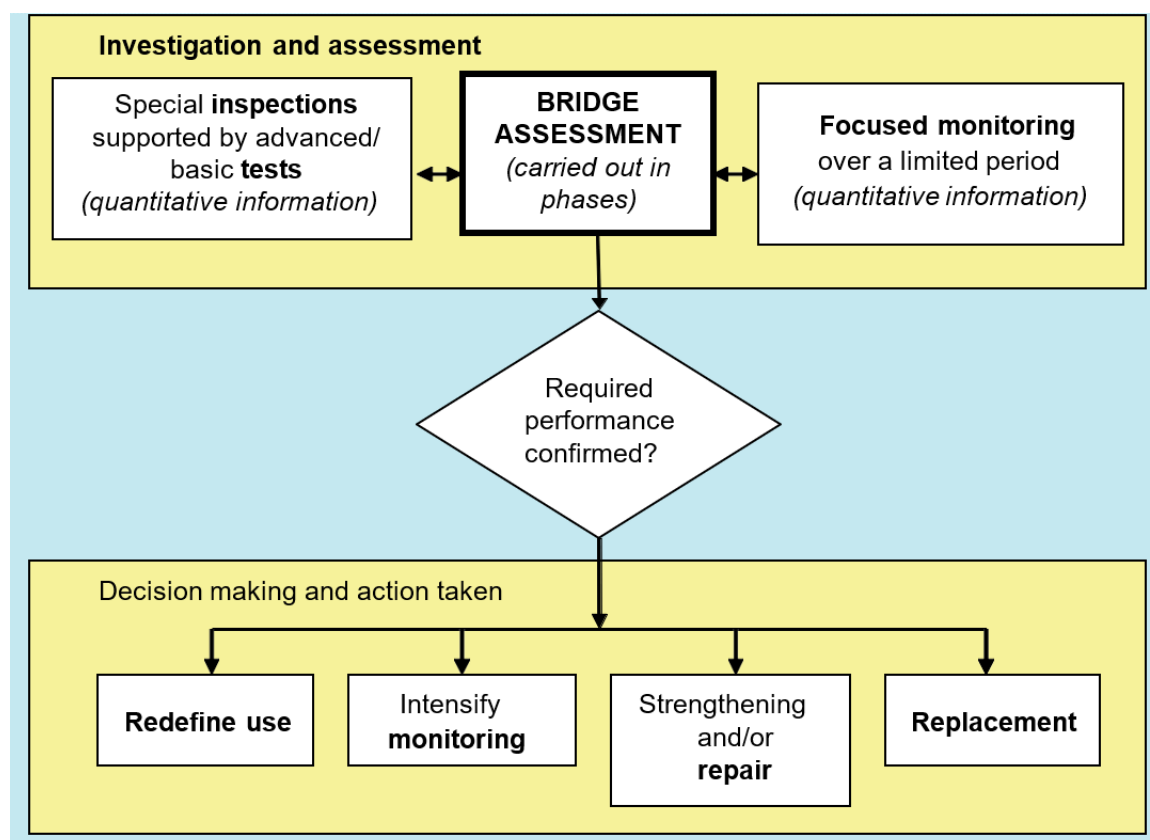


Fig. 2 - Special stage of operation and maintenance of bridges when there is a particular cause for concern regarding safety, serviceability or durability. Source: SB-guide (2007)

Once decisions and action have been taken (last line in the figure), the bridge returns to regular operations and maintenance according to Fig. 1 above. Fig. 3 below provides a more detailed illustration of the assessment procedure.

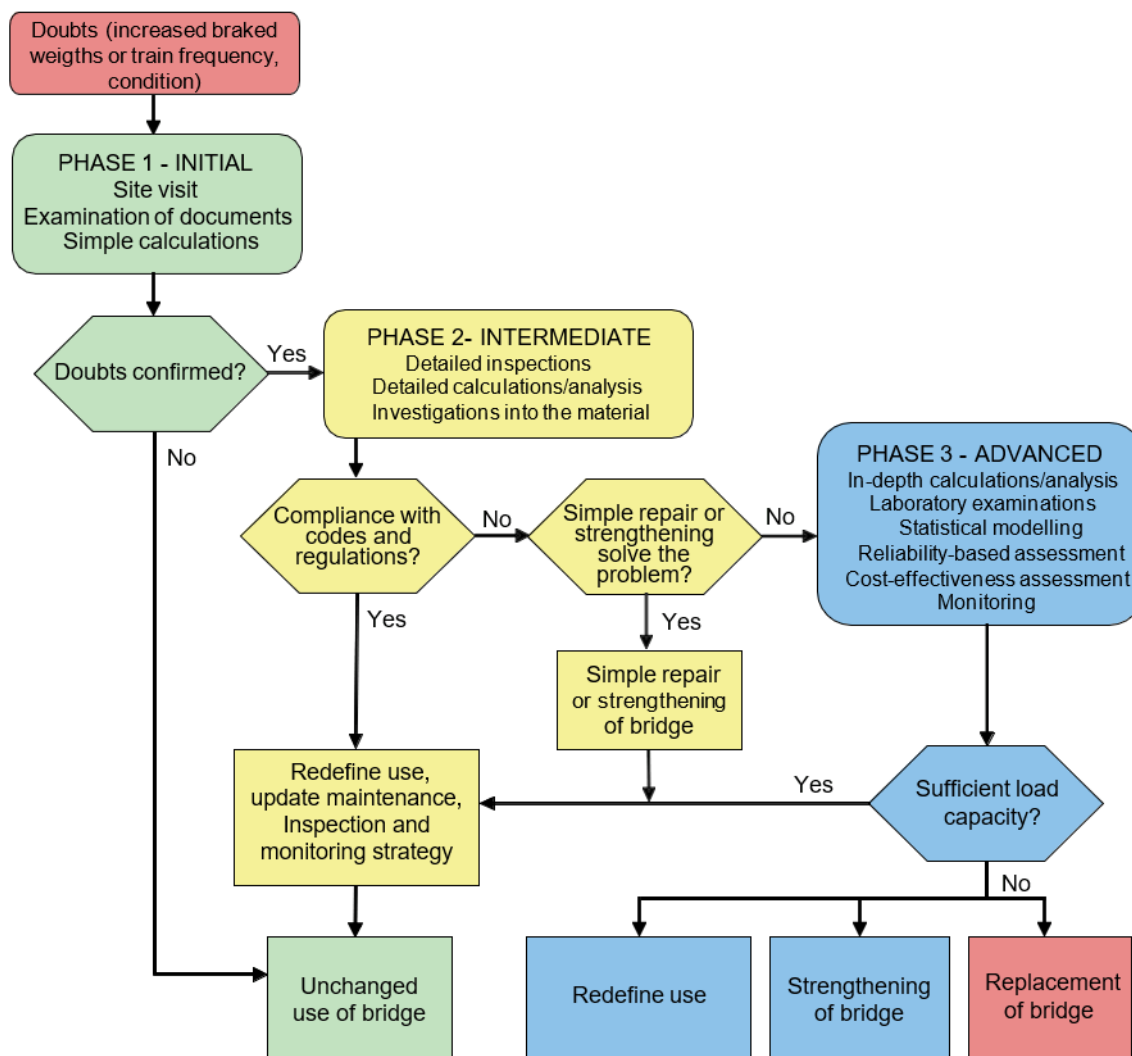


Fig. 3 - Flow chart for the bridge assessments as part of the process set out in Figure 2 including the special stage of operation and maintenance

There are three phases: initial (level 1), intermediate (level 2) and advanced (level 3), depending on the complexity of the issues and the extent of work required.

1.2 – Arrangements for inspection

1.2.1 – Precision and frequency

Inspections are to be carried out with varying degrees of precision and at varying frequency, depending on the type of inspection and the nature and prior condition of the structure. Apart from ordinary and ongoing monitoring of the bridge by train and track staff, a distinction is drawn between three levels of inspection:

- **Routine inspection:** Annual inspection from ground level by trained examiner.
- **Principal inspection:** In-depth visual inspection focusing on safety every (2 or) 3 years. The principal inspection may bring to light a need for further in-depth inspections, not necessarily covering the entire structure, but rather focusing on a particular component or problem area.
- **General inspection:** The most detailed inspection covering all parts of the bridge within touching distance (using a hammer to tap on concrete surfaces) takes place every 4 to 6 years. The frequency of inspections should reflect the nature of the bridge and the defects observed. In practice this means that inspection frequency varies according to bridge type and condition. The general inspection should result in a full and detailed report on the condition of the structure.

The inspection for definitive approval before the bridge enters into service or before a transfer of ownership (or following major repair work) serves as a benchmark indicating the required condition of the bridge.

Special equipment and facilities are generally required for these inspections as assistance to visual examination in locating more precisely any defects through special inspection methods.

All levels of inspections (routine, principal and general inspections) may be carried out with the support of unmanned Aircraft Systems (UAS) / drones. With photogrammetry data recorded during the drone flight 2D and 3D models of the structure can be created. For visible defects, this technology shall make it possible to identify their typology, location on structure (georeferenced defects), extension (measurable defects) and should provide valuable information on defects intensity. If Artificial Intelligence algorithms are applied, it is possible to automatically detect, locate and typecast visible defects on the structure, that must be verified and interpreted by a professional bridge engineer.

1.2.2 – Routine inspections

The inspector must be trained and have a basic understanding of bridges.

The standard equipment includes basic tools such as hammers, cameras and lighting devices.

Foundations should be inspected at low water. See below.

1.2.3 – Principal inspections

The inspector should be aware of the methods given in [point 2.2 - page 15](#).

A principal inspection consists of a visual examination of all parts of the bridge which can be accessed without the use of special equipment. All defects which are visible with the naked eye from