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Translation

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Recommendations for the fatigue design of railway bridges in reinforced and prestressed-concrete

*Recommandations pour le dimensionnement des ponts-rails en béton armé et précontraint à la fatigue
Empfehlung zur Ermüdungsbemessung von Eisenbahnbrücken aus Stahl- und Spannbeton*



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Contents

Summary	1
1 - Introduction	2
2 - Basic prescriptions - Notations - Units.....	3
2.1 - Capital letters.....	3
2.2 - Small letters	3
2.3 - Small Greek letters	3
2.4 - Capital Greek letters	4
2.5 - General indices.....	4
3 - General.....	5
3.1 - Principles	5
3.2 - Actions and combinations of actions	5
3.3 - Determining the internal forces and stresses	6
4 - Fatigue verification of the reinforcement steel in reinforced concrete and prestressed-concrete.....	8
4.1 - Principles	8
4.2 - Fatigue-strength.....	9
4.3 - Simplified verification	10
4.4 - General verification.....	10
5 - Fatigue verification of concrete.....	12
5.1 - Principles	12
5.2 - Verification of concrete in compression	12
5.3 - Verification of concrete in shear	13
6 - Fatigue resistant detailing.....	14

7 - Correction factors	15
7.1 - Reinforcing and prestressing steel	15
7.2 - Concrete subjected to compression	19
Bibliography	24

Summary

The aim of this Leaflet is to provide recommendations for fatigue verification of the elements of railway bridges in common cases. It is valid for high-cycle fatigue and applies to new bridges but may also be used for verification of existing bridges, providing the actual state of those bridges is taken into account (steel corrosion, etc.).

The limit-state design concept is used for obtaining adequate durability during the life of the structure, which also guarantees adequate safety. The leaflet defines the actions and the combination of actions applied on the structure. It also determines the internal forces and stresses based on these actions.

Methods and, in some possible cases, simplified methods allow the fatigue verification of the reinforcement steel and concrete for reinforced and prestressed structures. For those methods, the values of the applied factors and definitions are given in tables or formulas, and where necessary, references are specified. Finally, recommendations for reinforcement detailing are listed.

1 - Introduction

The last issue of *UIC Leaflet 774-1* published in July 1984 included a chapter (Chapter 8) on fatigue verification.

The former ERRI Specialists' Committees D 183 and then D 216 participated in the drafting of new rules concerning the fatigue of concrete structures, notably as regards the determination of the λ correction factors.

The present leaflet is the result of that work and therefore conforms to the Eurocode standards, which regulate bridge calculations in Europe. This leaflet was drawn up to replace the 2nd issue of *UIC Leaflet 774-1*.

The aim of this Leaflet is to provide recommendations for fatigue verification of the elements of railway bridges in common cases.

This Leaflet is valid for high-cycle fatigue.

This Leaflet applies to new bridges but may also be used for verification of existing bridges, providing the actual state of those bridges is taken into account (e.g. reduction of steel section as a result of corrosion).

2 - Basic prescriptions - Notations - Units

2.1 - Capital letters

A	=	area
D	=	diameter
G	=	permanent action
N	=	number of cycles
P	=	prestressing
Q	=	variable action
R	=	strength
S	=	internal force
T	=	temperature
V	=	shear force

2.2 - Small letters

f	=	strength of a material
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2.3 - Small Greek letters

γ	=	safety factor
ζ	=	reduction factor
η	=	increase factor
λ	=	correction factor
σ	=	normal stress
τ	=	shear stress
ξ	=	ratio of bond strength

2.4 - Capital Greek letters

- Δ = difference
- Θ = angle of inclination of concrete compression struts
- $\varnothing$ = diameter
- Φ = dynamic factor

2.5 - General indices

- c = concrete
- d = design
- fat = fatigue
- k = characteristic
- p = prestressing
- s = steel

3 - General

3.1 - Principles

When subjected to a high number of load cycles, the reinforced and prestressed-concrete elements of bridges may sustain progressive damage to the reinforcement or the concrete resulting in structural failure, even though the stress levels applied are lower than the static strength. This phenomenon is called fatigue.

The resistance of railway bridges to fatigue shall be verified. The aim of performing a fatigue-safety verification is to demonstrate that the fatigue-effects of rail traffic loads will not impair the safety of the railway bridge during its intended service life.

The fatigue-safety verification shall be performed on the bearing capacity of members and separately for concrete and steel.

To a large extent, fatigue damage can be avoided by following the rules for detailing reinforcement as set down in point 6 - page 14. Clearly, observance of the latter does not dispense with fatigue verification.

In general, fatigue can be expected to prevail in:

- reinforced-concrete and prestressed-concrete structural elements for which the ratio of variable to permanent internal forces is high;
- mechanical or welded joints in prestressed-concrete reinforcements and in joints achieved by coupling prestressed reinforcements, particularly in areas subjected to varying stress ranges.

Fatigue verification is in principle not necessary for bridge elements for which the dynamic coefficient is not necessary, e.g., bridges with sufficient earth cover or an adequate layer of other damping material, piers and abutments which are not rigidly connected to the superstructure (except the slabs and walls of hollow abutments and ballast-retaining walls) and foundations.

3.2 - Actions and combinations of actions

3.2.1 - Fatigue actions

Fatigue actions are mainly caused by traffic loads.

The internal forces and stresses involved shall be calculated using UIC Load Model 71 - as defined in *UIC Leaflet 702* (class k_0), including the dynamic factor Φ in accordance with *UIC Leaflet 776-1* (see [Bibliography - page 24](#)).

For certain elements of the bridge, it may be necessary to take into account the internal forces due to changes in wind speed and/or direction.