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# THE DYNAMIC AMPLIFICATION OF RAILWAY LOADS IN THE DESIGN OF UNDER-TRACK STRUCTURES

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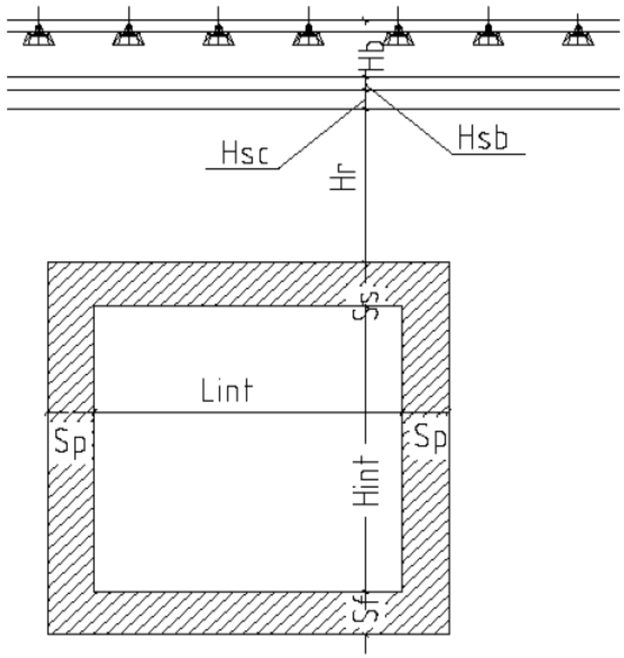
# The dynamic amplification of railway loads

Stresses and deformations caused on the under-track structures by the traffic loads static application must be increased to take into account the dynamic nature of the train traffic. Specifically, the following aspects need to be considered:




- rapid load variations determined by the trains transit speed and inertial effects induced on the structure;
- variations in the effects of axial loads resulting from the track and wheels irregularities.

Generally a static analysis will be performed: the theoretical load models (e.g. LM71, SW/2) are multiplied by an appropriate dynamic increment coefficient, ϕ.

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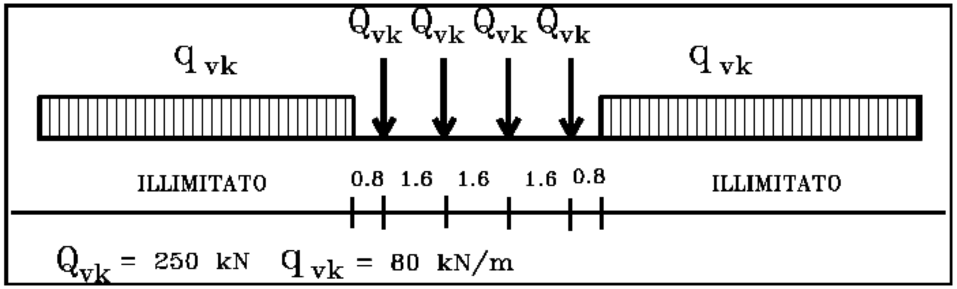
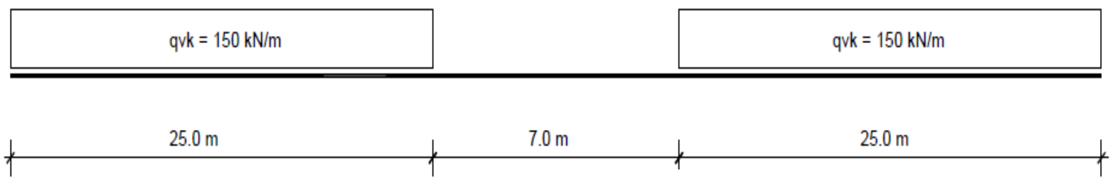
# Theoretical load models

Dynamic increment coefficient (ϕ) apply to theoretical load models (LM71, SW).

**LM71**

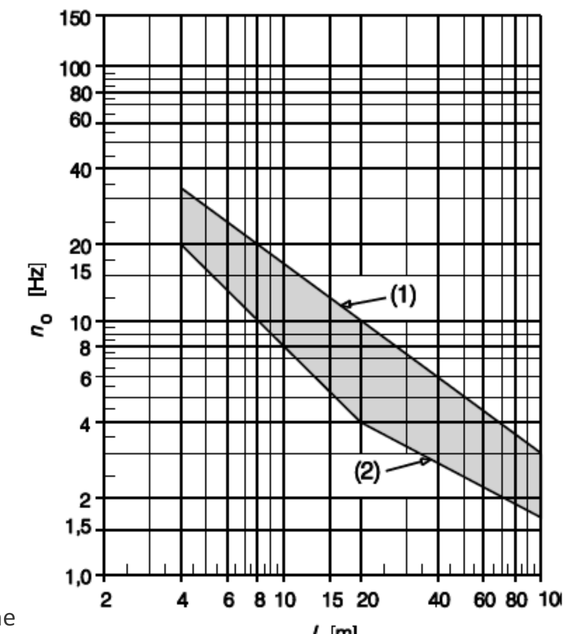



**SW/2**




In some cases, a dynamic analysis may also be required.

$$\varphi'_{Reale,f}(V) = \left|\frac{\delta_{din}(V)}{\delta_{stat}}\right|$$

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# The dynamic increment coefficients, $\phi$

The dynamic increment coefficients that increase the intensity of the load models are assumed to be $\phi_2$ or $\phi_3$, depending on the level of maintenance of the line.

In particular, the following will be assumed:

a) for lines with high maintenance standard:

$$\Phi_2 = \frac{1,44}{\sqrt{L_\phi} - 0,2} + 0,82 \qquad \text{with the limitation} \qquad 1,00 \le \Phi_2 \le 1,67$$

b) for lines with reduced maintenance standard:

$$\Phi_3 = \frac{2,16}{\sqrt{L_\phi} - 0,2} + 0,73 \qquad \text{with the limitation} \qquad 1,00 \le \Phi_3 \le 2,00$$

where $L_\phi$ represents the “characteristic” length in meters, defined in relation to the type of structural element.

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# The "characteristic" length, $L_\phi$

For underpasses with free height ≤ 5,0m and span ≤ 8,0m:

$$\phi_2 = 1{,}20\ ;\ \phi_3 = 1{,}35$$

Box-shaped structures that do not meet the previous limits are treated as a portal, ignoring the presence of the lower slab and considering a reductive coefficient of $\phi$ equal to 0.9, to be applied to the $\phi$ coefficient.

Portals ⇨ to be considered as a three-span continuous beam (considering the heights of the side walls and the length of the crossbeam)

Continuous beams and slabs on *n* spans, indicating with:

$$L_m = \frac{1}{n} * (L_1 + L_2 + \cdots + L_n)\ ;\ L_\phi = kL_m$$ where:

$$n = 2 - 3 - 4 - \geq 5$$

$$k = 1{,}2 - 1{,}3 - 1{,}4 - 1{,}5$$

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# Reduced dynamic coefficient

In the case of arch bridges or box-shaped structure, having a covering height "h" greater than 1.0 m, the dynamic coefficient can be reduced in the following manner:

$$\Phi_{rid} = \Phi - \frac{h - 1,00}{10} \geq 1,0$$

where h, in metres, is the covering height from the structure's extrados to the upper face of the sleeper.

$$\Phi_{2,3} = 1.0 \text{ per h} > 2.50 \text{ m}$$

Furthermore, track-structure interaction effects, resulting from:

- train braking and starting;
- thermal variations in the structure and track;
- deformations due to vertical loads

must also be considered.

Interaction effects caused by creep and shrinkage in reinforced concrete and prestressed concrete structures must be taken into account, where relevant.

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