Singapore National Annex to Eurocode 1: Actions on structures – Part 2: Traffic loads on bridges

AMENDMENT NO. 1

April 2017

1. Page 32, NA.2.45 Alternative load models for railway bridges [SS EN 1991-2:2012, 6.1 (2)]

(a) *Replace* the first sentence with "Alternative load models for non-public footpaths, actions due to traction and braking and Rapid Transit Systems (RTS) should be as set out in the following."

(b) *Insert* the following new subclauses after NA.2.45.2:

NA.2.45.3 RTS load model

NA.2.45.3.1 General

RTS load model is loading for use only on passenger RTS in Singapore.

Nominal type RTS consists of a single 200 kN concentrated load coupled with a uniformly distributed load of 50 kN/m for loaded lengths up to 100 m. For loaded lengths in excess of 100 m the distributed nominal load shall be 50 kN/m for the first 100 m and shall be reduced to 25 kN/m for lengths in excess of 100 m.

Alternatively, two concentrated nominal loads, one of 300 kN and the other of 150 kN, spaced at 2.4 m intervals along the track, shall be used on deck elements where this gives a more severe condition. These two concentrated loads shall be deemed to include dynamic effects.

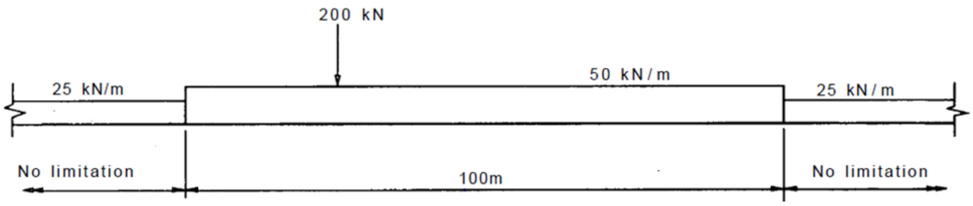

Figure NA.10 – RTS load model

NA.2.45.3.2 RTS live loading

The RTS design nominal live loading shall be as follows:

Table NA.13 – Nominal RTS live loading

RTS types	Nominal live loading
MRT	Type RTS in accordance with NA.2.45.3
LRT	Not less than: (a) Half of RTS loading in accordance with NA.2.45.3 (b) Actual system requirement

NA.2.45.3.3 Dynamic effects

The standard railway loadings specified in NA.2.45.3 (except the 300 kN and 150 kN concentrated alternative RTS) are equivalent static loadings and shall be multiplied by appropriate dynamic factors to allow for impact, oscillation and other dynamic effects including those caused by track and wheel irregularities. The dynamic factors given below shall be adopted, provided that maintenance of track and rolling stock is kept to a reasonable standard.

The dynamic factor for RTS, when evaluating moments and shears, shall be taken as 1.20, except for unballasted tracks where, for rail bearers and single-track cross girders, the dynamic factor shall be increased to 1.40.

The dynamic factor applied to temporary works may be reduced to unity when rail traffic speeds are limited to not more than 25 km/h.

NA.2.45.3.4 Dispersal of concentrated loads

Concentrated loads applied to the rail will be distributed both longitudinally by the continuous rail to more than one sleeper, and transversely over a certain area of deck by the sleeper and ballast.

It may be assumed that only two-thirds of a concentrated load applied to one sleeper will be transmitted to the bridge deck by that sleeper, and that the remaining one-third will be transmitted equally to the adjacent sleeper on either side.

Where the ballast depth is at least 200 mm, it may be assumed that only half of a concentrated load applied to one sleeper will be transmitted to the bridge deck by that sleeper, and that the remaining half will be transmitted equally to the adjacent sleeper on either side.

The load acting on the sleeper under each rail may be assumed to be distributed uniformly over the ballast at the level on the underside of the sleeper for a distance of 800 mm symmetrically about the centre line of the rail or to twice the distance from the centre line of the rail to the nearer end of the sleeper, whichever is the lesser. Dispersal of this load through the ballast onto the supporting structure shall be taken at 5° to the vertical.

The distribution of concentrated loads applied to a track not supported on ballast shall be calculated on the basis of the relative stiffnesses of the rail, its support on the bridge deck and the bridge deck itself.

In designing the supporting structure for the loads transmitted from the sleepers, distributed as set out above, any further distribution arising from the type of construction of the deck may be taken into account.

NA.2.45.3.5 Deck plates and similar local elements

Irrespective of the calculated distribution of axle loads, all deck plates and similar local elements shall be designed to support a nominal load of 168 kN for RTS at any point of support of a rail. These loads shall be deemed to include all allowances for dynamic effects and lurching.

NA.2.45.3.6 Application of RTS

RTS shall be applied to each and every track. Any number of lengths of the distributed load may be applied, but the total length of 50 kN/m intensity shall not exceed 100 m on any track. The concentrated loads shall only be applied once per track for any point under consideration.

NA.2.45.3.7 Lurching

Lurching results from the temporary transfer of part of the live loading from one rail to another, the total track load remaining unaltered.

The dynamic factor applied to RTS will not adequately take account of all lurching effects. To allow for this, 0.56 of the track load shall be considered acting on one rail concurrently with 0.44 of the track load on the other rail. This redistribution of load need only be taken into account on one track where members support two tracks. Lurching may be ignored in the case of elements that support load from more than two tracks.

NA.2.45.3.8 Nosing

An allowance shall be made for lateral loads applied by trains to the track. This shall be taken as a single nominal force of 100 kN, acting horizontally in either direction at right angles to the track at rail level and at such a point in the span as to produce the maximum effect in the element under consideration.

The vertical effects of this force on secondary elements such as rail bearers shall be considered. For elements supporting more than one track a single force, as specified, shall be deemed sufficient.

NA.2.45.3.9 Centrifugal force

Where the track on a bridge is curved, allowance for centrifugal action of moving loads shall be made in designing the elements, all tracks on the structure being considered occupied. The nominal centrifugal force F_c, in kN, per track acting radially at a height of 1.8 m above rail level shall be calculated from the following formula:

$$F_c = \frac{P\left(v_t + 10\right)^2 \text{ x f}}{127r}$$

where:

P is a distributed load of 40 kN/m multiplied by *L*;

r is the radius of curvature (in m);

v_t is the greatest speed envisaged on the curve in question (in km/h);

$$f = 1 - \left[\frac{v_t - 120}{1000}\right] \text{x} \left[\frac{814}{v_t} + 1.75\right] \text{x} \left[1 - \sqrt{\frac{2.88}{L}}\right]$$

for *L* greater than 2.88 m and v_t over 120 km/h

= unity for *L* less than 2.88 m or v_t less than 120 km/h;

L is the loaded length of the element being considered.

The number of tracks and loaded lengths considered for centrifugal force shall be consistent with the number assumed to be occupied for vertical loading. In addition, for a bridge located on a curve, the effects of cant shall be considered, both with and without centrifugal force.

NA.2.45.3.10 Actions due to traction and braking

Provision shall be made for the nominal actions due to traction and application of brakes as given in Table NA.14.

Table NA.14 – Nominal actions due to traction and braking

	Loaded length (m)	**Longitudinal force**
Traction (30% of force on driving wheels)	up to 8	80 kN
	from 8 to 30	10 kN/m
	from 30 to 60	300 kN
	from 60 to 100	5 kN/m
	over 100	500 kN
Braking (25% of force on braked wheels)	up to 8	64 kN
	from 8 to 100	8 kN/m
	over 100	800 kN

These forces shall be considered as acting at rail level in a direction parallel to the tracks. No addition for dynamic effects shall be made to the longitudinal forces calculated as specified in this subclause.

For bridges supporting ballasted track, up to one-third of the longitudinal forces may be assumed to be transmitted by the track to resistances outside the bridge structure, provided that no expansion switches or similar rail discontinuities are located on, or within, 18 m of either end of the bridge.

Structures and elements carrying single tracks shall be designed to carry the larger of the two forces produced by traction and braking in either direction parallel to the track.

Where a structure or element carries two tracks, both tracks shall be considered as being occupied simultaneously. Where the tracks carry traffic in opposite directions, the force due to braking shall be applied to one track and the force due to traction to the other. Structures and elements carrying two tracks in the same direction shall be subjected to braking or traction on both tracks, whichever gives the greater effect. Consideration, however, may have to be given to braking and traction, acting in opposite directions, producing rotational effects.

Where elements carry more than two tracks, longitudinal forces shall be considered as applied simultaneously to two tracks only.

NA.2.45.3.11 Aerodynamic effects from passing trains

Provision shall be made for the nominal actions due to aerodynamic effects from passing trains. The requirements shall be agreed with the relevant authority.

NA.2.45.3.12 Design derailment loads for RTS

Railway bridges shall be so designed that they do not suffer excessive damage or become unstable in the event of a derailment. The following conditions shall be taken into consideration:

(a) For the serviceability limit state, derailed coaches or light wagons remaining close to the track shall cause no permanent damage.

(b) For the ultimate limit state, derailed locomotives or heavy wagons remaining close to the track shall not cause collapse of any major element, but local damage may be accepted.

(c) For overturning or instability, a locomotive and one following wagon balanced on the parapet shall not cause the structure as a whole to overturn, but other damage may be accepted.

Conditions (a), (b) and (c) are to be considered separately and their effects are not additive. The following equivalent design static loads, with no addition for dynamic effects, may be deemed to comply with these requirements and shall be applied.

(i) For the serviceability limit state, either:

– a pair of parallel vertical line loads of 15 kN/m each, 1.4 m apart, parallel to the track and applied anywhere within 2 m either side of the track centre line (or within 1.4 m either side of the track centre line where the track includes a substantial centre rail for electric traction or other purposes); or

– an individual concentrated vertical load of 75 kN anywhere within the width limits specified above.

(ii) For the ultimate limit state, four individual concentrated vertical loads each of 120 kN, arranged at the corners of a rectangle of length 2.0 m and width 1.4 m, applied anywhere on the deck.

(iii) For overturning and instability, a single line vertical load of 30 kN/m, applied along the parapet or outermost edge of the bridge, limited to a length of 20 m anywhere along the span.

Loads specified in (i) and (ii) shall be applied at the top surface of the ballast or other deck covering and may be assumed to disperse at 30° to the vertical onto the supporting structure.

NA.2.45.3.13 Actions for fatigue investigations

All elements of bridges subject to railway actions shall be checked against the effects of fatigue caused by repeated cycles of live actions. The number of action cycles shall be based on a life expectancy of 120 years for bridges intended as permanent structures. The partial factor to be used in all cases when considering fatigue is 1.0.

For the fatigue assessment of railway bridges the characteristic values for RTS load model should be used, including the dynamic factor.

NA.2.45.3.14 Partial factors and Combinations of Actions

Partial factors and combinations of actions shall be applied in accordance with SS EN 1991-2 Load Model 71.

For serviceability limit states, a partial factor of 1.10 shall be applied to RTS actions.

2. Page 34, NA.2.50 Alternative requirements for a dynamic analysis, paragraph one [SS EN 1991-2:2012, 6.4.4 (1)]

Replace “Figure NA.10” and “Figure NA.11” with “Figure NA.11” and “Figure NA.12” respectively.

3. Page 35, Flow Chart for determining whether a dynamic analysis is necessary for “simple’ structures

(a) *Replace “*Figure NA.10” with “Figure NA.11”.

(b) *Replace “*Figure NA.14” with “Figure NA.13”.

4. Page 37, Flow Chart for determining whether a dynamic analysis is required for “simple’ and ‘complex’ structures

(a) *Replace “*Figure NA.11” with “Figure NA.12”.

(b) *Replace “*Figure NA.14” with “Figure NA.13”.

5. Page 39, Figure NA.12

*Replace “*Figure NA.12” with “Figure NA.13”.