Substructure: Design and construction. General technical requirements

1 Purpose and scope

This chapter provides general technical requirements for the design and construction of the railway's substructure.

The technical design and operational condition of the substructure must facilitate a safe and appropriate traffic flow, as well as safeguard the environment.

The substructure will otherwise be governed by local factors in terms of topography, soil conditions, hydrology, climate, etc. The final design and structural solutions will also be affected by safety level and cost.

The chapter includes, for example, a general outline of the construction-technical properties of various materials, a description of design loads, as well as geotechnical conditions. For classification of soil types, reference is made to vedlegg a.

2 Rock and soil types

The utilisation of rock (stone) and soil as a building material requires knowledge of how such materials behave physically under changing climatic conditions.

2.1 Rock types

The suitability of the various rock types in railway construction depends on what part of the structure such rock types are being used in. The most significant requirements are stipulated for materials being used as ballast. In a reinforcing layer and a frost protection layer, the majority of Norwegian rock types can be used. However, phyllite, shale and alum slate are examples of rock types that should not be used. Limestone, mica schist and greenschist must be carefully evaluated.

The majority of rock types may also be used in embankments under the formation, while rock types that are strongly schistose, efflorescent and/or have a high mica content, must be carefully evaluated. The suitability of such rock types must be determined based on a total evaluation of the degree of schistosity, efflorescence and mica content versus the embankment height, embankment slope, as well as requirements regarding inherent stability, permeability and settlement.

2.2 Soil types

For classification of soil types, reference is made to vedlegg a.

2.2.1 General construction-technical properties

Gravel possesses good construction-technical properties and significant water permeability.

Sand possesses good construction-technical properties but is very dependent on grain uniformity. Single graded sand is less stable than well graded sand containing more fractions. Sand subjected to a hydraulic gradient, e.g. during excavation of sand beneath groundwater level, will possess less stability.

Silt is particularly sensitive to the effect of water pressure and running water. Silt may be used in embankments if materials can be compacted satisfactorily while distribution proceeds. Otherwise, silt is best suited to berms and similar.

Clay varies considerably in its rigidity. Normally, the upper layer of a clay deposit, the crust, has greater rigidity than deeper layers. The thickness of the crust can be from zero to several metres. Clay crust deposits may be used in the construction of railway embankments. Quick clay liquefies when agitated and may not be used for railway embankments.

Peat is a highly compressible material and is not very suitable as a construction material.

3 Height reference

The height reference for the design and construction of the substructure whether concerning embankments, cuttings, bridges or tunnels must always be the top level of the lowest rail. For the distance between the top of the rail and the formation level, reference is made to Overbygning/Prosjektering/Ballast.

4 Design loads

[NS-EN 1991-1 Eurokode 1: Laster på konstruksjoner] applies to design loads.

4.1 Design traffic loads

The design traffic load = alpha factor x combination factor x load factor x typical line load/concentrated loads

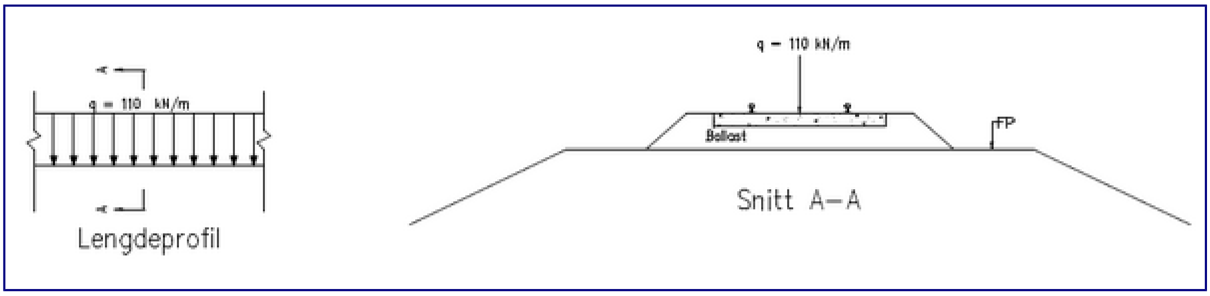
Combination factor and load factor are specified in NS-EN 1990:2002/A1:2005 + NA:2010

The alpha factor is used on more heavily trafficked lines, cf. Bruer/Prosjektering og bygging/Laster

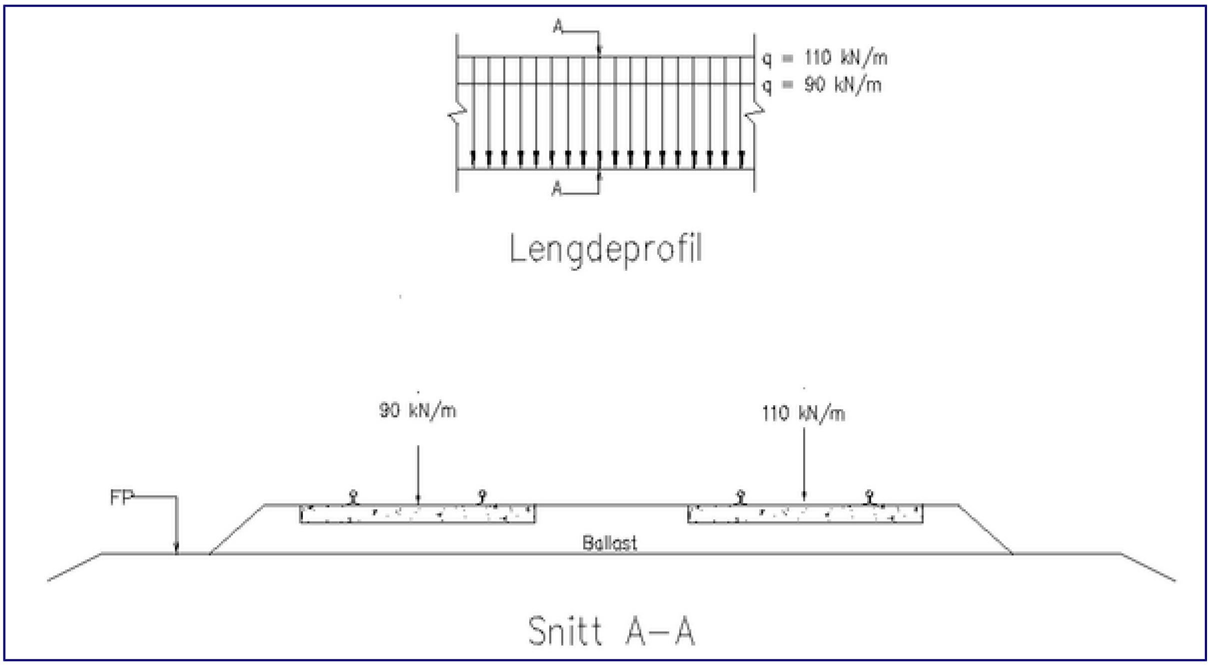
When undertaking geotechnical calculations of

- a railway embankment's stability and load-bearing capacity
- temporary/provisional track support

a typical line load is calculated to be equal to 110 kN per metre of track. Refer to Figur 1.



Figur 1: Typical line load for a single-track line
For a double-track line, the calculation is based on both tracks being loaded simultaneously. One track is loaded with 110 kN/m and the other track is loaded with 90 kN/m, where the least favourable load factor is used. Refer to Figur 2.



Figur 2: Typical line load for a double-track line

On the Ofot Line it is necessary to use 4 x axle loads of 300 KN each and a distributed load of 120 KN/m. Load placement is the same as shown in load model 71, cf. Bruer/Prosjektering og bygging/Laster

In the case of very heavy traffic, reference is made to Bruer/Prosjektering og bygging/Laster

For calculation and design of

- abutments
- retaining walls, permanent and provisional track support
- culverts and larger pipe crossings

reference is made to Bruer/Prosjektering og bygging/Laster.

4.2 Snow loads

Snow loads may be found in NS-EN 1991-1-3 Euro code 1: Structural loads, Part 3: Snow loads.

5 Geotechnical conditions

5.1 General

[NS-EN 1997-1 Eurokode 7: Geotechnical prosjektering] applies.

Substructure structures that require special foundations must be based on the requirements of /Bruer/Prosjektering_og_bygging/Fundamentering.

5.2 Surveys

Geological and geotechnical surveys must form part of the early stage of planning. The type and scope of the survey is dependent on, for example,

- the stage of the planning process (plan review – main plan – detail plan – construction plan)
- problem type (stability – settlement – support – flow)

- soil condition/soil type (clay – silt – sand – peat – moraine)
- adjacent conditions (distance)

The objective of the surveys is to ascertain the necessary geotechnical parameters for the calculation of stability, earth pressure, load-bearing capacity and deformations (settlement). The surveys will usually involve determining the depths to solid ground, extraction of undisturbed samples for laboratory processing, in-situ determination of relative and actual rigidity, and pore pressure and groundwater measurements.

The normal method for conducting geotechnical surveys is outlined in Tabell 1.

Tabell 1: Normal method for conducting geotechnical surveys

	Type of survey	Description
1	Definition of assignment	Loads, construction plans
2	Procurement of existing information	Maps, aerial photos, any previous surveys
3	Inspection	Topography, geology, adjacent terrain
4	Problem formulation and plan	Feasibility studies in the field and laboratory
5	Field work/drillings	Exploratory/for orientation purposes, sample-procuring, specialised
6	Laboratory testing	On extracted samples
7	Reporting	Preparation and presentation of data, calculations and evaluations, observations, conclusions
8	Possible further assistance	Additional surveys, revised plans, checks

6 Basic infrastructure on NNRA land

When crossing basic infrastructure (including water and sewage systems, culverts, high voltage cables, etc.) that does not form part of the railway's drainage system and pipe crossings, the following points must be considered:

1. The choice of route for pipelines across NNRA land (and underneath railway lines) must be approved by the NNRA.

2. At the point where it crosses the line, the upper side of the pipe must be sited:

- beneath the lineside ditch and at least 2.20 m under the upper edge of the lowest rail.

- under electrical cables, where applicable, with a minimum distance of 0.9 m to the cables.

the sheathing pipe must extend at least 3 metres beyond the base of the ballast bed and at least 5 metres from the nearest centre of track point.

Water and sewage pipes must be sited in a frost-free location.

In special conditions, an assessment may be made as to whether the 2.2 m requirement can be reduced if the other requirements (frost- free, beneath the lineside ditch and a distance of at least 0.9 m to electric cables) have been met.

7 Landfills

The specific landfills for excavation residue from tunnels, cuttings, etc. must be defined in the plans. Any restrictions regarding the use of landfills, geotechnical restrictions, etc. must be clarified.

8 Driving on the formation level

In order to prevent the reinforcing layer becoming degraded with materials containing fines, works traffic should not be driven on the formation level during the construction phase. Works traffic must, as far as possible, use the dedicated temporary site roads.

If, however, works traffic does drive along the formation level, a top layer of fines must be removed before ballast is distributed. The formation level must be permeable enough to prevent water from forming puddles following precipitation.

The formation level may, where applicable, be built up to a level 20–30 cm below the intended level before being built up to the proper level towards the end of the construction phase.

9 Construction during periods of frost and snow

Distributed substructure materials must not contain snow or ice. Following snowfall, snow that has accumulated on the formation must be removed before the distribution of materials continues.

10 Linking new and existing lines

At the connection points between new and existing lines, as well in the construction of new track adjacent to existing track, special consideration must be given to the following factors:

- replacement of any frost-susceptible materials in the existing track
- inspection of existing frost insulation, draining of peat, etc
- draining of closed formation
- additional settlement of existing track
- stability during the construction phase, use of soil reinforcement with section-by-section soil replacement
- adequate drainage
- risk of uneven elasticity in transition zones

10.1 Requirements for protective earthing

Structures made of conductive material that have been placed within the overhead contact line zone must be protectively earthed and segmented, where applicable, cf. Felles_elektro/Prosjektering_og_bygging/Jording. This applies to all structures made of conductive material.

11 Appendices

Vedlegg a Jordartsklassifisering

Vedlegg b Eksempel på dokumentasjonens innhold

Vedlegg c: Normgivende referanser