A WIRTGEN GROUP COMPANY

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Soil Treatment.

Base Layers with Hydraulic Binders

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1.6 Basic principles of earthworks

1.6.1 Compaction

At the start of compaction, the contractor has to complete a trial field to verify that the compaction requirements will be met.

The maximum bulk thickness (or maximum thickness of the improved layer respectively) must be such that the specified degree of compaction is achieved over the entire layer thickness.

Special conditions for compaction or construction apply to embankment shoulders. This may influence the bulk width of an embankment in case of soil stabilization or stabilization of the pavement.

When placing weather-sensitive construction materials, the bulk surfaces have to be built with a cross slope of no less than 6%.

1.6.2 Compaction requirements on subsoil and subgrade

The subsoil or subgrade of roads and paths has to be compacted so as to meet the following requirements on the minimum 10 percentile for the degree of compaction D_{Pr} or the maximum 10 percentile for the air voids ratio n_a respectively.

Area	Soil groups	D_{Pr} in %	n_a in % by volume
Subgrade to a depth of 1.00 m for embankments Subgrade to a depth of 0.50 m for cuts	GW, GI, GE SW, SI, SE GU, GT, SU, ST	100	–
1.00 m below grade to embankment base	GW, GI, GE SW, SI, SE GU, GT, SU, ST	98	–
Subgrade to embankment base Subgrade to a depth of 0.50 m for cuts	GU*, GT*, SU*, ST* U, T, OU[1], OT[1]	97	12[2]

1) These requirements apply to soils of groups OU and OT only if their suitability and placing conditions have been investigated separately and determined in consultation with the client.

2) If the soils are not improved by means of soil stabilization or qualified soil improvement, a requirement on the maximum 10 percentile for the air voids ratio is recommended as follows:
- 8% by volume when placing water-sensitive mixed-grained or fine-grained soils; and
- 6% by volume when placing rock of variable strength.

This has to be indicated in the specification of works.

1.6.3 Requirements on the subgrade

The subgrade must comply with specifications in terms of correct vertical and horizontal position, evenness and bearing capacity.

Requirements on the correct vertical and horizontal position:

Deviation: ± 3 cm from design level
± 2 cm if the subgrade is to be overlaid with a bound base layer

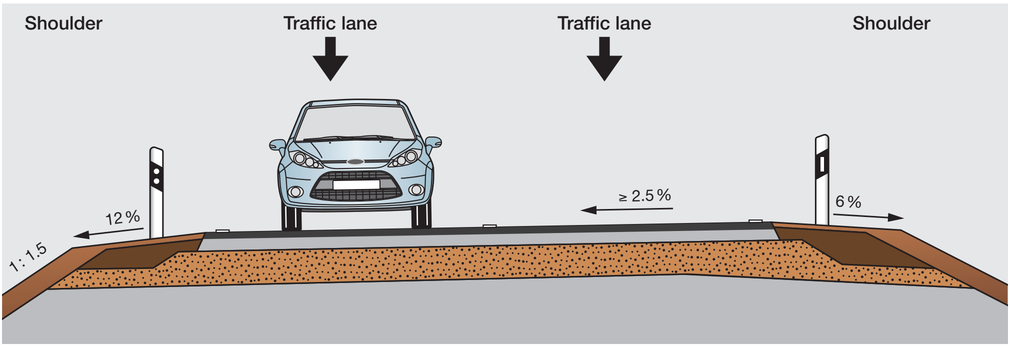
The subgrade must have the following cross slope:

> ≥ 4.0% for water-sensitive soils and construction materials
> ≥ 2.5% after soil treatment with binders

Reducing the cross slope after soil treatment results in huge potential savings in pavement material.

Example: $q_{Pavement}$ = 2.5%
$q_{Subgrade}$ = 4.0%
Width of subgrade = 6.00 m
→ **Savings: approx. 0.30 m^3/m**

At the raised edge of the carriageway, the subgrade has to be designed with a reverse gradient.



When performing soil improvement operations at subgrade level, the edge design of embankment structures may require excess profiling due to the production methods and equipment used.

1.12 Soil treatment – Construction

1.12.1 Mixing procedures

A general distinction is made between two different procedures which can be used to produce a soil-binder mixture.

> **Mixed-in-plant process**

Where the mixed-in-place process cannot be used for technical reasons (due to, for example, existing manholes, gullies, road widenings, structures, trenches etc.) or is uneconomical, soil-binder mixtures produced using the mixed-in-plant process can be placed instead.
In soil treatment operations, it is usually not economically feasible to produce soil-binder mixtures using the mixed-in-plant process.

> **Mixed-in-place process**

The mixed-in-place process is the standard construction method used in soil treatment operations.

The mixer travels on the layer prepared for treatment, working in the previously spread binder and, where appropriate, the required quantity of water.

Variations in the sequence of the individual operational steps are possible depending on the location of the excavation and paving sites.

> **Special process**

Where the paving site does not allow for a mixer to be used (in case of road widenings, refilling of utility trenches or structural backfills, or in areas or locations where binder drifts must be avoided etc.), the binder can be spread and mixed in at the excavation site. The soil-binder mixture is then transported to the paving site, placed and compacted.

1.12.2 Dust-free addition of binder

The “S-Pack” (Spreader-Pack), which can be integrated into the WR 240, WR 240i or WR 250 as an optional feature, is the ideal candidate for the dustless addition of binding agents in cold recycling or soil stabilization. Lime or cement is spread right in front of the milling and mixing rotor in a microprocessor-controlled operation. “S-Pack” is synonymous with the reliable and dustless processing of binders especially on motorways, in industrial estates specifying strict emission requirements, residential areas or nature reserves.

The “S-Pack” spreader is loaded to capacity in less than five minutes. A standard 27-tonne silo transporter is emptied within two hours. The spreading process is controlled and monitored intuitively via the integrated control screen. Paired with the outstanding all-terrain mobility of the WR model range, the “S-Pack” allows binders to be spread reliably and precisely even in those places which are not suitable for the use of heavily loaded, self-propelled binder spreaders.

2.2 Terminology

Depending on the technology, source material and mixing process used, base layers with hydraulic binders are distinguished into:

> **Stabilized layers with hydraulic binders**

Soil stabilization comprises a range of construction processes aiming at increasing the resistance of granular base layers to stresses caused by traffic loading and climate.
The construction material mixture is compacted after completion of the stabilizing operation.
In the process, hydraulic binders and water are added to the soils and/or construction material mixtures using the mixed-in-place or mixed-in-plant process.

- Mixed-in-place process
  The mixer travels on the layer prepared for soil stabilization, scarifying it and mixing in the specified hydraulic binder and required quantity of water.
- Mixed-in-plant process
  The soil or aggregate mixture is mixed with the specified binder and required quantity of water (mixing water) in stationary mixing plants, transported to the construction site and placed.

> **Hydraulically bound base layers**

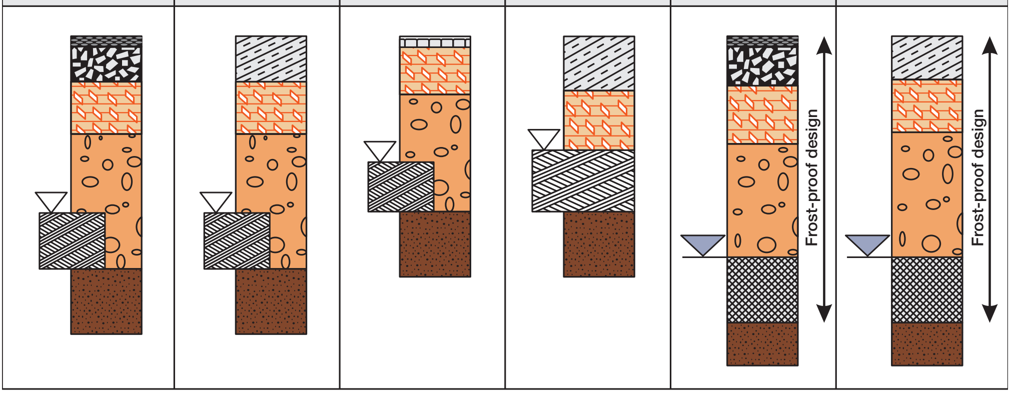
(produced using the mixed-in-plant process only)
Hydraulically bound base layers consist of uncrushed and / or crushed construction material mixtures and hydraulic binders.
Grading of the construction material mixture must be within specified grading ranges. The paving mix must be produced in mixing plants.

> **Concrete base layers**

Concrete base layers are base layers of concrete in accordance with DIN EN 206-1 and DIN 1045-2.

2.3 Base layers with hydraulic binders in accordance with ZTV Beton-StB [1] and soil stabilization in accordance with ZTV E-StB [2]

Position of the base layer with hydraulic binders according to ZTV Beton-StB [1]				**Position of the stabilized layer in the subsoil or subgrade according to ZTV E-StB [2]**	
Asphalt surfacing Asphalt base	Concrete surfacing	Stone paving	Concrete pavement	Asphalt surfacing Asphalt base	Concrete surfacing



Frost-proof material [frost blanket] (paved or native)

Base layers with hydraulic binders

Stabilization of subsoil or subgrade

Subsoil (F2 / F3 soils)

Deformation modulus on subgrade $E_{v2} \geq 45$ MN/mm²

Degree of compaction of stabilized layer $D_{Pr} \geq 98$ %

[1] Additional technical conditions of contract and directives for the construction of base layers with hydraulic binders and concrete pavements
[2] Additional technical conditions of contract and directives for earthworks in road construction

2.6.3 Aggregates and construction material mixtures for concrete base layers

Aggregates as described in section 2.6.2, Aggregates and construction material mixtures for hydraulically bound base layers, the only restriction being that suitable coal fly ash cannot be used as an addition to the aggregates but as an additive only. The grading curves to be complied with are based on the requirements of DIN EN 206-1 and DIN 1045-2.

2.6.4 Hydraulic binders

Cements in accordance with DIN EN 197 or DIN 1164-10 as shown in the table below or hydraulic soil and road binders in accordance with DIN 18506 (strength classes 12.5 and 32.5) are used as binders.

Main types of cement	Designation of cement types	Main constituents		
CEM I	Portland cement			
CEM II	Portland blast-furnace slag cement	A/B	S	Granulated blast-furnace slag
	Portland silica fume cement	A	D	Silica fume
	Portland pozzolanic cement	A/B	P/Q	Pozzolans
	Portland fly ash cement	A	V	Fly ash
	Portland burnt shale cement	A/B	T	Shale
	Portland limestone cement	A	LL	Limestone
CEM II-M	Portland composite cement	A		S-D, S-T, S-LL
				S-P, S-V
				D-T, D-LL, D-P
				D-V
				T-LL
				P-V, P-T, P-LL
				V-T, V-LL
		B		S-D, S-T, S-P
				D-T, D-P
				P-T
CEM III	Blast-furnace slag cement	A		S
		B		S
CEM IV	Pozzolanic cement	B		P[1]
CEM V	Composite cement	A		S-P[2]
		B		

[1] Applies only to trass according to DIN 51043 as the main constituent of up to max. 40% by mass
[2] Applies only to trass according to DIN 51043 as the main constituent