EXPERIENCES IN TUNNEL SURFACE CONSTRUCTION BASED ON PROJECTS IN AUSTRIA AND GERMANY (AND ITALY…)

MAY 2022

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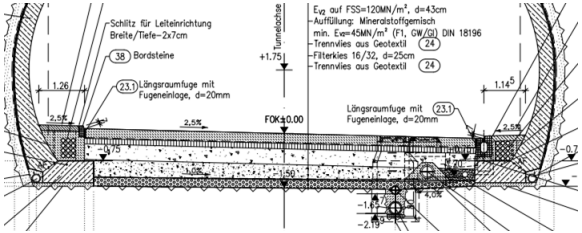
TEAMS WORK.

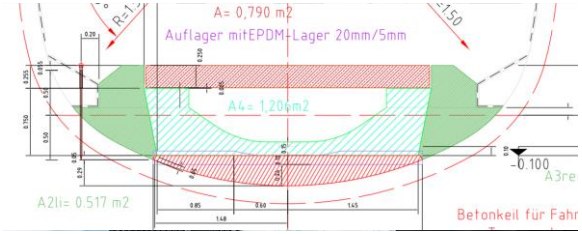
1 GENERAL



2 DESIGN (GERMANY)

3 EXECUTION WORKS

4 SPECIAL DETAIL



5 SPECIAL TASK

6 CONCLUSION

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1 GENERAL

GENERAL

REQUIREMENTS ON MODERN SUPERHIGHWAYS

- high capacity,
- high durability,
- low maintenance expenses
- long life-span

►Concrete pavements meet these demands

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GENERAL

CHARACTERISTICS OF MODERN CONCRETE PAVEMENTS

- High load capacity
- Resistant to deformations at any load and any temperature
- Very good evenness during the entire life-span
- No lane grooves (Aquaplaning)
- Good water conducting performance
- Long-lasting skid resistance & low noise emission
- Reduction of lighting costs in tunnels
- Reduction of fire load in tunnels
- High availability, few job sites, few traffic jams
- Life expectancy of at least 30 years
- During life-span only low maintenance und repair action needed

► **Megatrend: Sustainability**

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2
DESIGN

DESIGN (GERMANY)

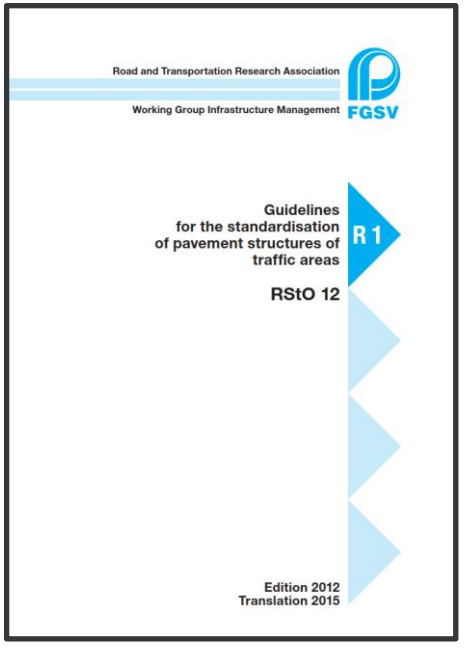
RSTO 12

- Guidelines for pavements structures
- Standardization of layer order and thickness

Plate 2: Structures with concrete surface course for carriageways on F2- and F3-subsoil/subgrade

(Thicknesses in cm; E_{v2} minimum values in MPa)

Line	Load class	BK100				BK32				BK10				BK3.2				BK1.8				BK1.0				BK0.3			
	B [million of ESALs]	> 32				> 10 – 32				> 3.2 – 10				> 1.8 – 3.2				> 1.0 – 1.8				> 0.3 – 1.0				≤ 0.3			
	Thickness of frost resistant pavement structure [1]	55	65	75	85	55	65	75	85	55	65	75	85	45	55	65	75	45	55	65	75	45	55	65	75	35	45	55	65
	Base course with hydraulic binders on frost blanket course or layer of non-frost-susceptible material																												
1.1	Concrete surface course Non-woven fabric[8] Hydraulically bound base course (HBB) Frost blanket course	▼120 ▼45			27 15 Σ42	▼120 ▼45			26 15 Σ41	▼120 ▼45			25 15 Σ40	▼120 ▼45			24 15 Σ39	▼120 ▼45			23 15 Σ38								
	Thickness of frost blanket course	–	–	33[3]	43	–	24[3]	34	44	–	25[3]	35	45	–	–	26[3]	36	–	–	27[3]	37								
1.2	Concrete surface course Non-woven fabric[8] Stabilized granular material layer of non-frost-susceptible material – widely or gap-graded in line with DIN 18196- Frost blanket course	▼45			27 20 Σ47	▼45			26 15 Σ41	▼45			25 15 Σ40	▼45			24 15 Σ39	▼45			23 15 Σ38								
	Thickness of layer of non-frost-susceptible material	8[4]	18[4]	28	38	14[4]	24	34	44	15[4]	25	35	45	6[4]	16	26	36	–	–	27[3]	37								
1.3	Concrete surface course Non-woven fabric [8] Stabilized granular material Layer of non-frost-susceptible material – narrowly graded in line with DIN 18196- Frost blanket course	▼45			27 25 Σ52	▼45			26 20 Σ46	▼45			25 20 Σ45	▼45			24 20 Σ44	▼45			23 20 Σ43	▼45			20 15 Σ35	▼45			20 15 Σ35
	Thickness of layer of non-frost-susceptible material	3[4]	13[4]	23	33	9[4]	19	29	39	10[4]	20	30	40	1[4]	11[4]	21	31	2[4]	12[4]	22	32	10[4]	20	30	40	–	10[4]	20	30
2	**Asphalt base course on frost blanket course** Concrete surface course Asphalt base course Frost blanket course	▼120 ▼45			26 10 Σ36	▼120 ▼45			25 10 Σ35	▼120 ▼45			24 10 Σ34	▼120 ▼45			23 10 Σ33	▼120 ▼45			22 8 Σ30								
	Thickness of frost blanket course	–	29[3]	39	49	–	30[3]	40	50	–	31[3]	41	51	–	–	32[3]	42	–	25[3]	35	45								
3.1	**Crushed rock base course on layer of non-frost-susceptible material** Concrete surface course Crushed rock base course Layer of non-frost-susceptible material	▼150 ▼45			29 30[10] Σ59	▼150 ▼45			28 30[10] Σ58	▼150 ▼45			27 30[10] Σ57	▼150 ▼45			26 30[10] Σ56	▼150 ▼45			24 30[10] Σ54								
	Thickness of layer of non-frost-susceptible material	Above 12 cm made of non-frost-susceptible material, lower remaining thickness is to be compensated by the material above																											
3.2	**Crushed rock base course on frost blanket course** Concrete surface course Crushed rock base course Frost blanket course	▼150 ▼120 ▼45			29 20 Σ49	▼150 ▼120 ▼45			28 20 Σ48	▼150 ▼120 ▼45			27 20 Σ47	▼150 ▼120 ▼45			26 20 Σ46	▼150 ▼120 ▼45			24 20 Σ44								
	Thickness of frost blanket course	–	–	26[1]	36	–	–	27[1]	37	–	–	28[1]	38	–	–	19[1]	29	–	–	21[1]	31								
4	**Frost blanket course** Concrete surface course Frost blanket course																					▼120 ▼45			21 Σ21	▼100 ▼45			21 Σ21
	Thickness of frost blanket course																					24[3]	34	44	54	14[3]	24	34	44



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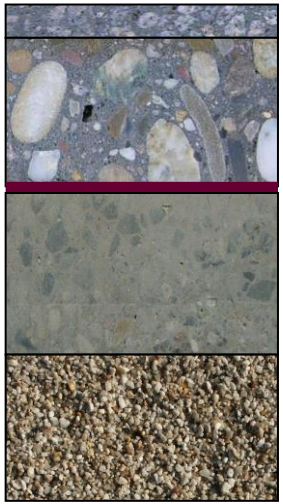
TEAMS WORK.

DESIGN (GERMANY)

RSTO 12

Plate 2: Structures with concrete surface course for ca

Line	Load class	BK100				BK32			
	B [million of ESALs]	> 32				> 10 – 32			
	Thickness of frost resistant pavement structure [1]	55	65	75	85	55	65	75	85
	Base course with hydraulic binders on frost blanket cou layer of non-frost-susceptible material								
1.1	Concrete surface course / Non-woven fabric[8] / Hydraulically bound base course (HBB) / Frost blanket course	27 / 15 / Σ42 / 120 / 45				26 / 15 / Σ41 / 120 / 45			
	Thickness of frost blanket course	–	–	33[2]	43	–	24[3]	34	44
	Asphalt base course on frost blanket course								
2	Concrete surface course / Asphalt base course / Frost blanket course	26 / 10 / Σ36 / 120 / 45				25 / 10 / Σ35 / 120 / 45			
	Thickness of frost blanket course	–	29[3]	39	49	–	30[2]	40	50



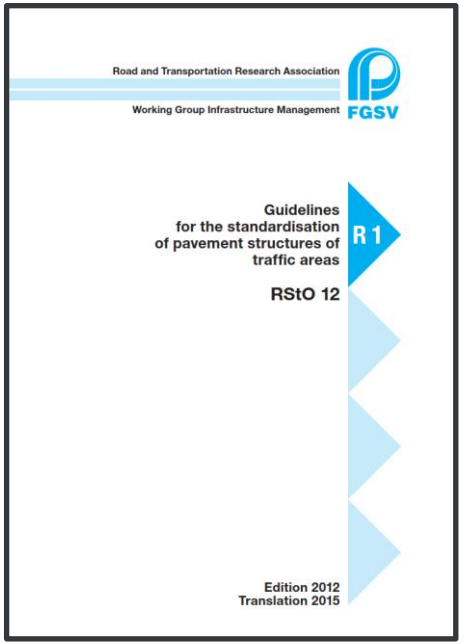
Upper layer 5 cm

Lower layer 17 … 24 cm

Geotextile

Bound or unbound Base course

De-icing layer / Unbound base course



- No specific rules for pavements in tunnels!

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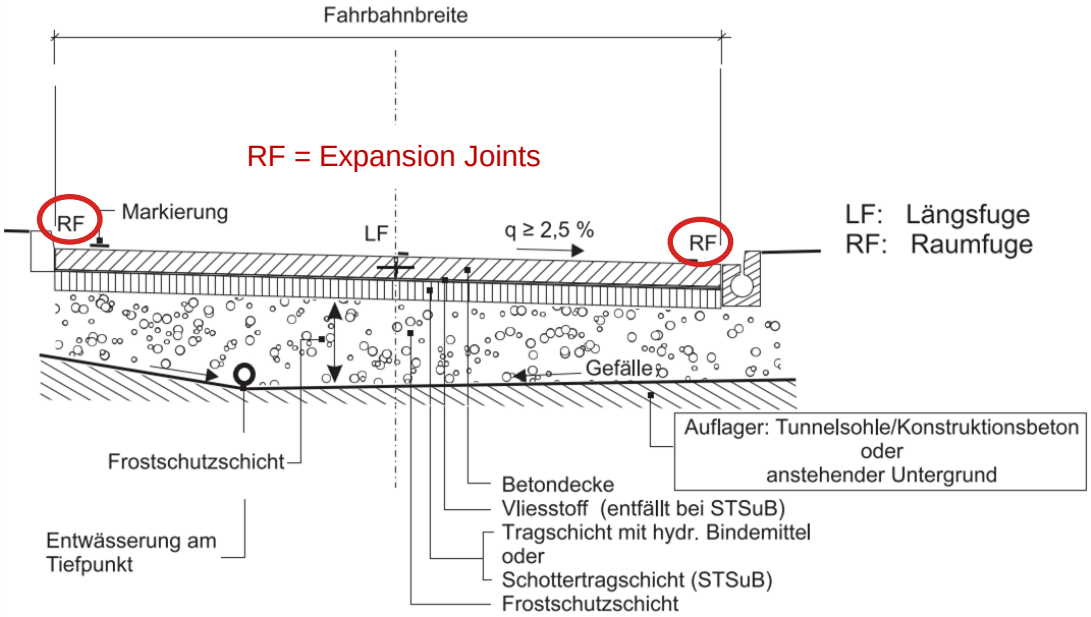
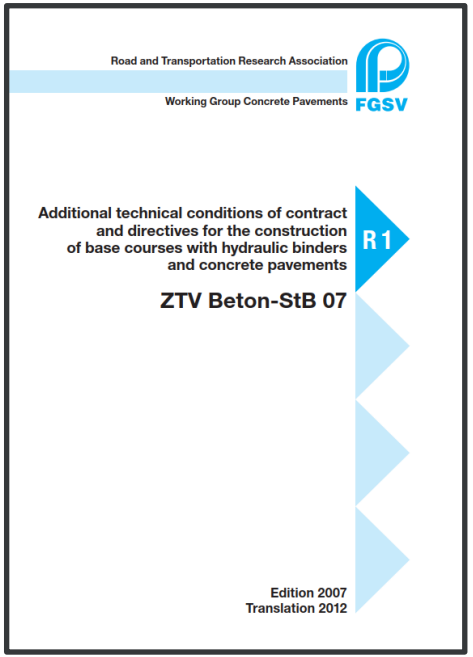
DESIGN (GERMANY)

ZTV BETON-STB

- Technical conditions of contract





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DESIGN (GERMANY)

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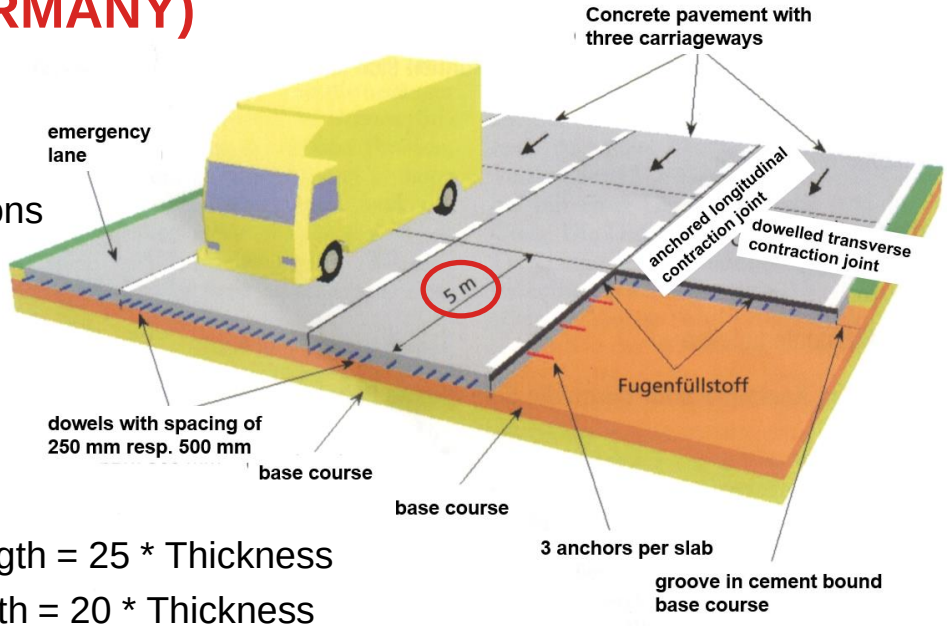

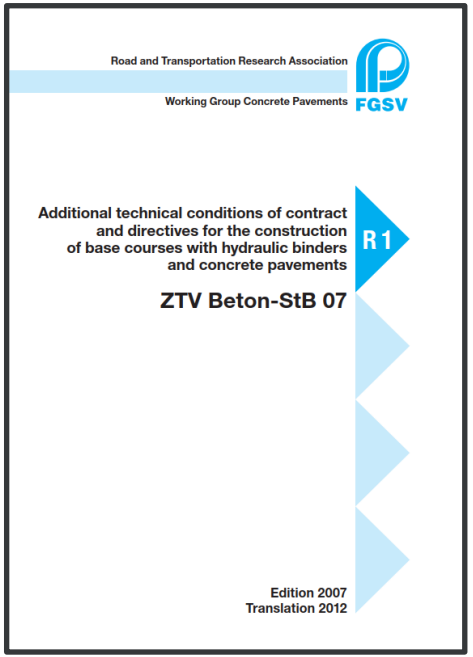

- Slab Dimensions:

  General: max Length = 25 * Thickness

  Tunnel: max Length = 20 * Thickness

Reason:

- More air movement in tunnel and therefore more evaporation in the upper layer
- Prevention of curving / bowing in the slab due to increased shrinkage

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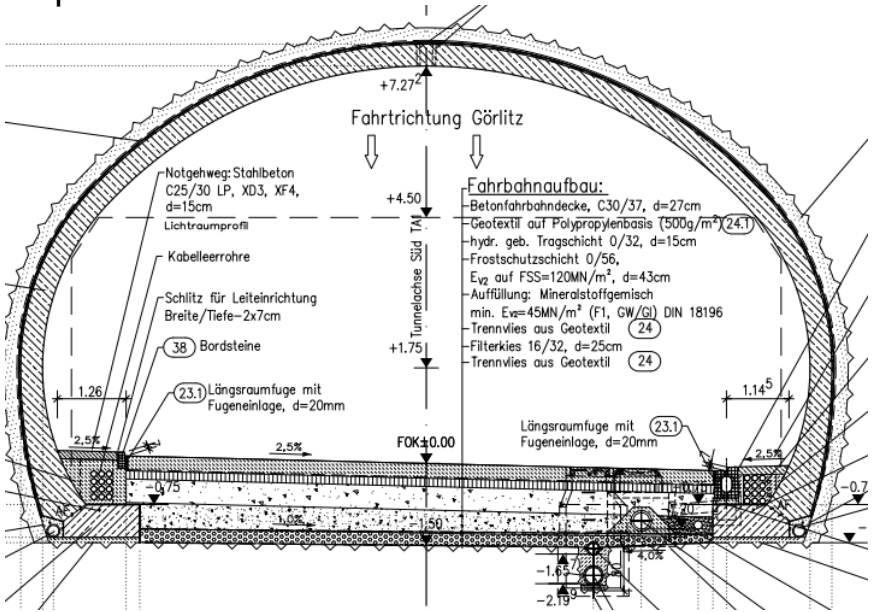
TEAMS WORK.

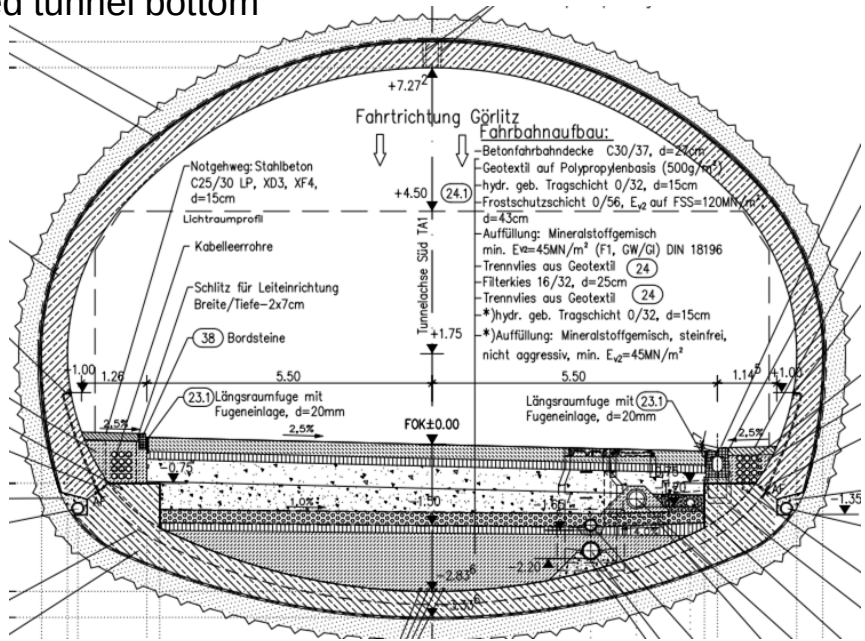
DESIGN (GERMANY)

PROJECT TUNNEL DESIGN (EXAMPLE: A4 TUNNEL JAGDBERG, GERMANY)

- open tunnel bottom



- closed tunnel bottom



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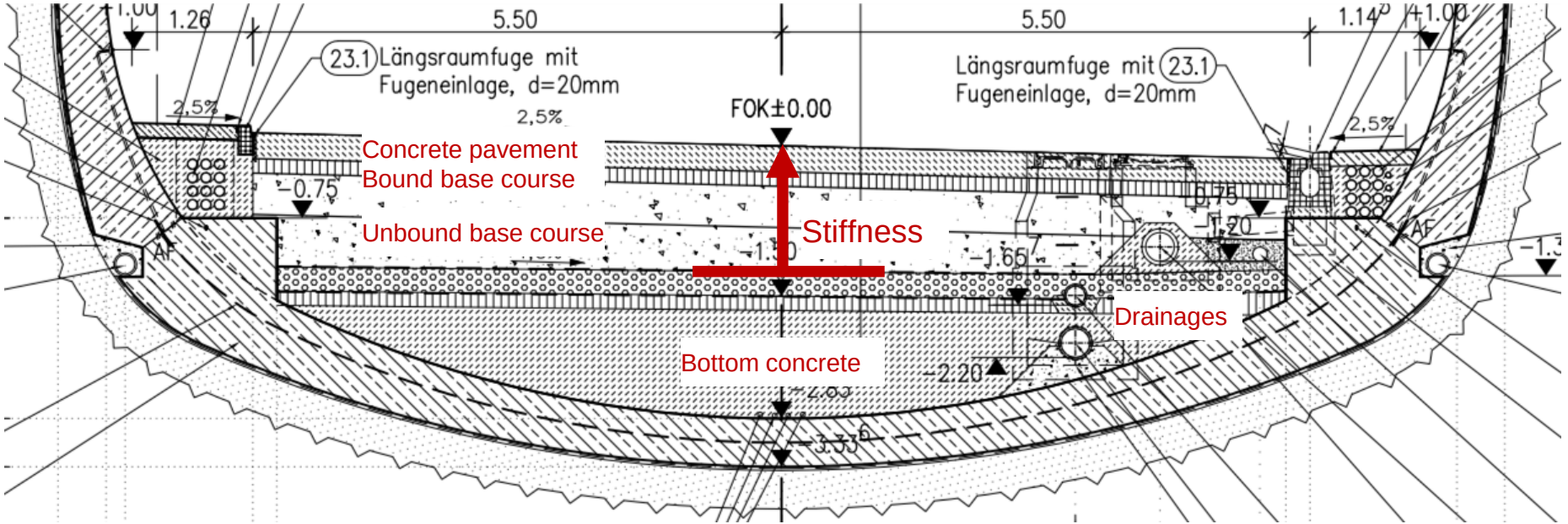
DESIGN (GERMANY)

PROJECT TUNNEL DESIGN



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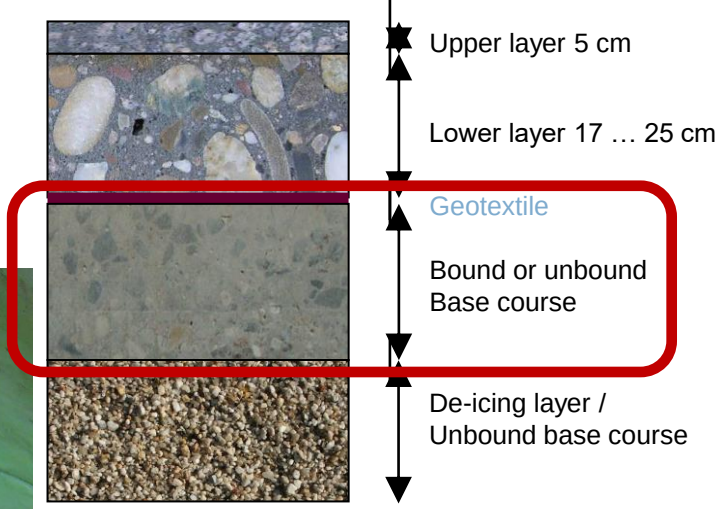
3
EXECUTION WORKS

EXECUTION WORKS

UNBOUND BASE COURSE

SS77 Val di Chienti (Italia), 2012



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TEAMS WORK.

EXECUTION WORKS

UNBOUND BASE COURSE

SS77 Val di Chienti (Italia), 2012

STRABAG
TEAMS WORK.

EXECUTION WORKS

UNBOUND BASE COURSE

SS77 Val di Chienti (Italia), 2012

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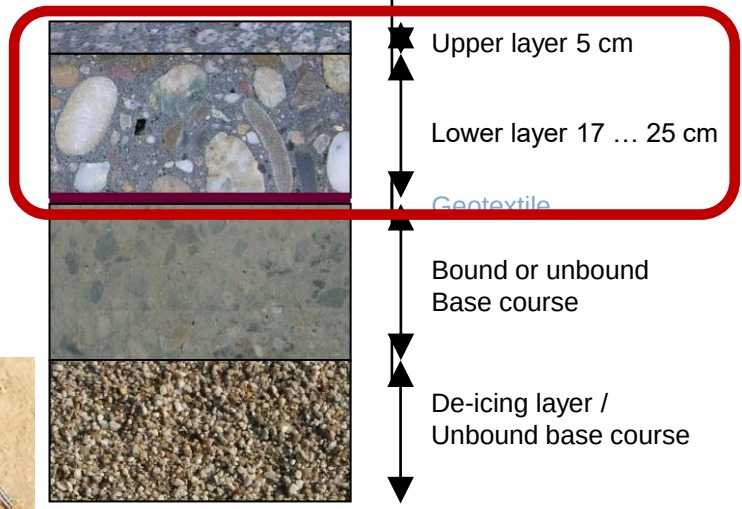
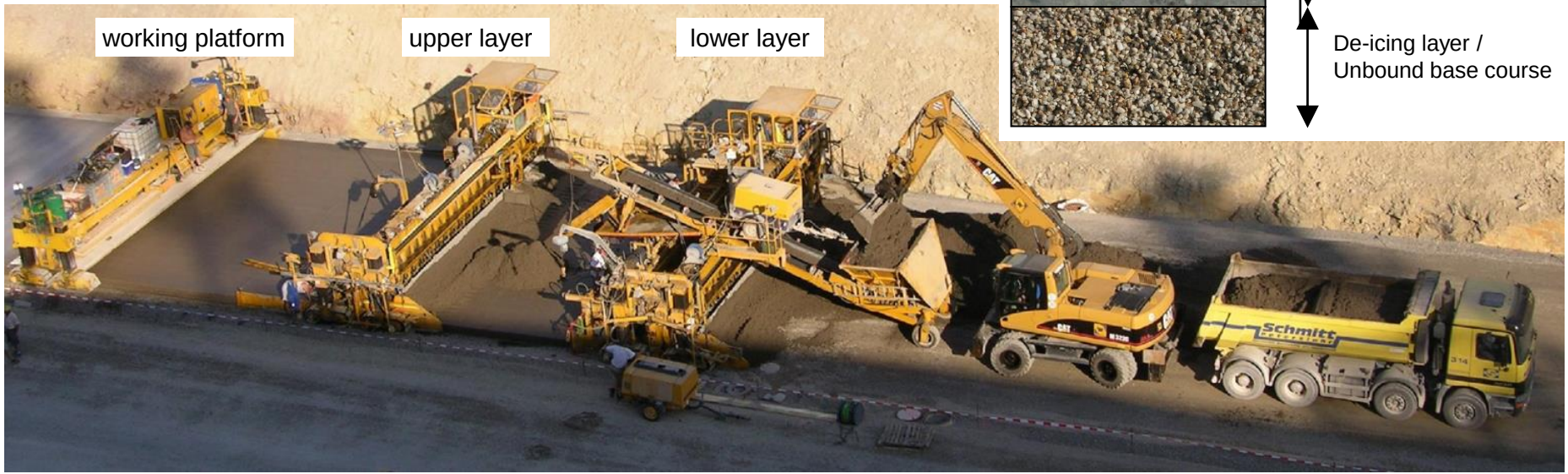
TEAMS WORK.

EXECUTION WORKS

PAVING TRAIN FOR TWO-LAYER CONCRETE PAVEMENT





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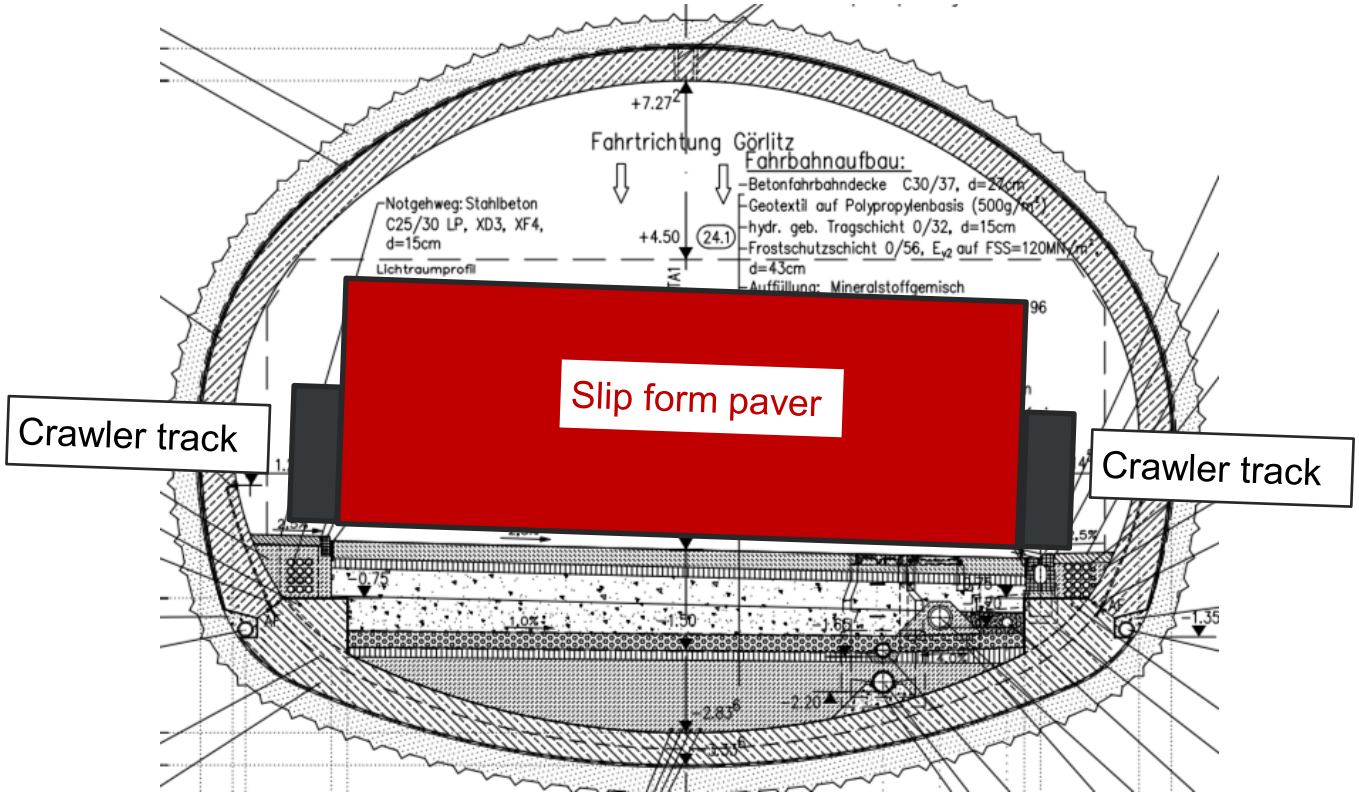
EXECUTION WORKS

TUNNEL CLEARANCE



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TEAMS WORK.

EXECUTION WORKS

LOWER LAYER CONCRETE

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TEAMS WORK.

EXECUTION WORKS

UPPER LAYER
CONCRETE

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EXECUTION WORKS

CONCRETE SURFACE

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TEAMS WORK.

EXECUTION WORKS

FINISHED
CONCRETE SURFACE

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TEAMS WORK.

EXECUTION WORKS

TUNNEL CLEARANCE

A10 Tunnel Katschberg (Austria), 2008

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TEAMS WORK.

EXECUTION WORKS

TUNNEL CLEARANCE

A10 Tunnel Katschberg (Austria), 2008

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4
SPECIAL DETAIL

SPECIAL DETAIL

MANHOLE: 2 OPTIONS

A70 Tunnel Schwarzer Berg (Germany), 2005

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TEAMS WORK.

SPECIAL DETAIL

MANHOLE (OPTION A)

A70 Tunnel Schwarzer Berg (Germany), 2005

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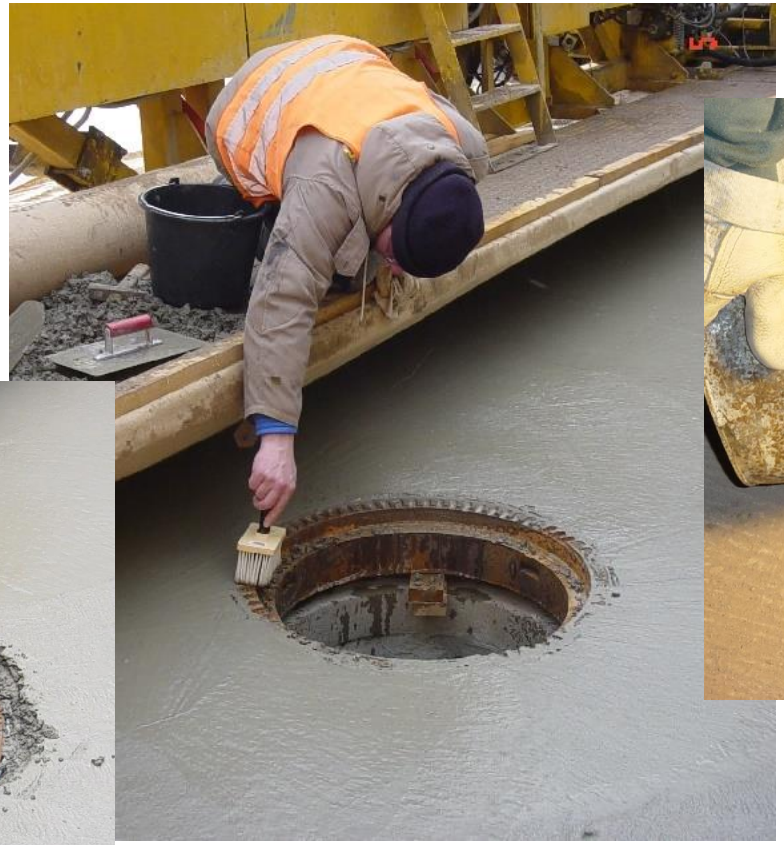
SPECIAL DETAIL

MANHOLE (OPTION A)



A70 Tunnel Schwarzer Berg (Germany), 2005

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SPECIAL DETAIL

MANHOLE (OPTION B)

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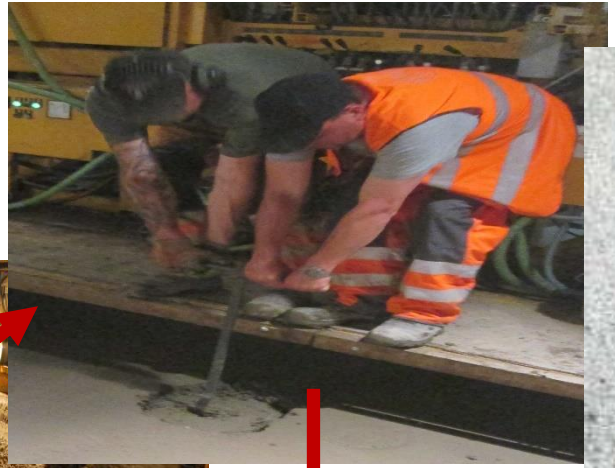
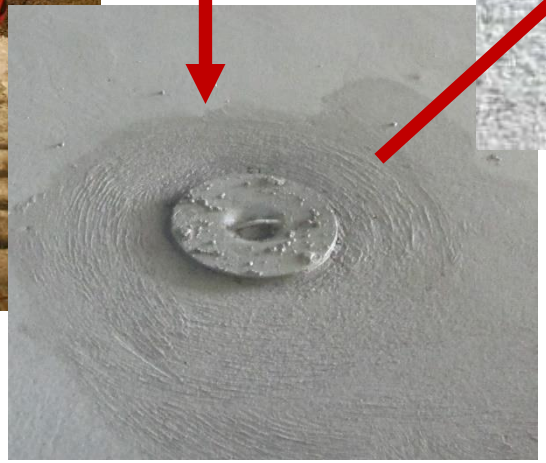
SPECIAL DETAIL

MANHOLE (OPTION B)





A94 Ampfing (Germany), 2011

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SPECIAL DETAIL

MANHOLE (OPTION B)

core drilling device

A94 Ampfing (Germany), 2011

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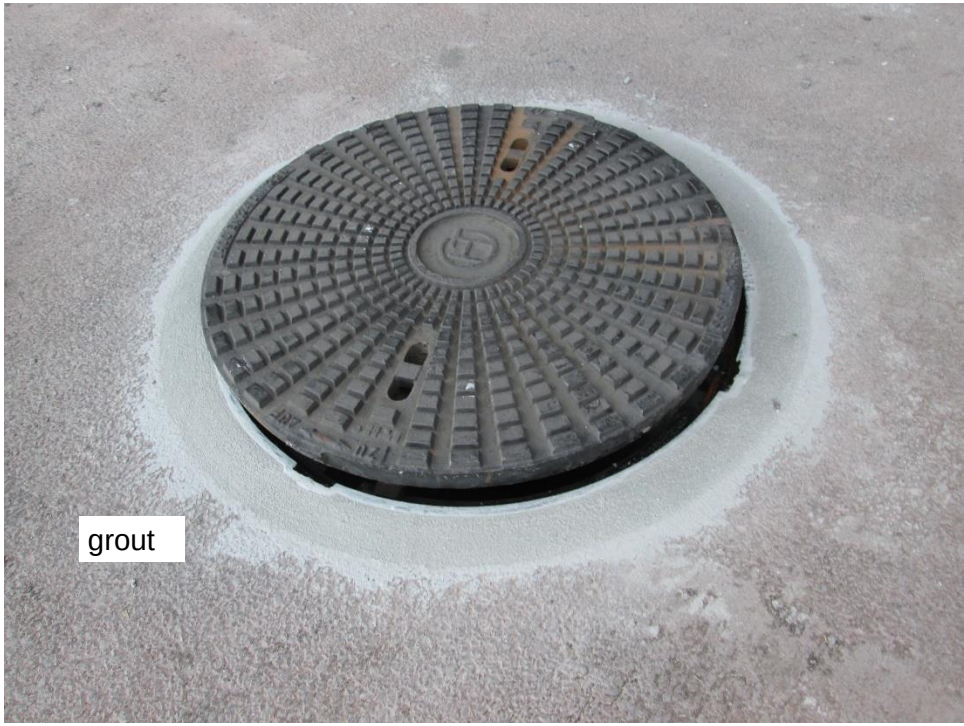
SPECIAL DETAIL

MANHOLE (OPTION B)



A94 Ampfing (Germany), 2011

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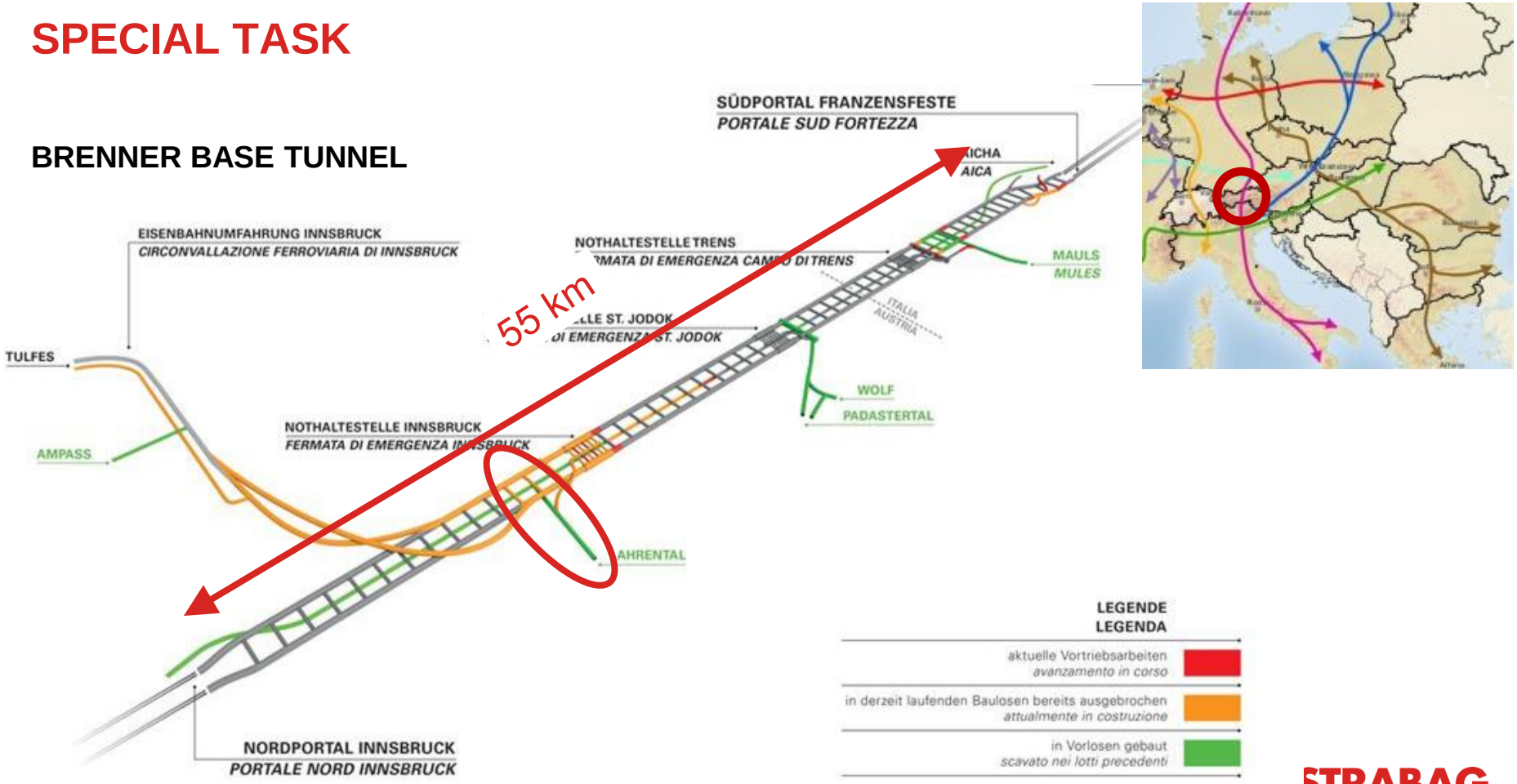
5
SPECIAL TASK

SPECIAL TASK

BRENNER BASE TUNNEL



Brenner Base Tunnel (Austria), 2012

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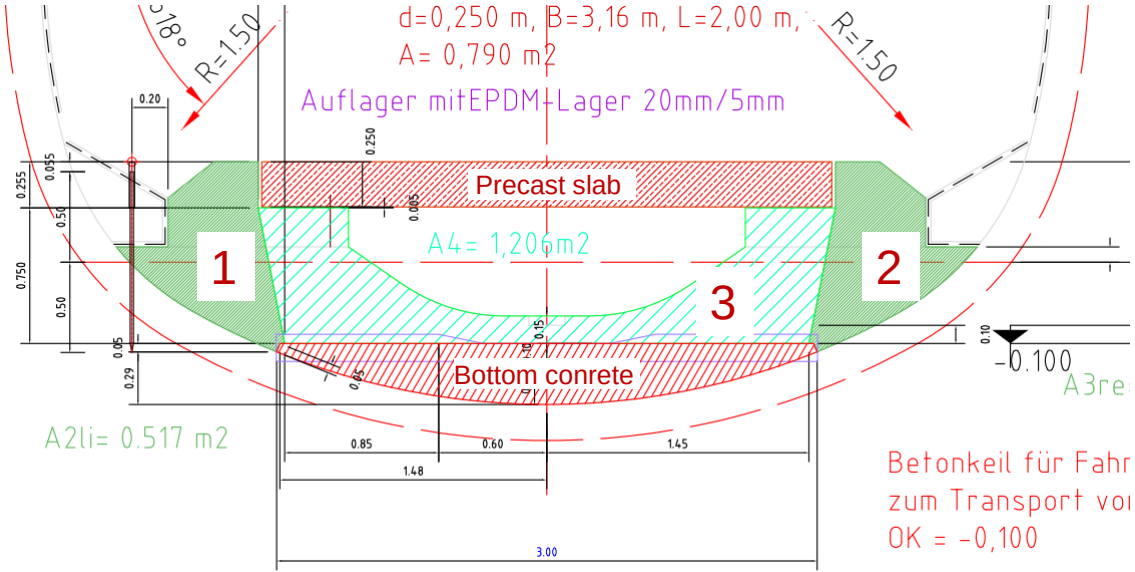
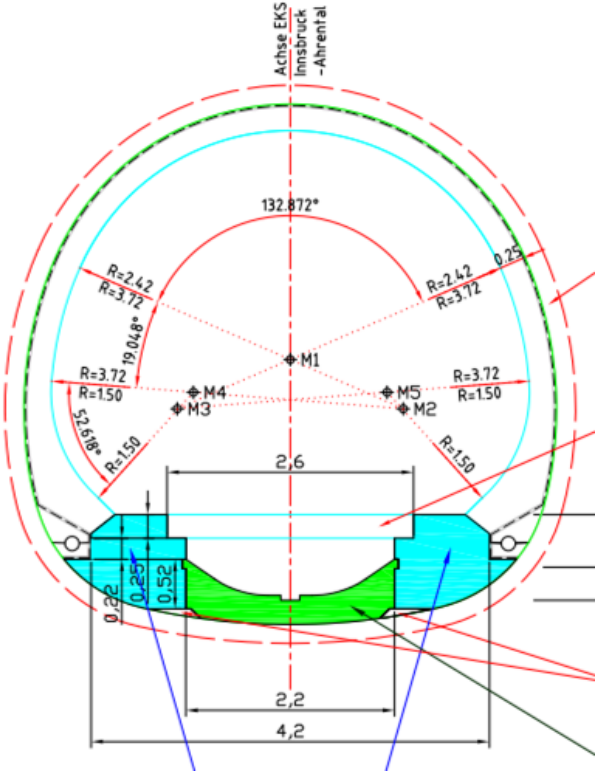
TEAMS WORK.

SPECIAL TASK

GUTTER, EMERGENCY AND EXPLORATORY TUNNEL





Brenner Base Tunnel (Austria), 2012

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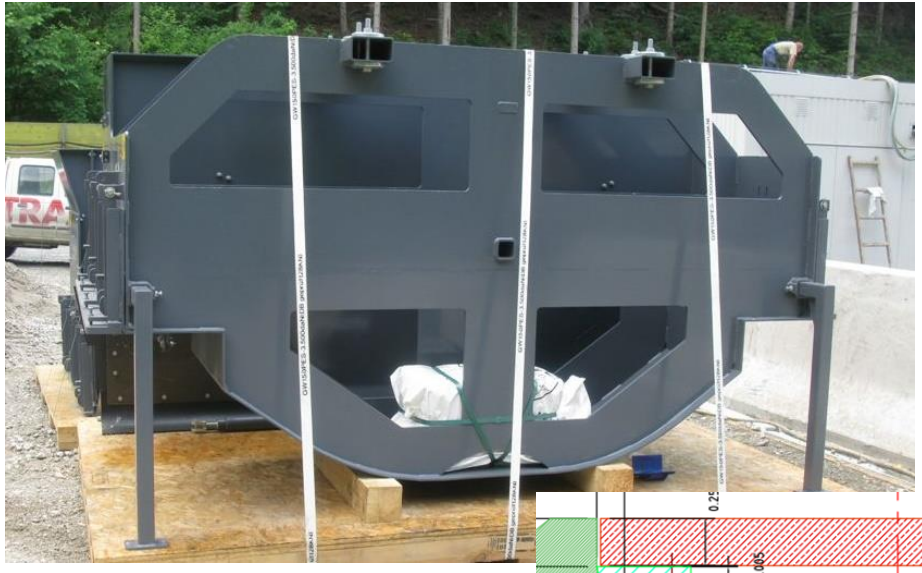
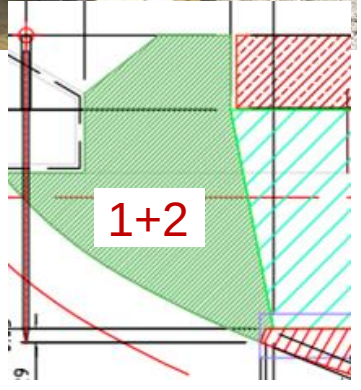
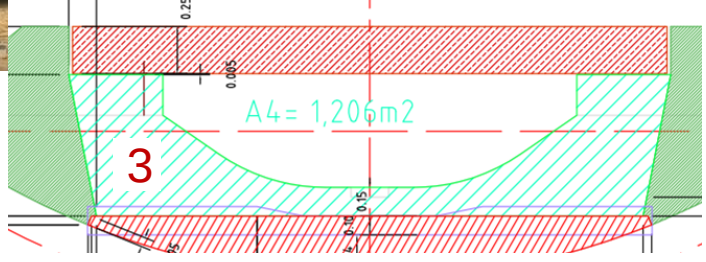
TEAMS WORK.

SPECIAL TASK

GUTTER, EMERGENCY AND EXPLORATORY TUNNEL







Brenner Base Tunnel (Austria), 2012

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SPECIAL TASK

GUTTER, EMERGENCY AND EXPLORATORY TUNNEL

Brenner Base Tunnel (Austria), 2012

STRABAG
TEAMS WORK.

SPECIAL TASK

GUTTER, EMERGENCY AND EXPLORATORY TUNNEL

Brenner Base Tunnel (Austria), 2012

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TEAMS WORK.

6 CONCLUSION

CONCLUSION

CONCRETE PAVEMENTS IN TUNNEL

- Design… is not substantially different from outdoor pavements
- Execution of works… has to be carried out under special conditions
- Special Details… require special types of execution
- Special Tasks… can be performed with slip form technology

STRABAG
TEAMS WORK.