betonTEST.de

Inspection of Concrete Tunnel Linings

According to The German Guideline RI-ZFP-TU —

The German Guideline for Non-Destructive Testing of Tunnel Linings

Samples Taken from Several Projects

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Inhaltsverzeichnis

1 The German Guideline for NDT of Tunnel Linings – RI-ZFP-TU

In 2001 the German federal agency for road construction (BAST) issued the *Guideline for Non-Destructive Testing of Tunnel Linings* in the newsletter of the ministry of transport. It was found that reinforcement bars which were not properly covered by concrete perforated the waterproofing - a defect which is most likely in the zone of the soffit. Another failure caused by abrupt changes of the thickness led to failures of the waterproofing - these failures had been found rather often at the joints of two blocks. In the past these damages caused considerable repair costs already shortly after completion of the inner shells. By means of early detection of areas with unsufficient or unequal thickness of the inner shell defects of the seal should be avoided.

In this document four samples of thickness measurements according to RI-ZFP-TU are presented. These were taken from some projects which Betontest carried out in the last years. First a block close to the portal is shown. Here the wall thickness exceeds in some areas the planned thickness remarkably. The second block presented exhibits to small thickness values over the whole area. The third block shows the correct wall thickness. Finally the fourth block has a void at the joint to the former block.

2 Procedure

2.1 The Measurement Grid

The recommended grid consists of lines with 3,20 m length in the area of the tunnel soffit and four longer lines between three and nine o'clock at the block endings. The distance of the last line to the joint amounts 20 cm. The lines of measurement - so called layers - are distributed along the whole tunnel soffit, the distance between the single lines should not exceed 80 cm. A sketch of the grid is given in figure 1.

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2.2 Representation of Results

The wall thickness determined by ultrasonic experiments are given in section 3 tabularly. The numbering of the lines of the measurements complies with figure 1. The location of the points of measurements relating to one joint is given in column *position* of the tabulars, the location in the direction of the circumference is given in the head line. The zero point is located at twelve o'clock i.e. in the middle of the tunnel soffit. Values dropping below the minimum wall thickness are written in red text color.

In addition the wall thickness in the area of the suffit is given as contour plot. The minimum value allowed is marked with black color in a continuous color map.

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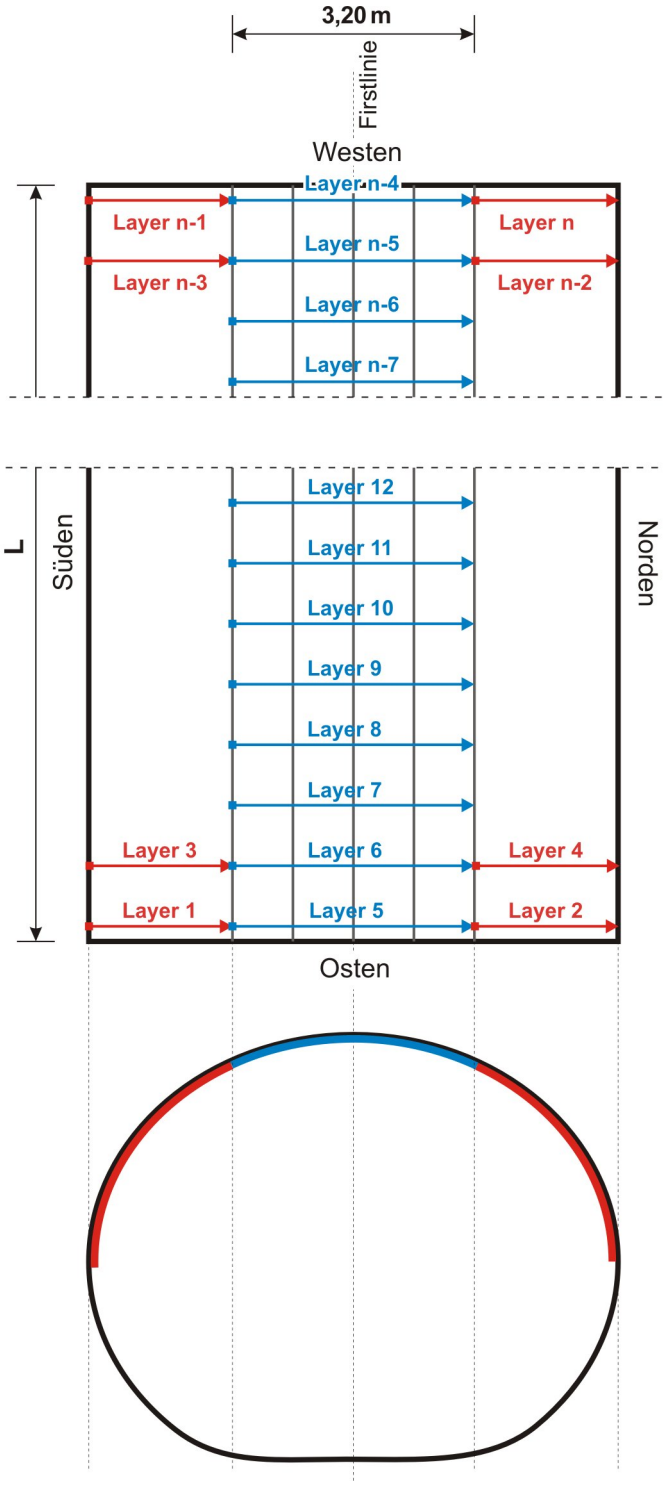

Abbildung 1: Layers – increasing layer numbers in western (Westen) direction

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3 Samples

3.1 Block 1 – Change from 60 cm to 30 cm minimum wall thickness

The minimum wall thickness changes from 60 cm to 30 cm. In the first 50 cm the minimum wall thickness amounts 60 cm. Between L = 0,5 m and L = 3,5 m the minimum wall thickness changes from 60 cm to 30 cm. Behind L = 3,5 m the minimum wall thickness amounts 30 cm. The color scale depends on a minimum wall thickness of 30 cm. Values which are smaller than the minimum wall thickness are printed in red color.

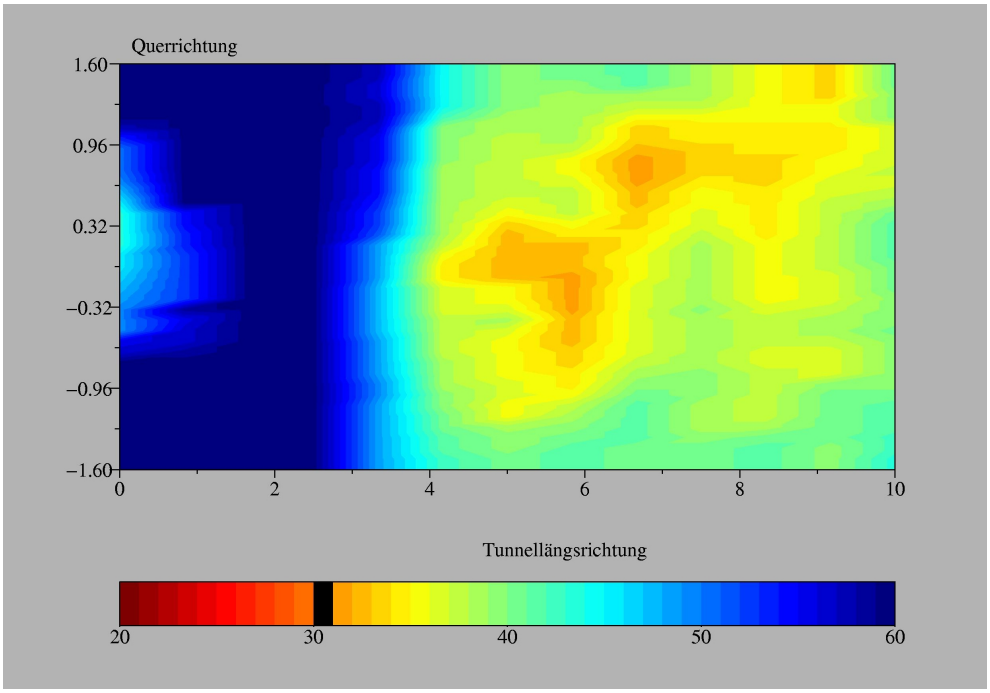

Abbildung 2: Contourplot of Block 1 (axis in meter, wall thickness in cm)

Tabelle 1: Wall thickness at the ends of block 1 (in cm)

layer	position	-4,0 m	-3,2 m	-2,4 m
1	**0,20 m**	72	71	76
3	**1,00 m**	69	69	67
18	**9,00 m**	43	44	43
20	**9,80 m**	41	43	43

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Tabelle 2: Wall thickness at the ends of block 1 (in cm)

layer	position	2,4 m	3,2 m	4,0 m
2	**0,20 m**	75	73	72
4	**1,00 m**	70	72	72
19	**9,00 m**	35	33	38
21	**9,80 m**	40	38	36

Tabelle 3: Wall thickness of the suffit of block 1 (in cm)

layer	position	-1,6 m	-0,8 m	0 m	0,8 m	1,6 m
5	**0,20 m**	76	60	45	51	67
6	**1,00 m**	71	60	53	64	68
7	**1,80 m**	66	68	67	67	72
8	**2,60 m**	62	63	64	69	71
9	**3,40 m**	49	49	49	56	58
10	**4,20 m**	43	38	36	39	44
11	**5,00 m**	41	36	32	37	39
12	**5,80 m**	41	33	32	38	41
13	**6,60 m**	41	37	35	32	42
14	**7,40 m**	41	39	38	33	39
15	**8,20 m**	42	36	36	34	35
16	**9,00 m**	40	36	37	34	33
17	**9,80 m**	44	39	41	36	41

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3.2 Block 2 – minimum wall thickness 40 cm – Failure in the middle of the block

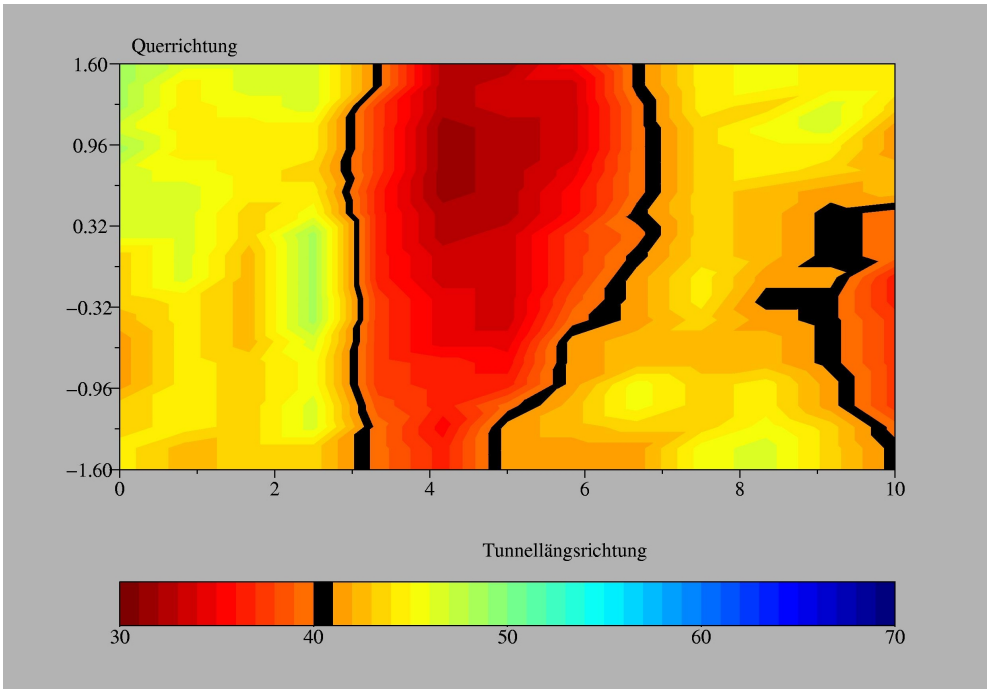

Abbildung 3: Contourplot of Block 2 (axis in meter, wall thickness in cm)

Tabelle 4: Wall thickness at the ends of block 2 (in cm)

layer	position	-6,4 m	-5,6 m	-4,8 m	-4,0 m	-3,2 m	-2,4 m
1	**0,20 m**	42	41	41	41	43	41
3	**1,00 m**	48	47	42	45	42	38
18	**9,00 m**	52	50	49	45	47	43
20	**9,80 m**	52	50	50	46	46	43

Tabelle 5: Wall thickness at the ends of block 2 (in cm)

layer	position	2,4 m	3,2 m	4,0 m	4,8 m	5,6 m	6,4 m
2	**0,20 m**	48	47	42	44	42	45
4	**1,00 m**	51	51	49	45	45	40
19	**9,00 m**	50	51	50	52	52	53
21	**9,80 m**	53	54	55	58	54	51

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Tabelle 6: Wall thickness of the suffit of block 2 (in cm)

layer	position	-1,6 m	-0,8 m	0 m	0,8 m	1,6 m
5	**0,20 m**	44	41	44	48	48
6	**1,00 m**	43	44	47	45	47
7	**1,80 m**	43	43	43	45	47
8	**2,60 m**	43	46	48	44	46
9	**3,40 m**	39	38	36	38	41
10	**4,20 m**	36	36	33	33	33
11	**5,00 m**	41	35	33	33	33
12	**5,80 m**	41	41	37	33	35
13	**6,60 m**	41	42	41	39	40
14	**7,40 m**	45	43	43	44	44
15	**8,20 m**	47	43	42	44	45
16	**9,00 m**	43	40	40	45	45
17	**9,80 m**	40	37	39	41	45

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3.3 Block 3 – minimum wall thickness 35 cm

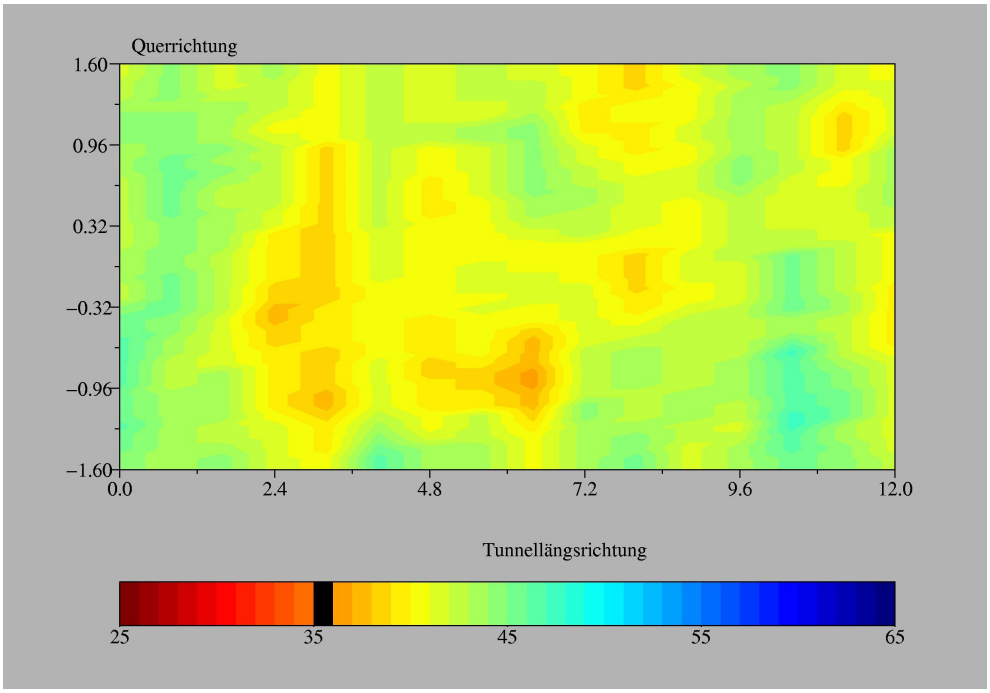

Abbildung 4: Contourplot of Block 3 (axis in meter, wall thickness in cm)

Tabelle 7: Wall thickness at the ends of block 3 (in cm)

layer	position	-8,0 m	-7,2 m	-6,4 m	-5,6 m	-4,8 m	-4,0 m	-3,2 m	-2,4 m
1	**0,20 m**	52	38	40	37	39	35	38	51
3	**1,00 m**	59	44	42	45	47	50	50	50
21	**10,95 m**	45	45	48	52	53	51	48	47
23	**11,75 m**	53	49	49	49	51	48	47	45

Tabelle 8: Wall thickness at the ends of block 3 (in cm)

layer	position	2,4 m	3,2 m	4,0 m	4,8 m	5,6 m	6,4 m	7,2 m	8,0 m
2	**0,20 m**	42	43	37	38	34	37	47	48
4	**1,00 m**	43	41	41	41	35	39	46	53
22	**10,95 m**	44	44	42	43	42	43	42	51
24	**11,75 m**	41	40	40	40	41	40	37	40

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Tabelle 9: Wall thickness of the suffit of block 3 (in cm)

layer	position	-1,6 m	-0,8 m	0 m	0,8 m	1,6 m
5	**0,20 m**	45	47	43	43	42
6	**1,00 m**	43	43	44	45	45
7	**1,35 m**	45	42	43	44	42
8	**2,15 m**	42	39	39	42	43
9	**2,95 m**	40	38	38	39	41
10	**3,75 m**	47	41	41	43	43
11	**4,55 m**	43	39	41	40	42
12	**5,35 m**	43	40	40	42	43
13	**6,15 m**	40	37	40	45	42
14	**6,95 m**	44	42	40	41	40
15	**7,75 m**	45	44	39	40	38
16	**8,55 m**	42	42	41	41	41
17	**9,35 m**	43	43	43	44	43
18	**10,15 m**	46	47	46	43	45
19	**10,95 m**	45	43	43	38	41
20	**11,75 m**	42	41	40	43	41

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3.4 Block 4 – minimum wall thickness 35 cm

This is the adjacent block of block 3. Block 3 is located on the left side of the figure shown here. In the joint area a wall thickness lower then the minimum was detected. The abrupt change of the wall thickness amounts 13 cm.

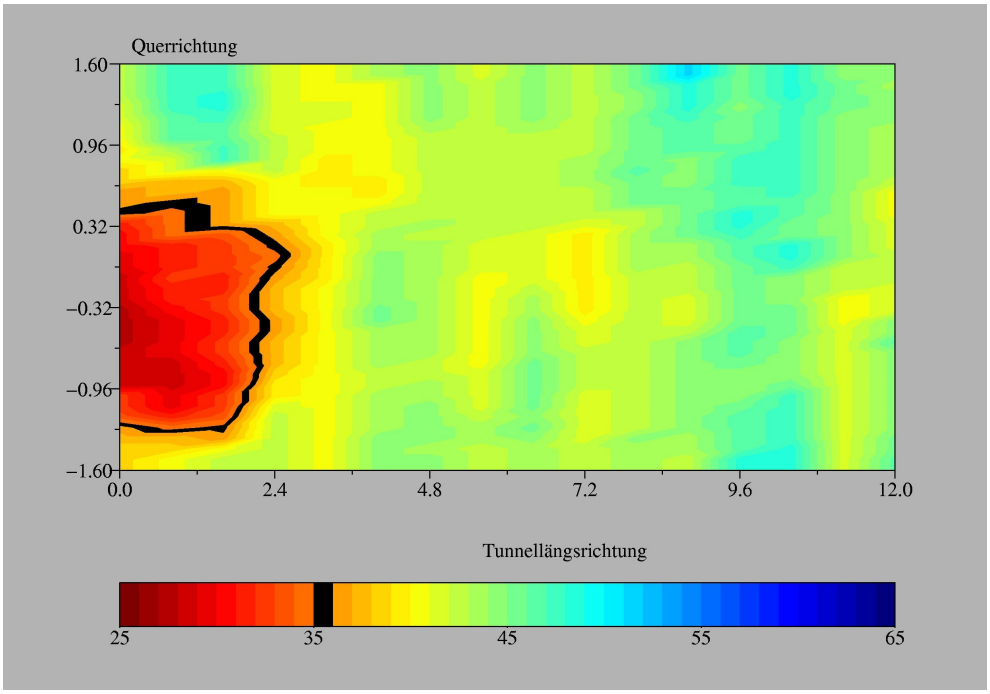

Abbildung 5: Contourplot of Block 4 (axis in meter, wall thickness in cm)

Tabelle 10: Wall thickness at the ends of block 4 (in cm)

layer	position	-8,0 m	-7,2 m	-6,4 m	-5,6 m	-4,8 m	-4,0 m	-3,2 m	-2,4 m
1	**0,20 m**	59	47	51	53	54	48	44	43
3	**1,00 m**	53	54	52	52	57	54	46	44
21	**10,95 m**	53	40	39	42	44	44	45	45
23	**11,75 m**	55	38	37	42	43	45	47	49

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Tabelle 11: Wall thickness at the ends of block 4 (in cm)

layer	position	2,4 m	3,2 m	4,0 m	4,8 m	5,6 m	6,4 m	7,2 m	8,0 m
2	**0,20 m**	40	43	40	41	39	39	38	50
4	**1,00 m**	48	49	53	43	39	40	44	44
22	**10,95 m**	45	45	46	47	43	42	42	52
24	**11,75 m**	46	48	49	50	46	46	48	50

Tabelle 12: Wall thickness at the ends of block 4 (in cm)

layer	position	-1,6 m	-0,8 m	0 m	0,8 m	1,6 m
5	**0,20 m**	38	28	29	39	42
6	**1,00 m**	41	28	32	43	48
7	**1,35 m**	42	31	33	47	48
8	**2,15 m**	42	37	34	42	41
9	**2,95 m**	41	41	39	40	40
10	**3,75 m**	44	44	44	40	44
11	**4,55 m**	45	43	43	42	44
12	**5,35 m**	42	41	41	42	41
13	**6,15 m**	43	46	41	43	44
14	**6,95 m**	42	43	39	43	42
15	**7,75 m**	43	43	43	46	46
16	**8,55 m**	43	45	43	47	51
17	**9,35 m**	48	46	46	47	46
18	**10,15 m**	49	44	49	47	49
19	**10,95 m**	41	41	44	45	45
20	**11,75 m**	46	45	42	43	44

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