Experimentelle und theoretische Untersuchungen der Frischbetoneigenschaften von Selbstverdichtendem Beton

Anhang
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<td>Bild A. 1: Sedimentationszylinder der Eignungsversuche im Versuchsprogramm III und IV (Einfüllseite ist jeweils oben); die lfd. Nr. der Betonrezeptur kann den Tabellen A.1 bis A.22 entnommen werden</td>
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### Bild A. 2: Sedimentationszyylinder der Eignungsversuche im Versuchsprogramm V (Einfüllseite ist jeweils oben): die lfd. Nr. der Betonrezeptur kann den Tabellen A.1 bis A.22 entnommen werden
Füllertyp, Versuchsprogramm: KSM (B), VI

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*) E = Eignungsversuch, Ref. = Referenzmischung, %FM bzw. %St = Fließmittel- bzw. Stabilisierergehalt, weitere Abkürzungen siehe Symbolverzeichnis
Tabelle A.2: Ergebnisse der rheologischen Untersuchungen

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| *) E = Eignungsversuch, Ref. = Referenzmischung, %FM bzw. %St = Fließmittel- bzw. Stabilisierergehalt, weitere Abkürzungen siehe Symbolverzeichnis
## Tabelle A. 3: Ergebnisse der rheologischen Untersuchungen

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### Messwerte

- **Trichterauslaufzeit Lehm**
  - $t_{T,Leim}$ [s]  
- **Setzfließversuch Mörtel**
  - $s_{f,M}$ [mm]  
- **Setzfließversuch Beton, Setzfließmaß**
  - $s_{f,B}$ [mm]  
- **Blockierungsversuch, Fließzeit**
  - $t_{B}$ [s]  
- **Blockierungsversuch, Höhenunterschied**
  - $h_{B}$ [mm]  
- **Frischbetondichte**
  - $\rho_B$ [kg/dm³]  
- **Luftgehalt**
  - $a_B$ [%]  

### Rheometer

- **Herschel-Bulkley**
  - Fließgrenze $\tau_{0,HB}$ [Pa]  
  - Plastische Viskosität $\eta_{pl,HB}$ [Pa.s]  
- **Bingham**
  - Fließgrenze $\tau_{0,B}$ [Pa]  
  - Plastische Viskosität $\eta_{pl}$ [Pa.s]  

### Messpunkte

- **Drehzahl**
  - $n_1$ [1/s]  
  - $n_2$ [1/s]  
  - $n_3$ [1/s]  
  - $n_4$ [1/s]  
- **Drehmoment**
  - $\Gamma_1$ [Nm]  
  - $\Gamma_2$ [Nm]  
  - $\Gamma_3$ [Nm]  
  - $\Gamma_4$ [Nm]  

*) E = Eignungsversuch, Ref. = Referenzmischung, %FM bzw. %St = Fließmittel- bzw. Stabilisierergehalt, weitere Abkürzungen siehe Symbolverzeichnis
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**Messwerte**

| Trichterauslaufzeit Lehm | \( t_{V,\text{Leim}} \) [s] | - | - | - | - | - | 19,0 | 18,0 | 18,0 | 18,0 |
| Trichterauslauf Zement | \( \Delta t \) [mm] | 3,60 | 3,60 | 3,60 | 3,60 | 3,60 | 3,60 | 3,60 | 3,60 | 3,60 |
| Setzfließversuch Beton, Setzfließmaß | \( sf_B \) [mm] | - | - | - | - | - | 380 | 360 | 365 | 380 |
| Trichterauslauf Beton | \( t_{V,B} \) [s] | 9,0 | 6,0 | 6,0 | 8,0 | 6,0 | 12,0 | 15,0 | 15,0 | 15,0 |
| Blockzieglerversuch, Setzfließmaß | \( sf_{B,J} \) [mm] | 680 | 750 | 700 | 710 | 750 | 750 | 570 | 685 | 670 |
| Blockziegler, Fließzeit | \( f_{500,B,J} \) [s] | 7,0 | 5,0 | 5,0 | 7,0 | 6,0 | 3,5 | 7,0 | 4,5 | 7,0 |
| Luftgehalt | \( a_B \) [%] | 2,00 | 1,50 | 1,80 | 1,40 | 1,20 | 2,60 | 4,40 | 4,00 | 2,90 |
| Sedimentation (R = Rheometer, S = statisch) | | | | | | | S, R | | | |
| **Rheometer** | | | | | | | | | | |
| Herschel-Bulkley | | | | | | | | | | |
| Fließmoment | \( \Gamma_{0,HB} \) [Nm] | - | - | - | - | - | - | 1,2578 | 1,392 | - | 2,4877 |
| Parameter | \( A \) [-] | - | - | - | - | - | - | 3,25739 | 3,381 | - | 1,65262 |
| Parameter | \( b \) [-] | - | - | - | - | - | - | 3,17113 | 3,1 | - | 1,74742 |
| Herschel-Bulkley und Bingham | | | | | | | | | | |
| Fließgrenze | \( \tau_{0,HB} \) [Pa] | - | - | - | - | - | - | 349 | 386 | - | 135 |
| Plastische Viskosität | \( \eta_{pl,HB} \) [Pa.s] | - | - | - | - | - | - | 138 | 165 | - | 59 |
| **Bingham** | | | | | | | | | | |
| Fließgrenze | \( \tau_{0,B} \) [Pa] | - | - | - | - | - | - | 249 | 386 | - | 44 |
| Plastische Viskosität | \( \eta_{pl,B} \) [Pa.s] | - | - | - | - | - | - | 168 | 165 | - | 46 |

**Messpunkte**

| Drehzahl | \( n_1 \) [1/s] | - | - | - | - | - | 0,806 | 0,795 | 0,8 | 0,796 | 0,803 |
| Drehzahl | \( n_2 \) [1/s] | - | - | - | - | - | 0,655 | 0,66 | 0,66 | 0,663 | 0,659 |
| Drehzahl | \( n_3 \) [1/s] | - | - | - | - | - | 0,52 | 0,538 | 0,532 | 0,511 | 0,516 |
| Drehzahl | \( n_4 \) [1/s] | - | - | - | - | - | 0,378 | 0,386 | 0,386 | 0,378 | 0,377 |
| Drehzahl | \( n_5 \) [1/s] | - | - | - | - | - | 0,24 | 0,233 | 0,27 | 0,239 | 0,228 |
| Drehzahl | \( n_6 \) [1/s] | - | - | - | - | - | 0,13 | 0,135 | 0,116 | 0,085 | 0,136 |
| Drehmoment | \( \tau_{0,1} \) [Nm] | - | - | - | - | - | 3,366 | 3,687 | 4,097 | 3,986 | 4,169 |
| Drehmoment | \( \tau_{0,2} \) [Nm] | - | - | - | - | - | 2,398 | 3,124 | 3,604 | 2,584 | 1,296 |
| Drehmoment | \( \tau_{0,3} \) [Nm] | - | - | - | - | - | 2,658 | 2,676 | 3,208 | 2,244 | 1,004 |
| Drehmoment | \( \tau_{0,4} \) [Nm] | - | - | - | - | - | 2,268 | 2,245 | 2,722 | 1,909 | 0,793 |
| Drehmoment | \( \tau_{0,5} \) [Nm] | - | - | - | - | - | 2,104 | 1,72 | 2,282 | 1,694 | 0,613 |
| Drehmoment | \( \tau_{0,6} \) [Nm] | - | - | - | - | - | 2,176 | 1,315 | 1,945 | 1,341 | 0,309 |

*) E = Eignungsversuch, Ref. = Referenzmischung, %FM bzw. %St = Fließmittel- bzw. Stabilisierergehalt, weitere Abkürzungen siehe Symbolverzeichnis
## Tabelle A.5: Ergebnisse der rheologischen Untersuchungen

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<td>KSM (A)</td>
<td>KSM (A)</td>
<td>KSM (A)</td>
<td>KSM (A)</td>
</tr>
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</table>

### Messwerte

| Trichterauslaufzeit Leim | \( t_{V,Leim} \) [s] | 18,0 | 18,0 | 27,0 | 23,5 | 19,0 | 19,5 | 19,1 | 18,8 | 18,0 |
| Trichterauslaufzeit Mörtel | \( t_{V,M} \) [s] | 4,5 | 3,5 | 7,5 | 6,0 | 5,5 | 5,5 | 4,5 | 7,0 | 5,0 |
| Setzfließversuch Mörtel | \( sf_M \) [mm] | 375 | 385 | 325 | 345 | 355 | 335 | 325 | 325 | 325 |
| Fließzeit | \( t_{500,J} \) [s] | 11,5 | 6,0 | 7,0 | 7,0 | 7,0 | 7,0 | 7,0 | 7,0 | 7,0 |
| Fließgrenze | \( \tau_{0,HB} \) [Pa] | 257 | 371 | 458 | 458 | 472 | 472 | 472 | 472 | 472 |
| Plastische Viskosität | \( \eta_{pl,HB} \) [Pa.s] | 86 | 81 | 253 | 183 | 157 | 157 | 157 | 157 | 157 |

### Rheometer

| Herschel-Bulkley | Fließmoment | \( \Gamma_{0,HB} \) [Nm] | 0,9263 | 1,3364 | 1,64984 | 1,75667 | 1,62799 | 1,70287 | 0,963 | 1,27732 | 2,21805 |
| Parameter | A | - | 2,25502 | 1,654 | 5,96501 | 4,51248 | 3,90173 | 3,36978 | 3,75917 | 2,25273 | 8,95658 |
| Parameter | b | - | 1,54791 | 1 | 1,32318 | 1,4166 | 1,43745 | 1,12977 | 1,296 | 1,38284 | 1,11964 |

### Bingham

| Fließgrenze | \( \tau_{0,B} \) [Pa] | 151 | 371 | 263 | 309 | 297 | 432 | 277 | 271 | 469 |
| Plastische Viskosität | \( \eta_{pl} \) [Pa.s] | 118 | 81 | 310 | 236 | 203 | 170 | 134 | 118 | 231 |

### Messpunkte

| Drehzahl | \( n_1 \) [1/s] | 0,798 | 0,802 | 0,799 | 0,798 | 0,81 | 0,803 | 0,803 | 0,81 | 0,808 |
| Drehzahl | \( n_2 \) [1/s] | 0,664 | 0,653 | 0,661 | 0,66 | 0,658 | 0,657 | 0,657 | 0,64 | 0,721 |
| Drehzahl | \( n_3 \) [1/s] | 0,509 | 0,497 | 0,512 | 0,514 | 0,525 | 0,512 | 0,512 | 0,516 | 0,496 |
| Drehzahl | \( n_4 \) [1/s] | 0,374 | 0,385 | 0,383 | 0,377 | 0,369 | 0,369 | 0,376 | 0,37 | 0,379 | 0,379 |
| Drehzahl | \( n_5 \) [1/s] | 0,239 | 0,255 | 0,211 | 0,245 | 0,232 | 0,236 | 0,236 | 0,228 | 0,241 | 0,242 |
| Drehzahl | \( n_6 \) [1/s] | 0,067 | 0,171 | - | 0,168 | 0,128 | 0,106 | 0,091 | 0,139 | 0,139 | 0,098 |
| Drehmoment | \( \tau_{1} \) [Nm] | 2,526 | 2,576 | 6,53 | 3,049 | 4,454 | 4,382 | 3,795 | 2,96 | 9,297 | 4,659 |
| Drehmoment | \( \tau_{2} \) [Nm] | 2,101 | 2,394 | 4,196 | 3,731 | 3,727 | 3,727 | 3,727 | 3,727 | 3,727 | 4,059 |
| Drehmoment | \( \tau_{3} \) [Nm] | 1,718 | 2,155 | 4,81 | 3,58 | 3,157 | 3,307 | 2,55 | 2,18 | 6,563 | 2,985 |
| Drehmoment | \( \tau_{4} \) [Nm] | 1,442 | 2,03 | 4,444 | 2,871 | 2,871 | 2,871 | 2,871 | 2,871 | 2,871 | 4,205 |
| Drehmoment | \( \tau_{5} \) [Nm] | 1,16 | 1,726 | 2,953 | 2,37 | 2,105 | 2,341 | 1,516 | 1,581 | 4,058 | 1,873 |
| Drehmoment | \( \tau_{6} \) [Nm] | 0,839 | 1,41 | - | 1,761 | 1,781 | 1,814 | 0,911 | 1,006 | 2,777 | 1,179 |

*) E = Eignungsversuch, Ref. = Referenzmischung, %FM bzw. %St = Fließmittel- bzw. Stabilisierergehalt, weitere Abkürzungen siehe Symbolverzeichnis.
### Tabelle A. 6: Ergebnisse der rheologischen Untersuchungen

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<td>18,0</td>
<td>18,0</td>
<td>18,0</td>
<td>18,0</td>
<td>18,0</td>
<td>17,5</td>
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<td>355</td>
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<td>375</td>
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<td>740</td>
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<td>720</td>
<td>599</td>
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<td>365</td>
<td>475</td>
<td>640</td>
<td>670</td>
<td>670</td>
<td>680</td>
<td>650</td>
<td>450</td>
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<td>11,0</td>
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<td>12,5</td>
<td>18,0</td>
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<td>61</td>
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<td>3,90</td>
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<td>0,807</td>
<td>0,788</td>
<td>0,803</td>
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<td>0,658</td>
<td>0,655</td>
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<td>0,662</td>
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<td>0,663</td>
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*) E = Eignungsversuch, Ref. = Referenzmischung, %FM bzw. %St = Fließmittel- bzw. Stabilisierergehalt, weitere Abkürzungen siehe Symbolverzeichnis
Tabelle A. 7: Ergebnisse der rheologischen Untersuchungen

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Messwerte

- Viskosität: Lehm, Mörtel, Beton, Setzfliessmaß, Blockierringversuch, Fließzeit
- Luftgehalt
- Sedimentation (R = Rheometer, S = statisch)

Herschel-Bulkley

- Fließmoment: Φ_{\text{HB}} [Nm]
- Fließgrenze: τ_{\text{HB}} [Pa]
- Plastische Viskosität: η_{\text{pl,HB}} [Pa.s]

Bingham

- Fließmoment: Φ_{\text{B}} [Nm]
- Fließgrenze: τ_{\text{B}} [Pa]
- Plastische Viskosität: η_{\text{pl}} [Pa.s]

Messpunkte

- Drehzahl n1 [1/s] & 0,799 & 0,802 & 0,801 & 0,808 & 0,801 & 0,796 & 0,8 & 0,793 & - & 0,813 |
- Drehzahl n2 [1/s] & 0,659 & 0,656 & 0,66 & 0,661 & 0,668 & 0,671 & 0,652 & 0,669 & - & 0,665 |
- Drehmoment R1 [Nm] & 3,888 & 3,567 & 4,186 & 4,195 & 2,679 & 5,015 & 2,965 & 6,393 & - & 6,946 |

*) E = Eignungsversuch, Ref. = Referenzmischung, %FM bzw. %St = Fliessmittel- bzw. Stabilisierergehalt, weitere Abkürzungen siehe Symbolverzeichnis
Tabelle A. 8: Ergebnisse der rheologischen Untersuchungen

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| Tabelle A. 8: Ergebnisse der rheologischen Untersuchungen (Fortsetzung)
| Herschel-Bulkley | | | | | | | | | | |
| Fließmoment | f_0,HB | [Nm] | 0,4727 | 0,5571 | 0,9022 | 0,4434 | 1,16357 | 0,28962 | 0,95421 | 2,94 | 0,99861 |
| Parameter | A | [-] | 5,8607 | 5,9126 | 6,236 | 5,209 | 5,57839 | 4,6613 | 5,29557 | 5,49292 | 6,19469 |
| Parameter | b | [-] | 5,8607 | 5,9126 | 6,236 | 5,209 | 5,57839 | 4,6613 | 5,29557 | 5,49292 | 6,19469 |
| Herschel-Bulkley und Bingham | | | | | | | | | | |
| Fließgrenze | τ_0,HB | [Pa] | 131 | 155 | 250 | 123 | 323 | 80 | 265 | 394 | 816 |
| Plastische Viskosität | η_pl,HB | [Pa.s] | 237 | 243 | 263 | 199 | 212 | 222 | 401 | 231 | 398 |
| Bingham | | | | | | | | | | |
| Fließgrenze | τ_0,B | [Pa] | 95 | 63 | 41 | 128 | 46 | 51 | 6 | 182 | 816 | 277 |
| Messpunkte | | | | | | | | | | |
| Drehzahl | n_1 | [1/s] | 0,808 | 0,803 | 0,803 | 0,805 | 0,804 | 0,804 | 0,804 | 0,804 | 0,804 |
| Drehzahl | n_2 | [1/s] | 0,664 | 0,669 | 0,662 | 0,668 | 0,672 | 0,663 | 0,654 | 0,667 | 0,667 |
| Drehzahl | n_3 | [1/s] | 0,521 | 0,52 | 0,527 | 0,535 | 0,521 | 0,527 | 0,526 | 0,518 | 0,512 |
| Drehmoment | f_1 | [Nm] | 5,8607 | 5,9126 | 6,236 | 5,209 | 5,57839 | 4,6613 | 5,29557 | 5,49292 | 6,19469 |
| Drehmoment | f_2 | [Nm] | 95 | 63 | 41 | 128 | 46 | 51 | 6 | 182 | 816 | 277 |
| Drehmoment | f_3 | [Nm] | 237 | 243 | 263 | 199 | 212 | 222 | 401 | 231 | 398 |
| Drehmoment | f_4 | [Nm] | 304 | 307 | 324 | 273 | 293 | 260 | 481 | 291 | 398 |
| Drehmoment | f_5 | [Nm] | 304 | 307 | 324 | 273 | 293 | 260 | 481 | 291 | 398 |
| Drehmoment | f_6 | [Nm] | 304 | 307 | 324 | 273 | 293 | 260 | 481 | 291 | 398 |

*) E = Eignungsversuch, Ref. = Referenzmischung, %FM bzw. %St = Fließmittel- bzw. Stabilisierergehalt, weitere Abkürzungen siehe Symbolverzeichnis.
### Tabelle A. 9: Ergebnisse der rheologischen Untersuchungen

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| *) E = Eignungsversuch, Ref. = Referenzmischung, %FM bzw. %St = Fließmittel- bzw. Stabilisierergehalt, weitere Abkürzungen siehe Symbolverzeichnis
Tabelle A. 10: Ergebnisse der rheologischen Untersuchungen

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**Messwerte**

| | | | | | | | | | | |
| **Trichterauslaufzeit Lehmm** | tV,Leim [s] | 35,0 | 40,5 | 44,0 | 17,0 | 17,0 | 17,0 | 18,5 | 19,5 | 19,5 | 8,5 |
| **Setzfließversuch Mörtel** | sf M [mm] | 330 | 325 | 300 | - | 355 | - | 320 | 305 | - | - |
| **Setzfließversuch Beton, Setzfließmaß** | sf B [mm] | 780 | 760 | 645 | 400 | 780 | 75 | 765 | 75 | 75 | 575 |
| **Setzfließversuch, Fließzeit** | t500,B [s] | 5,5 | 5,5 | 5,5 | - | 4,0 | 2,8 | 4,0 | 2,8 | 2,8 | 13,0 |
| **Trichterauslaufzeit Beton** | tV,B [s] | 12,0 | 12,5 | 13,5 | 26,0 | 15,0 | 12,5 | 17,6 | 13,5 | 12,5 | 61,0 |
| **Blockierungsversuch, Setzfließmaß** | sf B,J [mm] | 745 | 710 | 515 | - | 730 | 610 | - | 730 | 790 | 445 |
| **Blockierungs, Fließzeit** | t500,J [s] | 8,0 | 8,0 | 9,0 | - | 5,0 | - | 6,0 | 6,0 | 6,0 | 4,2 |
| **Fruchtbetonichte** | ρB [kg/dm³] | 2,30 | 2,50 | 2,70 | - | 3,50 | - | 0,80 | 3,20 | 2,10 |
| **Sedimentation (R = Rheometer, S = statisch)** | | - | - | - | - | R, S | - | R, S | - | - |
| **Rheometer** | | | | | | | | | | |
| **Herschel-Bulkley** | | | | | | | | | | |
| **Setzfließversuch, Fließgrenze** | τ0,HB [Pa] | 200 | 121 | 497 | 701 | - | 730 | 610 | - | 730 | 790 |
| **Plastische Viskosität** | ηpl,HB [Pa.s] | 202 | 252 | 283 | 156 | - | 92 | - | 109 | 253 |
| **Bingham** | | | | | | | | | | |
| **Plastische Viskosität** | ηpl [Pa.s] | 265 | 236 | 372 | 186 | - | 157 | 253 | - | 157 | 253 |
| **Messpunkte** | | | | | | | | | | |
| **Drehzahl** | n1 [1/s] | 0,807 | 0,801 | 0,798 | 0,805 | 0,806 | 0,797 | 0,8 | 0,798 | 0,8 | 0,802 |
| **Drehzahl** | n2 [1/s] | 0,658 | 0,664 | 0,67 | 0,662 | 0,662 | 0,665 | 0,661 | 0,66 | 0,66 | 0,662 |
| **Drehzahl** | n3 [1/s] | 0,517 | 0,524 | 0,508 | 0,518 | 0,522 | 0,513 | 0,523 | 0,535 | 0,535 | 0,516 |
| **Drehzahl** | n4 [1/s] | 0,382 | 0,381 | 0,382 | 0,37 | 0,378 | 0,379 | 0,393 | 0,384 | 0,377 | 0,371 |
| **Drehzahl** | n5 [1/s] | 0,237 | 0,242 | 0,242 | 0,239 | 0,239 | 0,239 | 0,226 | 0,236 | 0,252 | 0,226 |
| **Drehzahl** | n6 [1/s] | 0,073 | 0,074 | 0,152 | 0,128 | - | 0,134 | 0,134 | 0,102 | 0,139 | 0,139 |
| **Drehmoment** | Γ1 [Nm] | 4,447 | 4,558 | 6,964 | 5,287 | 5,229 | 5,539 | 5,529 | 5,209 | 5,777 | 4,544 |
| **Drehmoment** | Γ2 [Nm] | 2,269 | 2,021 | 3,621 | 3,611 | 3,611 | 3,621 | 3,611 | 3,621 | 3,611 | 3,621 |
| **Drehmoment** | Γ3 [Nm] | 1,302 | 1,382 | 2,633 | 3,089 | 1,601 | 2,491 | 1,567 | 1,056 | 1,254 | 1,744 |
| **Drehmoment** | Γ4 [Nm] | 0,556 | 0,533 | 1,324 | 3,723 | - | 2,167 | - | 0,947 | 0,827 | 1,049 |

*) E = Eignungsversuch, Ref. = Referenzmischung, %FM bzw. %St = Fliessmittel- bzw. Stabilisierergehalt, weitere Abkürzungen siehe Symbolverzeichnis.
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| *) E = Eignungsversuch, Ref. = Referenzmischung, %FM bzw. %St = Fließmittel- bzw. Stabilisierergehalt, weitere Abkürzungen siehe Symbolverzeichnis
### Tabelle A.12: Betonzusammensetzung und abgeleitete Kennwerte

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*) E = Eignungsversuch, Ref. = Referenzmischung, %FM bzw. %St = Fließmittel- bzw. Stabilisierergehalt, weitere Abkürzungen siehe Symboleverzeichnis

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### Tabelle A.13: Betonzusammensetzung und abgeleitete Kennwerte

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<tr>
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<td>196</td>
<td>177</td>
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<td><strong>Einwaage der Gesteinskörnung</strong></td>
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<td><strong>Anteil ( \leq 0,125 \text{ mm} )</strong></td>
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<td><strong>Anteil ( \leq 0,125 \text{ mm} )</strong></td>
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<tr>
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<td>173</td>
<td>172</td>
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</table>

*) E = Eignungsversuch, Ref. = Referenzmischung, %FM bzw. %St = Fließmittel- bzw. Stabilisierergehalt, weitere Abkürzungen siehe Sym- bolverzeichnis.
Tabelle A. 14: Betonzusammensetzung und abgeleitete Kennwerte

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<td>46,80</td>
<td>46,80</td>
<td>46,80</td>
<td>46,80</td>
<td>46,80</td>
<td>46,80</td>
<td>46,80</td>
<td>46,80</td>
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</tr>
<tr>
<td>Anteil &lt;= 0,09 mm</td>
<td>[M.-%]</td>
<td>32,76</td>
<td>32,76</td>
<td>32,76</td>
<td>32,76</td>
<td>32,76</td>
<td>32,76</td>
<td>32,76</td>
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<tr>
<td>Anteil &lt;= 0,09 mm</td>
<td>[M.-%]</td>
<td>0,78</td>
<td>0,78</td>
<td>0,78</td>
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<td>0,78</td>
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</tr>
<tr>
<td>Korndichte Zusatzstoff 1</td>
<td>$\rho_{k}$ [kg/dm³]</td>
<td>2,59</td>
<td>2,59</td>
<td>2,59</td>
<td>2,59</td>
<td>2,59</td>
<td>2,59</td>
<td>2,59</td>
<td>2,59</td>
<td>2,59</td>
</tr>
<tr>
<td>Korndichte Zusatzstoff 2</td>
<td>$\rho_{k}$ [kg/dm³]</td>
<td>3,964</td>
<td>3,994</td>
<td>4,051</td>
<td>4,066</td>
<td>4,036</td>
<td>4,082</td>
<td>4,136</td>
<td>4,201</td>
<td>4,082</td>
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<tr>
<td>Grosstropfenanteil [cm²/g]</td>
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<td>18,0</td>
<td>18,0</td>
<td>18,0</td>
<td>18,0</td>
<td>18,0</td>
<td>18,0</td>
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<tr>
<td>Lehmzusatz [mm]</td>
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<td>0,0237</td>
<td>0,0290</td>
<td>0,0277</td>
<td>0,0302</td>
<td>0,0264</td>
<td>0,0317</td>
<td>0,0344</td>
<td>0,0264</td>
<td>0,0241</td>
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*) E = Eignungsversuch, Ref. = Referenzmischung, %FM bzw. %St = Fließmittel- bzw. Stabilisierergehalt, weitere Abkürzungen siehe Symbolverzeichnis
Tabelle A.15: Betonzusammensetzung und abgeleitete Kennwerte

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<th>37</th>
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<td>II</td>
<td>II</td>
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<td>III</td>
<td>III</td>
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<td>III</td>
<td>III</td>
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<tr>
<td>Variation *)</td>
<td>m₁</td>
<td>m₂</td>
<td>m₃</td>
<td>m₄</td>
<td>%FM</td>
<td>m₁</td>
<td>%FM</td>
<td>E</td>
<td>Ref.</td>
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<td>32,5R</td>
<td>32,5R</td>
<td>32,5R</td>
<td>32,5R</td>
<td>32,5R</td>
<td>32,5R</td>
<td>32,5R</td>
<td>32,5R</td>
<td>32,5R</td>
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<td>SFA (B)</td>
<td>SFA (B)</td>
<td>SFA (B)</td>
<td>SFA (B)</td>
<td>SFA (B)</td>
<td>KSM (A)</td>
<td>KSM (A)</td>
<td>KSM (A)</td>
<td>KSM (A)</td>
<td>KSM (A)</td>
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**Betonzusammensetzung**

- Zementgehalt \( m₂ \) [kg/m³]: 330, 333, 337, 316, 323, 239, 239, 239, 239, 239
- Feinfraktion \( m₃ \) [kg/m³]: 3,00, 3,00, 3,00, 3,00, 3,00, 3,00, 3,00, 3,00, 3,00, 3,00
- Gesteinskörnung \( m₁ \) [kg/m³]: 4,129, 4,161, 4,013, 5,063, 4,849, 2,385, 2,385, 2,385, 2,385, 2,385
- Dichte des Fließmittels \( ρ_{FM} \) [kg/dm³]: 1,250, 1,250, 1,260, 1,500, 1,250, 1,500, 1,000, 1,000, 1,000, 1,000
- Stabilisierungseffekt \( m_{sgke} \) [kg/m³]: 0,396, 0,399, 0,404, 0,379, 0,388, 0,000, 0,000, 0,000, 0,000, 0,000

**Angaben zur Gesteinskörnung**

- Einwaage der Gesteinskörnung \( m_{gke} \) [kg]: 170, 172, 174, 164, 163, 176, 166, 166, 166, 163, 163, 163
- Korndichte Zusatzstoff 1 \( ρ_{k1} \) [kg/dm³]: 2,60, 2,60, 2,60, 2,60, 2,60, 2,60, 2,60, 2,60, 2,60, 2,60
- Korndichte Zusatzstoff 2 \( ρ_{k2} \) [kg/dm³]: 337, 337, 336, 336, 336

**Kernwerte**

| Versuchsprogramm | III | III | III | III | III | III | III | III | III | III |
| Variation *) | m₁ | m₂ | m₃ | m₄ | %FM | m₁ | %FM | E | Ref. | Ref. | Ref. | E |

*) E = Eignungssicherung, Ref. = Referenzmischung, %FM bzw. %St = Fließmittel- bzw. Stabilisierergehalt, weitere Abkürzungen siehe Symbolverzeichnis


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<td>Variation *)</td>
<td>E</td>
<td>Ref.</td>
<td>V1/Vm</td>
<td>V2/Vm</td>
<td>V3/Vm</td>
<td>V4/Vm</td>
<td>V5/Vm</td>
<td>V6/Vm</td>
<td>V7/Vm</td>
<td>V8/Vm</td>
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<td>0,86</td>
<td>0,86</td>
<td>0,86</td>
<td>0,86</td>
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<td>Dichte der Kornfraktion</td>
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<tr>
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<td>2,6</td>
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<td>2,6</td>
<td>2,6</td>
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<td>615</td>
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<td>2,6</td>
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<td>[M.-%]</td>
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*) E = Eignungsversuch, Ref. = Referenzmischung, %FM bzw. %St = Fließmittel- bzw. Stabilisierergehalt, weitere Abkürzungen siehe Symbolverzeichnis

Tabelle A.16: Betonzusammensetzung und abgeleitete Kennwerte

Variation *) E = Eignungsversuch, Ref. = Referenzmischung, %FM bzw. %St = Fließmittel- bzw. Stabilisierergehalt, weitere Abkürzungen siehe Symbolverzeichnis
### Tabelle A. 17: Betonzusammensetzung und abgeleitete Kennwerte

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<th>Einwaage der Gesteinskörnung</th>
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<td>[kg/m³]</td>
<td>[kg/m³]</td>
<td>[kg/m³]</td>
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<td>&lt; 1,2 mm</td>
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<td>4 bis 8 mm</td>
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<td></td>
<td>8 bis 16 mm</td>
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<td>16 bis 32 mm</td>
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<td>512 bis 1024 mm</td>
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<td>16384 bis 32768 mm</td>
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### Anhang

**E =** Eignungsversuch, **Ref. =** Referenzmischung, **%FM =** Fließmittel- bzw. Stabilisierergehalt, **%St =** Stabilisierergehalt
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*) E = Eignungsversuch, Ref. = Referenzmischung, %FM bzw. %St = Fließmittel- bzw. Stabilisierergehalt, weitere Abkürzungen siehe Symbolverzeichnis

Anhang
### Tabelle A. 19: Betonzusammensetzung und abgeleitete Kennwerte

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*) E = Eignungsversuch, Ref. = Referenzmischung, %FM bzw. %St = Fließmittel- bzw. Stabilisierergehalt, weitere Abkürzungen siehe Symbolverzeichnis
### Tabelle A. 20: Betonzusammensetzung und abgeleitete Kenndaten

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#### Betonzusammensetzung

- Zementgehalt $m_z$ (kg/m³) 346 305 334 354 311 337 356 346 345 345
- Kornzugehörigkeit $d_50$ (kg/m³) 3,35 3,05 3,05 3,05 3,05 3,05 3,05 3,05 3,05 3,05
- Äquivalenter Wasserzementwert $w_{eq}$ [%] 0,43 0,43 0,43 0,43 0,43 0,43 0,43 0,43 0,43 0,43
- Flächenmittebezeichnung $f_1$ [-] A A A A A A A A A A
- Dichte des Flächenmittels $\rho_{fl}$ (kg/dm³) 1,08 1,08 1,08 1,08 1,08 1,08 1,08 1,08 1,08 1,08
- Flächenmittel $m_{fl}$ (kg/m³) 3,467 3,203 3,578 3,717 3,537 3,376 3,530 3,247 3,376 3,376
- Flächenmittebezeichnung (Rössige Masse) $m_{fl}/m_z$ ( [%]) 1,000 1,000 1,050 1,050 1,050 1,050 1,050 1,050 1,050 1,050
- Stabilisiergehalt $m_{s}$ (kg/m³) 0,000 0,000 0,354 0,354 0,311 0,337 0,356 0,346 0,345 0,345
- Stabilisiergehalt (auf Zement bezogen) $m_{s}/m_z$ ( [%]) 0,00 0,10 0,10 0,10 0,10 0,10 0,10 0,10 0,10 0,10
- Gesamtmasse Wasse bindemittel $m_{w+b}$ (kg/m³) 169,7 149,9 163,8 173,9 152,5 165,4 174,9 169,7 169,6 169,6
- Zusatzstoff 1 $\rho_{s1}$ (kg/dm³) 2,3 2,3 2,3 2,3 2,3 2,3 2,3 2,3 2,3 2,3
- Zusatzstoff 2 $\rho_{s2}$ (kg/dm³) - - - - - - - - - -
- Zusatzstoff 3 $\rho_{s3}$ (kg/dm³) - - - - - - - - - -

#### Angaben zur Gesteinskörnung

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<th>Anteil &lt;= 31,5 mm [%]</th>
<th>Anteil &lt;= 0,063 mm [%]</th>
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#### Siliciumgehalt $w_{Si}$ [%] 1,3 1,3 1,3 1,3 1,3 1,3 1,3 1,3 1,3 1,3

#### Kenndaten

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#### Wasser-Bindemittel-Verhältnis $V_w/V_z$ [-] 0,858 0,858 0,858 0,858 0,858 0,858 0,858 0,858 0,858 0,858

#### Leimvolumen $V_L$ (dm³/m³) 838 341 371 393 346 374 395 384 383 383

#### Leimkornvolumen (ohne Zuschlagantlit) $V_L$ (dm³/m³) 98 90 90 100 90 91 100 91 98 98

#### Anhang

- $E = \text{Eignungsversuch}, \text{Ref.} = \text{Referenzmischung}, \%FM = \text{Fließmittel-}, \%St = \text{Stabilisierergehalt}, \text{weitere Abkürzungen siehe Symbolverzeichnis}$.  

*) $E$ = Eignungsversuch, Ref. = Referenzmischung, %FM bzw. %St = Fließmittel- bzw. Stabilisierergehalt, weitere Abkürzungen siehe Symbolverzeichnis.
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### Angaben zum Stickstoffgehalt

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### Kennwerte

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### *) E = Eignungsversuch, Ref. = Referenzmischung, %FM bzw. %St = Fließmittel- bzw. Stabilisierergehalt, weitere Abkürzungen siehe Symbolverzeichnis
Tabelle A. 22: Betonzusammensetzung und abgeleitete Kennwerte

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<tr>
<td>Zementgehalt</td>
<td>( m_p ) [kg/m³]</td>
<td>264</td>
<td>299</td>
<td>299</td>
<td>495</td>
<td>495</td>
<td>468</td>
<td>410</td>
<td>451</td>
<td>438</td>
</tr>
<tr>
<td>Korndichte Zement</td>
<td>( \rho ) [kg/dm³]</td>
<td>3.05</td>
<td>3.05</td>
<td>3.05</td>
<td>3.05</td>
<td>3.05</td>
<td>3.15</td>
<td>3.15</td>
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<tr>
<td>Äquivalenter Wasserzementwert</td>
<td>( (w/z)_E )</td>
<td>0.65</td>
<td>0.49</td>
<td>0.49</td>
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<td>0.33</td>
<td>0.43</td>
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<td>Fließmittelbezeichnung</td>
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<td>A</td>
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<td>B</td>
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<tr>
<td>Dichte des Fließmittels</td>
<td>( \rho_{FM} ) [kg/dm³]</td>
<td>1.08</td>
<td>1.08</td>
<td>1.08</td>
<td>1.08</td>
<td>1.08</td>
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<tr>
<td>Fließmittelmasse</td>
<td>( m_{FM} ) [kg]</td>
<td>3.965</td>
<td>3.175</td>
<td>3.950</td>
<td>5.026</td>
<td>5.871</td>
<td>4.728</td>
<td>4.797</td>
<td>4.676</td>
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<td>Fließmittelmasse (Nüsse Masse)</td>
<td>( m_{FM,eq} ) [kg/m³]</td>
<td>1.500</td>
<td>1.663</td>
<td>1.175</td>
<td>1.015</td>
<td>1.175</td>
<td>1.011</td>
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<td>Stabilisierergehalt</td>
<td>( m_p ) [kg/m³]</td>
<td>1.189</td>
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<td>Stabilisierergehalt (auf Zement bezogen)</td>
<td>( m_{FM,eq} ) [kg/m³]</td>
<td>0.45</td>
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<td>Gesamtgewicht</td>
<td>( m ) [kg]</td>
<td>171.9</td>
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<td>Zusatzstoff 1</td>
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<tr>
<td>Zusatzstoffart 1</td>
<td>( f_1 ) [-]</td>
<td>SFA (A)</td>
<td>SFA (A)</td>
<td>SFA (A)</td>
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<tr>
<td>Zusatzstoffart 2</td>
<td>( f_2 ) [-]</td>
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<td>( \rho ) [kg/dm³]</td>
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<td>Angaben zur Gesteinskörnung</td>
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<tr>
<td>Korndurchmesser</td>
<td>( d ) [mm]</td>
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<td>Einwaage der Gesteinskörnung</td>
<td>( m_{d,eq} ) [kg/m³]</td>
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<tr>
<td>Dichte der Gesteinskörnung</td>
<td>( \rho_{d,eq} ) [kg/dm³]</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Korndichte Zement</td>
<td>( \rho_1 ) [kg/dm³]</td>
<td>264</td>
<td>299</td>
<td>299</td>
<td>495</td>
<td>495</td>
<td>468</td>
<td>410</td>
<td>451</td>
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<td>Füllertyp</td>
<td>KSM (A)</td>
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</table>

*) E = Eignungsversuch, Ref. = Referenzmischung, %FM bzw. %St = Fließmittel- bzw. Stabilisierergehalt, weitere Abkürzungen siehe Symbolverzeichnis