Steenbergen / Vervuurt Method

Bibliography (10) – 2012

This method gives an alternative procedure to the one detailed in EN 13791 for determining the specified concrete strength from cores drilled in situ. This method is based on EN 1990 Annex D but implemented with a different statistical uncertainity, that is introducing a minimum constant standard deviation so that to find the in situ equivalent specified strength of concrete :

method A :

$$\boxed{f_{ck,A} = e^{f_{cm}(Y)} * e^{(-t_{n-1,p=0.05} * s(Y) * \sqrt{1+\frac{1}{n}})}}$$

Where :

$f_{ck,A}$: in situ equivalent specified strength of concrete (EN 1990) (N/mm^2)

$f_{cm}(Y)$: mean of natural logarithm of in situ measured strengths (N/mm^2)

n : q.ty of cores tested (-)

s(Y) : standard deviation of natural logarithm of in situ measured strengths (N/mm^2)

t_{n-1} : value according to student t-distribution as per following table (complete table attached at the end)

n-1	1	2	3	4	5	6	7	8	9	10	20	30	∞
t_{n-1}	6.31	2.92	2.35	2.13	2.02	1.94	1.89	1.86	1.83	1.81	1.72	1.7	1.64

NOTE : above formula comply with EN 1990 where the strength is assumed to have a log-normal distribution. The specified concrete compressive strength is defined as that strength value with a probability of non-exceedance of 5 %

Method B (EN 1990 modified) :

$$\boxed{f_{ck,B} = e^{f_{cm}(Y)} * e^{(-1.64 * s_{min}(Y) * \sqrt{1+\frac{1}{n}})}}$$

Where $s_{min}(Y)$, in the log-normal domain, can be calculated with the formula :

$$s_{min}(Y) = \sqrt{\ln\left[1 + \left(\frac{s_{min}}{f_{cm}}\right)^2\right]}$$

type	s_{min} in N/mm² related to probability of beeing exceeded				
	80 %	50 %	35 %	20 %	10 %
I	5	7	9	10	11
II	10	11	12	13	14

The specified concrete compressive strength,based on a log-normal distribution, is then obtained from the lower value calculated with method A and B

Note that the last row also gives critical points: a *t*-distribution with infinitely many degrees of freedom is a normal distribution.

The first column is the number of degrees of freedom.

One-sided	**75%**	**80%**	**85%**	**90%**	**95%**	**97.5%**	**99%**	**99.5%**	**99.75%**	**99.9%**	**99.95%**
Two-sided	**50%**	**60%**	**70%**	**80%**	**90%**	**95%**	**98%**	**99%**	**99.5%**	**99.8%**	**99.9%**
1	1.000	1.376	1.963	3.078	6.314	12.71	31.82	63.66	127.3	318.3	636.6
2	0.816	1.080	1.386	1.886	2.920	4.303	6.965	9.925	14.09	22.33	31.60
3	0.765	0.978	1.250	1.638	2.353	3.182	4.541	5.841	7.453	10.21	12.92
4	0.741	0.941	1.190	1.533	2.132	2.776	3.747	4.604	5.598	7.173	8.610
5	0.727	0.920	1.156	1.476	2.015	2.571	3.365	4.032	4.773	5.893	6.869
6	0.718	0.906	1.134	1.440	1.943	2.447	3.143	3.707	4.317	5.208	5.959
7	0.711	0.896	1.119	1.415	1.895	2.365	2.998	3.499	4.029	4.785	5.408
8	0.706	0.889	1.108	1.397	1.860	2.306	2.896	3.355	3.833	4.501	5.041
9	0.703	0.883	1.100	1.383	1.833	2.262	2.821	3.250	3.690	4.297	4.781
10	0.700	0.879	1.093	1.372	1.812	2.228	2.764	3.169	3.581	4.144	4.587
11	0.697	0.876	1.088	1.363	1.796	2.201	2.718	3.106	3.497	4.025	4.437
12	0.695	0.873	1.083	1.356	1.782	2.179	2.681	3.055	3.428	3.930	4.318
13	0.694	0.870	1.079	1.350	1.771	2.160	2.650	3.012	3.372	3.852	4.221
14	0.692	0.868	1.076	1.345	1.761	2.145	2.624	2.977	3.326	3.787	4.140
15	0.691	0.866	1.074	1.341	1.753	2.131	2.602	2.947	3.286	3.733	4.073
16	0.690	0.865	1.071	1.337	1.746	2.120	2.583	2.921	3.252	3.686	4.015
17	0.689	0.863	1.069	1.333	1.740	2.110	2.567	2.898	3.222	3.646	3.965
18	0.688	0.862	1.067	1.330	1.734	2.101	2.552	2.878	3.197	3.610	3.922
19	0.688	0.861	1.066	1.328	1.729	2.093	2.539	2.861	3.174	3.579	3.883
20	0.687	0.860	1.064	1.325	1.725	2.086	2.528	2.845	3.153	3.552	3.850
21	0.686	0.859	1.063	1.323	1.721	2.080	2.518	2.831	3.135	3.527	3.819
22	0.686	0.858	1.061	1.321	1.717	2.074	2.508	2.819	3.119	3.505	3.792
23	0.685	0.858	1.060	1.319	1.714	2.069	2.500	2.807	3.104	3.485	3.767
24	0.685	0.857	1.059	1.318	1.711	2.064	2.492	2.797	3.091	3.467	3.745
25	0.684	0.856	1.058	1.316	1.708	2.060	2.485	2.787	3.078	3.450	3.725
26	0.684	0.856	1.058	1.315	1.706	2.056	2.479	2.779	3.067	3.435	3.707
27	0.684	0.855	1.057	1.314	1.703	2.052	2.473	2.771	3.057	3.421	3.690
28	0.683	0.855	1.056	1.313	1.701	2.048	2.467	2.763	3.047	3.408	3.674
29	0.683	0.854	1.055	1.311	1.699	2.045	2.462	2.756	3.038	3.396	3.659
30	0.683	0.854	1.055	1.310	1.697	2.042	2.457	2.750	3.030	3.385	3.646
40	0.681	0.851	1.050	1.303	1.684	2.021	2.423	2.704	2.971	3.307	3.551
50	0.679	0.849	1.047	1.299	1.676	2.009	2.403	2.678	2.937	3.261	3.496
60	0.679	0.848	1.045	1.296	1.671	2.000	2.390	2.660	2.915	3.232	3.460
80	0.678	0.846	1.043	1.292	1.664	1.990	2.374	2.639	2.887	3.195	3.416
100	0.677	0.845	1.042	1.290	1.660	1.984	2.364	2.626	2.871	3.174	3.390
120	0.677	0.845	1.041	1.289	1.658	1.980	2.358	2.617	2.860	3.160	3.373
∞	0.674	0.842	1.036	1.282	1.645	1.960	2.326	2.576	2.807	3.090	3.291

The number at the beginning of each row in the table above is ν, which has been defined above as $n - 1$. The percentage along the top is $100\%(1 - \alpha)$. The numbers in the main body of the table are $t_{\alpha,\nu}$. If a quantity T is distributed as a Student's *t*-distribution with ν degrees of freedom, then there is a probability $1 - \alpha$ that T will be less than $t_{\alpha,\nu}$. (Calculated as for a one-tailed or one-sided test, as opposed to a two-tailed test.)