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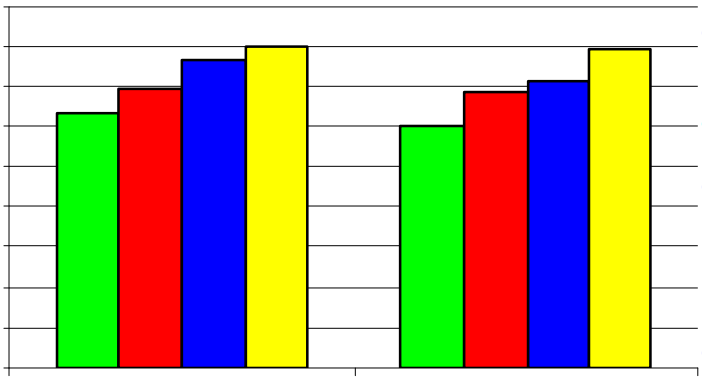
ELASTOPLASTIC CONCRETE PROPERTIES



Project: **Elastoplastic concrete (EPC) properties**

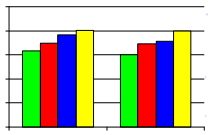
Project description: **Determination of elastoplastic concrete (EPC) properties suitable for use in analyses and calculations of the Cupolex slab**

Project number: **2012006**

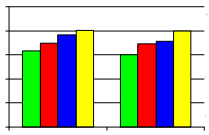
Prepared by: **Josef Novak**

Prepared for: **Elastoplastic concrete (EPC)**

Date: **May 2012**



1. CONTENT

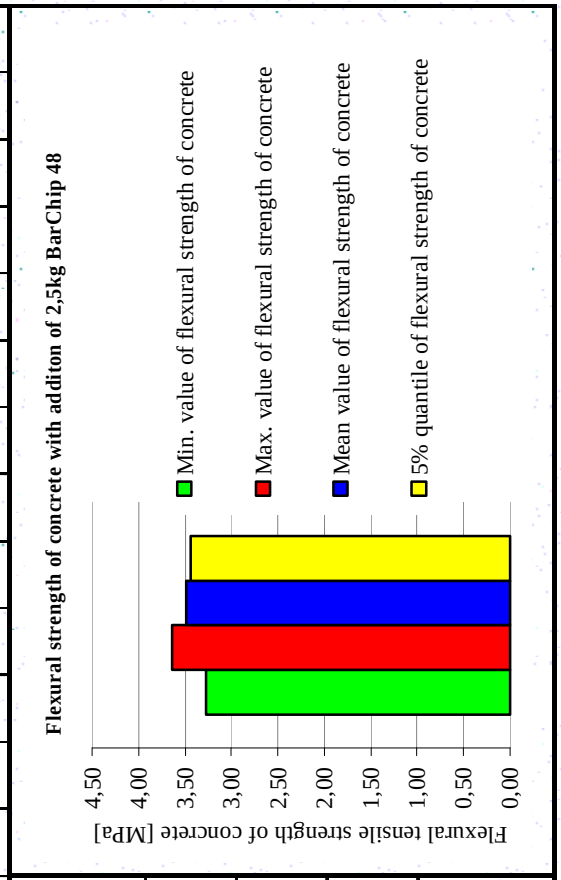


2. PRELUDE

This report is written to describe and compare properties of concrete with different BarChip48 fibre dosage. The report also shows a formula for determination of flexural tensile concrete strength at 28 days in relation to BarChip48 fibre dosage. All results and values mentioned in the report are necessary for analyzing all structures from fibre concrete with addition of BarChip48 (comparison of fibre concrete and reinforced concrete, Cupolex slab analysis) All data included in the report is based on results of fibre concrete beams testing (19/06/2009) provided by Elastoplastic Concrete company (EPC).

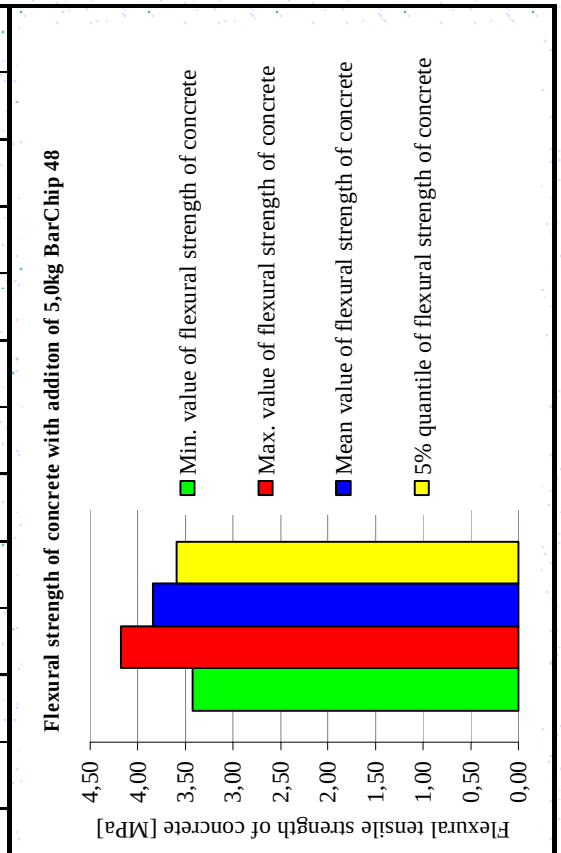
3. EPC WITH ADDITION OF 2,5 KG BARCHIP48

BarChip48 2.5 kg																				
Sample No.	Age [days]	Modulus of rupture [MPa]	Residual strength		Equivalent residual strength					Energy absorption				ASTM Toughness					$R_{e,3}$ [%]	Offset [mm]	Fibres per face [ks]	UCS cyl
			0.75 (L/600) [Mpa]	3 mm (L/150) [Mpa]	0.75 mm [MPa]	1.00 mm [MPa]	3.00 mm [MPa]	4.00 mm [MPa]		0.75 mm [J]	1.0 mm [J]	3.0 mm [J]	4.0 mm [J]	I_5	I_{10}	I_{20}	I_{30}	I_{50}				
1	28	3,46	1,20	0,67	1,35	1,32	1,05	0,94		7,80	10,12	24,13	28,93	3,39	5,22	8,54	11,94	18,81	30,20	66,00	32,50	
2	28	3,51	1,00	0,72	1,34	1,25	0,99	0,90		7,79	9,68	23,01	28,07	3,78	5,82	8,72	11,58	17,07	28,10	4,00	35,00	
3	28	3,27	1,26	1,03	1,36	1,34	1,27	1,18		7,92	10,43	29,53	36,76	3,36	5,31	8,91	12,70	20,86	38,70	40,50	44,00	27,10
4	28	3,64	1,35	0,83	1,58	1,59	1,23	1,11		8,91	11,94	27,75	33,41	3,79	6,29	10,18	11,86	20,85	33,80	97,50	36,00	
5	28	3,55	1,41	0,91	1,66	1,59	1,27	1,17		9,64	12,30	29,63	36,25	3,86	6,23	10,40	14,43	22,04	35,90	52,50	36,50	
Mean value of flexural tensile strength of concrete: $f_{ct,f} = (1 / n) \cdot \sum f_{ct,f,i}$		3,486	1,244	0,832	1,458	1,418	1,162	1,060														
Standard deviation: $s=(\sum f_{ct,f,i}^2 - n.f_{ct,f}^2)/(n-1)$		0,019	0,025	0,021	0,023	0,026	0,018	0,017														
Variation factor: $v = s / f_{ct,f}$		0,005	0,020	0,025	0,016	0,018	0,015	0,016														
Factor k_n :		2,330	2,330	2,330	2,330	2,330	2,330	2,330														
5% quantile of flexural tensile strength of concrete: $f_{ct,f,0,05}=f_{ct,f}.(1-k_n.v)$		**3,442**	**1,185**	**0,783**	**1,405**	**1,358**	**1,121**	**1,020**														



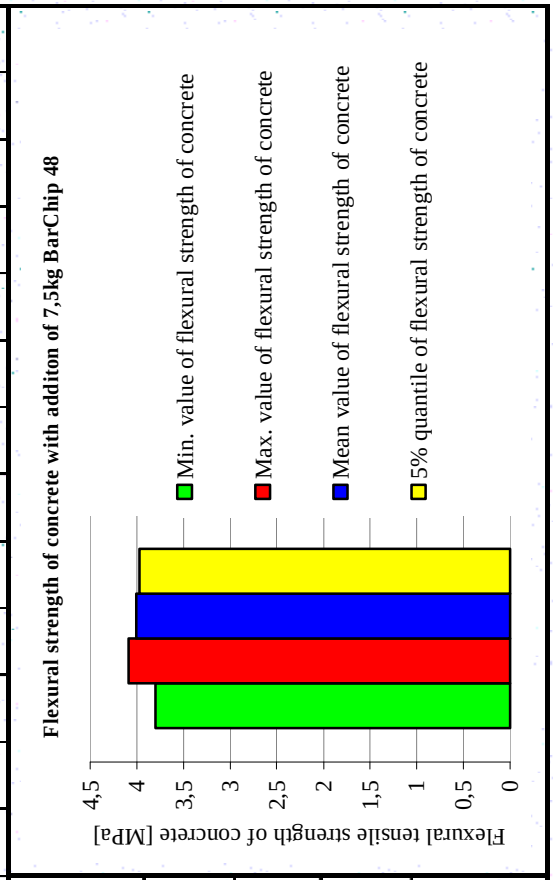
4. EPC WITH ADDITION OF 5,0 KG BARCHIP48

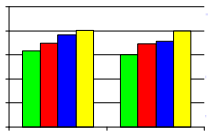
BarChip48 5.0 kg	Sample No.	Age [days]	Modulus of rupture [MPa]	Residual strength		Equivalent residual strength				Energy absorption				ASTM Toughness					$R_{e,3}$ [%]	Offset [mm]	Fibres per face [ks]	UCS cyl
				0.75 (L/600) [MPa]	3 mm (L/150) [MPa]	0.75 mm [MPa]	1.00 mm [MPa]	3.00 mm [MPa]	4.00 mm [MPa]	0.75 mm [J]	1.0 mm [J]	3.0 mm [J]	4.0 mm [J]	I_5	I_{10}	I_{20}	I_{30}	I_{50}				
	1	28	3,42	2,58	1,81	2,37	2,43	2,34	2,17	13,87	18,96	54,85	67,83	3,85	7,10	14,08	21,58	36,82	68,50	19,50	85,00	28,8
	2	28	3,83	1,85	1,52	2,04	2,00	1,86	1,74	12,01	15,67	43,68	54,59	3,96	6,59	11,43	16,27	25,56	48,40	9,00	76,00	
	3	29	3,62	1,85	1,28	1,94	1,93	1,73	1,58	11,18	14,83	39,86	48,65	3,87	6,53	11,58	16,65	26,28	47,80	1,50	68,50	
	4	29	4,18	2,20	1,55	2,20	2,20	2,00	1,85	12,60	16,78	45,81	56,66	3,57	5,94	10,90	16,12	26,35	47,80	54,00	74,50	
	5	29	4,15	2,27	1,61	2,15	2,22	2,01	1,88	12,50	17,14	46,69	58,16	3,38	5,87	11,01	15,62	27,15	48,50	48,00	74,50	
Mean value of flexural tensile strength of concrete: $f_{ct,f} = (1 / n) \cdot \sum f_{ct,f,i}$			3,840	2,150	1,554	2,140	2,156	1,988	1,844													
Standard deviation: $s=(\sum f_{ct,f,i}^2 - n.f_{ct,f}^2)/(n-1)$			0,109	0,095	0,036	0,027	0,039	0,052	0,047													
Variation factor: $v = s / f_{ct,f}$			0,028	0,044	0,023	0,012	0,018	0,026	0,026													
Factor k_n :			2,330	2,330	2,330	2,330	2,330	2,330	2,330													
5% quantile of flexural tensile strength of concrete: $f_{ct,f,0,05}=f_{ct,f}.(1-k_n.v)$			**3,586**	1,928	1,470	2,078	2,065	1,867	1,734													



5. EPC WITH ADDITION OF 7,5 KG BARCHIP48

BarChip48 7,5 kg	Sample No.	Age [days]	Modulus of rupture [MPa]	Residual strength		Equivalent residual strength				Energy absorption				ASTM Toughness					$R_{e,3}$ [%]	Offset [mm]	Fibres per face [ks]	UCS cyl
				0.75 (L/600) [Mpa]	3 mm (L/150) [Mpa]	0.75 mm [MPa]	1.00 mm [MPa]	3.00 mm [MPa]	4.00 mm [MPa]	0.75 mm [J]	1.0 mm [J]	3.0 mm [J]	4.0 mm [J]	I_5	I_{10}	I_{20}	I_{30}	I_{50}				
	1	29	4,06	3,32	2,17	2,96	3,11	2,85	2,63	17,29	24,16	66,61	81,75	4,18	7,77	15,35	23,43	39,33	70,3	55,5	110	
	2	29	4,02	1,91	1,51	1,92	1,93	1,83	1,71	11,25	15,09	42,95	53,6	3,36	5,69	10,13	14,79	24,63	45,6	64,5	102,5	
	3	29	4,09	2,86	2,06	2,69	2,73	2,55	2,4	15,38	20,84	58,35	73,14	3,65	6,83	13,48	20,44	34,43	62,3	45	109,5	27,3
	4	29	3,8	2,53	2,07	2,36	2,41	2,41	2,3	13,71	18,65	55,99	71,09	3,77	6,52	12,82	19,31	33	63,5	32,5	102,5	
	5	29	4,06	2,87	2	2,71	2,76	2,57	2,38	15,78	21,45	60	74,14	3,87	7,07	13,74	20,84	35,01	63,3	66,5	103	
Mean value of flexural tensile strength of concrete: $f_{ct,f} = (1 / n) \cdot \sum f_{ct,f,i}$			4,006	2,698	1,962	2,528	2,588	2,442	2,284													
Standard deviation: $s=(\sum f_{ct,f,i}^2 - n.f_{ct,f}^2)/(n-1)$			0,014	0,273	0,068	0,161	0,197	0,143	0,118													
Variation factor: $v = s / f_{ct,f}$			0,003	0,101	0,034	0,064	0,076	0,058	0,052													
Factor k_n :			2,330	2,330	2,330	2,330	2,330	2,330	2,330													
5% quantile of flexural tensile strength of concrete: $f_{ct,f,0,05}=f_{ct,f}.(1-k_n.v)$			**3,974**	**2,062**	**1,805**	**2,153**	**2,130**	**2,110**	**2,009**													



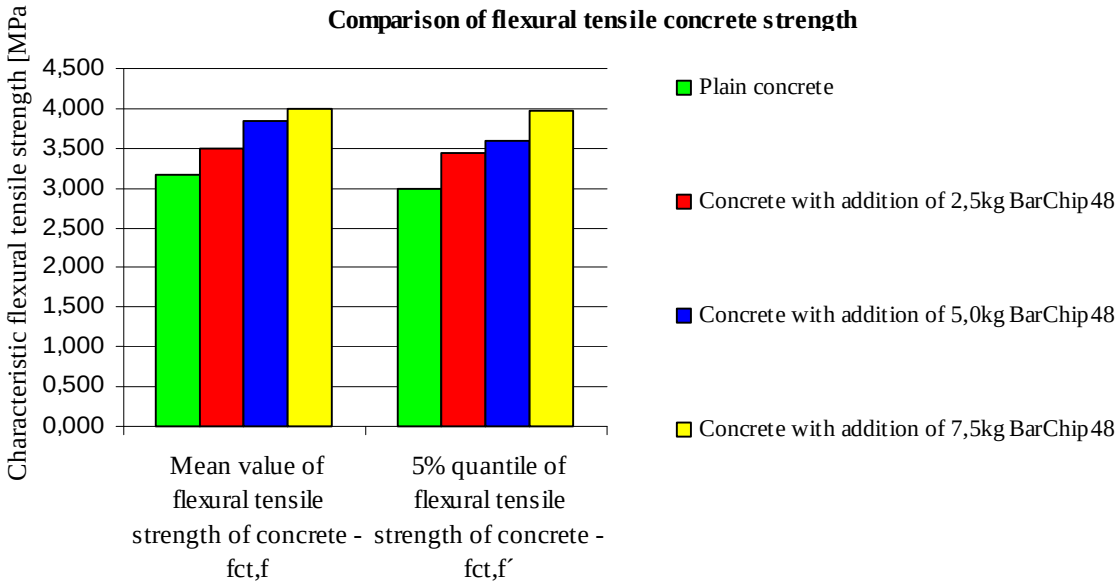


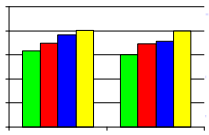
6. FLEXURAL TENSILE STRENGTH OF FIBRE CONRETE IN RELATION TO BARCHIP48 FIBRE DOSAGE

Type of characteristic flexureal tensile strength of concrete	Plain concrete [MPa]	Concrete with addition of 2,5kg BarChip48 [MPa]	Concrete with addition of 5,0kg BarChip48 [MPa]	Concrete with addition of 7,5kg BarChip48 [MPa]
Mean value of flexural tensile strength of concrete - $f_{ct,f}$	$f_{ct,f} = 0,6 \cdot (f_{cm})^{0,6}$ 3,17	3,49	3,84	4,01
5% quantile of flexural tensile strength of concrete - $f_{ct,f}´$	$f_{ct,f}´ = 0,6 \cdot (f_{c}´)^{0,5}$ 3,00	3,44	3,59	3,97

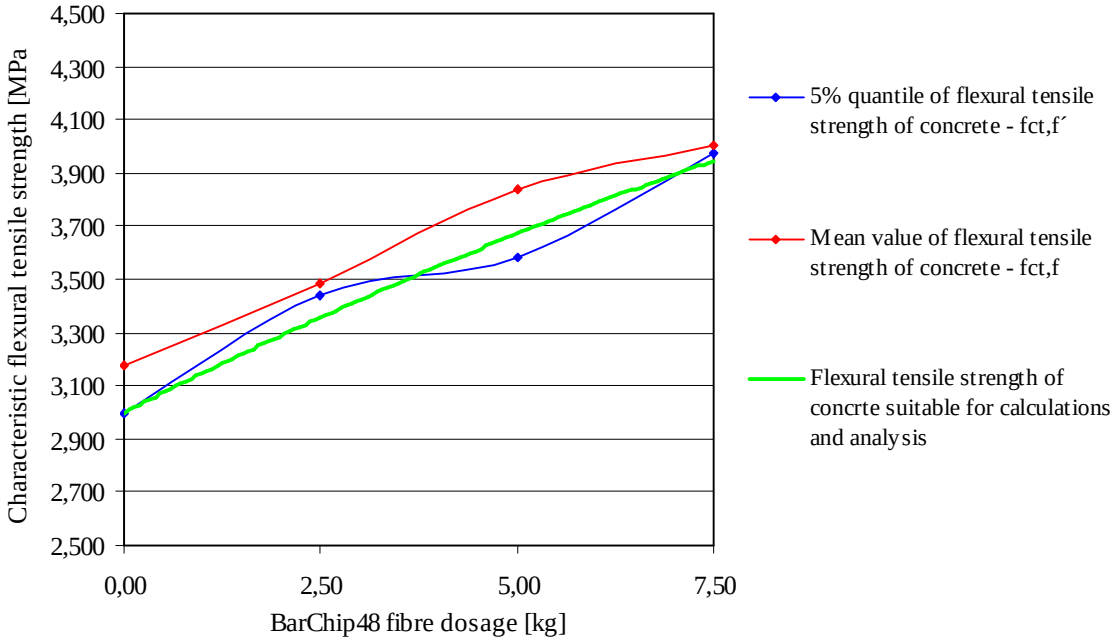
$f_{c}´$ = characteristic compressive cylinder strength of concrete at 28 days

f_{cm} = mean value of characteristic cylinder strength of concrete at 28 days





Relation of concrete flexural tensile strength to fibre dosage

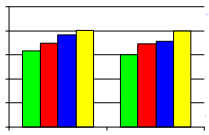


The formula for determination of flexural tensile strength of fibre concrete in relation to fibre BarChip 48 dosage can be used for dosage 0 – 7,5 kg / m3. The flexural tensile strength is characteristic.

$$\mathbf{f_{fct,f}´ = - 0{,}00329824 \cdot x^2 + 0{,}15075247 \cdot x + 3 \quad [MPa]}$$

$f_{fct,f}´$ - characteristic value of flexural tensile strength of fibre concrete with addition of BarChip 48 fibre from 0 – 7,5 kg/m^3 [MPa]

x – BarChip48 fibre dosage per cubic meter of concrete [kg]



6. CONCLUSION

The results and values mentioned in the report seem to be reasonable and suitable. In my opinion the data can be used for other calculations. The formula for determination of fibre concrete flexural tensile strength can be used for analyses and calculations of fibre concrete structures with addition of BarChip48 fibres from 0 – 7,5 kg.