D1.2 Report on required field properties of concrete

Concrete mixtures

The optimization of five concrete mixtures was performed, based on the best rheology achievable, in order to reach a desired compressive strength (40 MPa at 28 days of curing) and consistency (consistency class S4 according to UNI EN 206 standard). Specific superplasticizers were selected, and set retarding agents were used to compensate the accelerator effect of chlorides.
The five different mixtures produced are characterized considering fresh and hardened concrete properties, resistance to concrete degradation, and resistance to carbonation and chloride penetration, fundamental to the following studies related to reinforcements. Table 1 shows all tests planned, some of which belong to WP1, and are reported in this report.

Table 1- Summery of the concrete tests planned

Test	Reference standard
Fresh concrete properties	
Slump test	UNI EN-12350-2
Fresh density	UNI EN 12350-6
Air content	UNI EN 12350-7
Hardened concrete properties	
Hardened density	UNI EN 12390-7
Compressive strength test	UNI EN 12390-3
Resistance to concrete degradation	
Drying shrinkage	UNI 11307
Presence and effect of Sulphate	Flat prism Method
Presence and effect of alkalis	UNI 8520-22
Resistance to freeze-thaw attack	CEN/TS 12390-9
Eluate analysis	DAfStb-guidelines: tank test
Resistance to carbonation and chloride penetration	
Water absorption and capillary suction	UNI EN 13057
Resistance to the penetration of carbonation under accelerated conditions and natural exposure condition	
Resistance to the penetration of chloride ions	NT-Build 492

Preliminary results

In Table 2 the mixture proportions for the five types of concrete, investigated in WP1, are presented.

The equivalent binder content was determined according to the K factor depending on the cement used, following EN 450 standard, and through the following formula:

$$b = c + K \cdot fa$$

where:
c is the cement content in kg/m^3
fa is the fly ash content in kg/m^3
b is the total binder content in kg/m^3

Table 2- Mixture proportions

Ingredients	Units	*Mix A*	*Mix B*	*Mix C*	*Mix D*	*Mix E*
Reference cement	kg/m^3	335	-	335	335	-
Fly ash	kg/m^3	30	30	30	30	80
Seacon cement	kg/m^3	-	320	-	-	325
Fresh water	l/m^3	175	175	-	180	180
Seawater	l/m^3	-	-	175	-	-
Sand 0-2 mm	kg/m^3	493	493	493	489	475
Sand 0-4 mm	kg/m^3	600	600	600	496	579
Gravel 4-12.5 mm	kg/m^3	744	744	743	369	717
RCA	kg/m^3	-	-	-	347	-
Superplasticizer	kg/m^3	3.1	4.1	3.5	3.5	3.8
Retarding agent	kg/m^3	-	-	0.8	-	0.8
w/b ratio	-	0.51	0.51	0.51	0.53	0.53

The tests are still going, anyway some preliminary results already available are presented below, in particular the fresh properties and the strength development of the concrete's mixtures.
Table 3 reports the test results for voids content, fresh density and slump at the initial time, and at one hour after mixing. The fresh density values range from 2,372 to 2,414 kg/m^3. Mix D exhibits the lowest value due to the minor density of RCA (2,574 kg/m^3 compared to 2,740 kg/m^3 of the natural gravel).
The voids content values do not change significantly from a mix to another.
The slump test values demonstrate that all the mixtures exhibit a consistency in complying with the provisions of the consistency class chosen (160-210 mm). Nevertheless, most of the mixtures do not maintain the workability over time. In fact, the values measured one hour after initial mixing are rather reduced compared with those measured at the mixing time. Accordingly, a more accurate study on the use of specific admixtures is necessary to extend the workability.

Table 3- Fresh properties

Fresh properties	Units	*Mix A*	*Mix B*	*Mix C*	*Mix D*	*Mix E*
Voids content	%	2.3	1.9	1.9	2.1	2.0
Fresh density	kg/m^3	2411	2414	2404	2372	2405
Slump t=0	mm	180	210	170	175	190
Slump t=60 min	mm	155	170	120	40	145

Fig. 3 shows the strength development of the five mixtures up to 90-days. At 28-days, all mixtures exceeded the design limit value of 40 MPa.

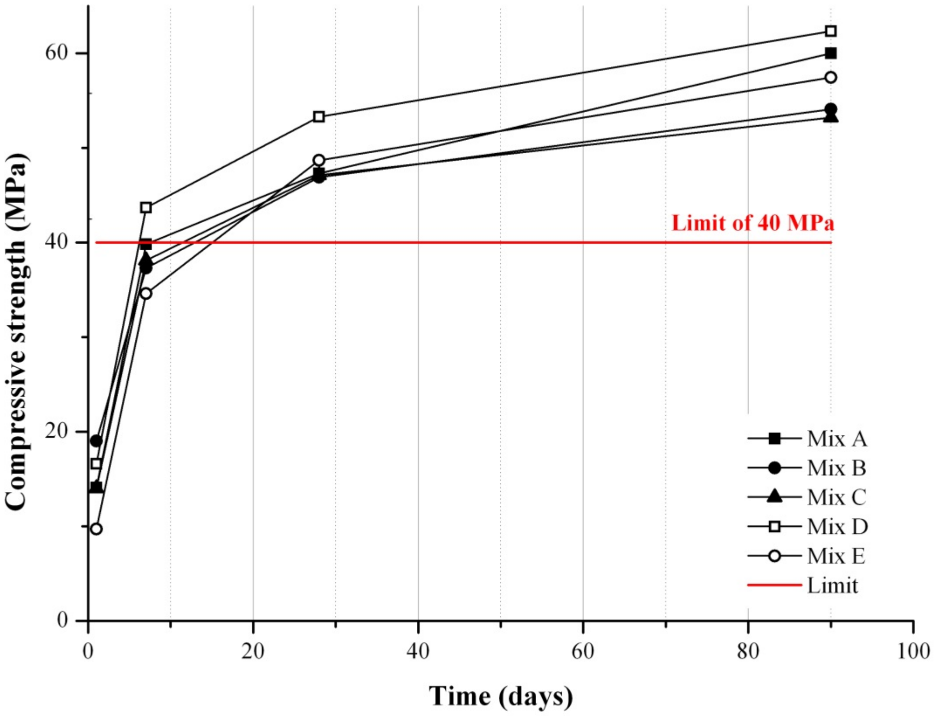

Figure 1- Compressive strengths over time

The eluate analysis was performed in order to assess the leaching of the main elements (chloride and sulphate) according to the DAfStb-guidelines, Tank test (ref. Grundsätze zur Bewertung der Auswirkungen von Bauprodukten auf Boden und Grundwasser, pag. 58, Table II-A.3).
Table 4 reports the chloride and sulphate amount in ppm released at different time (1, 3, 7, 16, 32 and 56 days) and the total sum for all the investigated mixtures.

Table 4- Chloride and sulphate amount through ionic cromatography

ppm		Chloride	Sulphate
Mix A	1 d	-	1.46
	3 d	-	1.41
	7 d	-	1.41
	16 d	-	0.74
	32 d	-	2.92
	56 d	-	2.54
	Sum	-	10.48
Mix B	1 d	0.56	1.24
	3 d	0.57	1.04
	7 d	0.31	-
	16 d	7.97	-
	32 d	0.96	-
	56 d	0.64	-
	Sum	11.01	2.28
Mix C	1 d	11.72	1.25
	3 d	6.95	1.01
	7 d	4.08	-
	16 d	0.32	-

ppm		Chloride	Sulphate
	32 d	12.94	-
	56 d	10.06	-
	Sum	46.07	2.27
Mix D	1 d	4.08	0.73
	3 d	3.29	0.89
	7 d	3.62	1.47
	16 d	2.94	1.96
	32 d	3.45	2.88
	56 d	2.47	1.98
	Sum	19.85	9.91
Mix E	1 d	1.89	1.79
	3 d	1.73	1.28
	7 d	1.85	1.48
	16 d	1.74	1.75
	32 d	1.96	2.57
	56 d	1.42	1.63
	Sum	10.59	10.5

The eluate results highlight that the presence of a chloride-contaminated component is sufficient to find chloride in the contact solution.

Mix A, the reference one, doesn't contain chloride; on the contrary, Mix C, produced using seawater, releases the greatest amount. Besides, Mix D, containing contaminated RCA, releases a high amount of chloride.

The addition of fly ash in the mixtures seems to be ineffective in the reduction of the mobility of the chloride ions.

Therefore, these results show the need for some addition in the mixtures in order to counteract the chloride release phenomena.