BYG515-G Specialization Project

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Title:

A Study of Chloride Intrusion in White Concrete for The New Knubben Harbour Bath

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Case

The outdoor swimming harbor bath Knubben in Arendal is proposed reconstructed as a gift for the upcoming 300-year anniversary of Arendal in 2023. The architect firm Snøhetta has developed the new concept inspired by islets and skerries along the Norwegian coastline, which can be viewed in Figure 1. The old facility needs extensive modernization to become a multi-use site that can be used for much more than just swimming activities.

Figure 1 The new Knubben harbour bath

The superstructure is proposed made in cast-in-place concrete. This project stands out in that the architects have decided to use white concrete. The structure needs to withstand the wear and tear from the marine environment.

The quay decks, skirts and structures in tidal zones shall be carried out the qualities shown in Figure 2.

Concrete qualities		
Exposure class	Durability class	Strength
XS3	MF40	B45

Figure 2 White concrete quality

The aim for this project is to compare chloride intrusion in context with compressive strength between seldom used white concrete and ordinary grey concrete (Figure 3).

Figure 3 Test specimens

This aim led to the following research question:

Research Question

How is the white concrete affected by chloride intrusion in the early stages of the curing phase?

- How is the chloride intrusion of the white concrete compared to grey concrete of equivalent quality?
- How is the relation between the chloride intrusion and the compressive strength of the concrete?

Testing methods

To test the compressive strength the Norwegian Public Roads Administration's handbook R210 "Laboratory Examinations", method "421 Compressive Strength, Cubes and Cylinders" was used. For testing the chloride intrusion, the test method NT BUILD 492 "Chloride migration coefficient from non-steady-state migration experiments" was utilized.

Results

The results of the test are as shown in Figure 4 and 5.

	ID-nr.	Strength [MPa]	Average
	White		
2 days	2.1	38,1	38,567
2 days	2.2	39,3	
2 days	2.3	38,3	
2 days	Gray		
2 days	2.1	37,8	
7 days	White		
7 days	7.1	48,1	48,867
7 days	7.2	48,9	
7 days	7.3	49,6	
7 days	Gray		
7 days	7.1	50,8	
14 days	White		
14 days	14.1	47,7	51,267
14 days	14.2	54	
14 days	14.3	52,1	
14 days	Gray		
14 days	14.1	58,5	

Figure 4 Compressive strength

	ID-nr.	Dnssm [×10-12 m2/s]	Average
		2 days	
White	1	16,935	17,748
White	2	25,793	
White	3	10,518	
Grey	4	24,669	24,887
Grey	5	25,105	
		7 days	
White	6	15,950	14,000
White	7	13,800	
White	8	12,251	
Grey	9	12,013	13,601
Grey	10	15,189	
		14 days	
White	11	12,212	12,129
White	12	12,482	
White	13	11,693	
Grey	14	6,976	6,394
Grey	15	5,812	

Figure 5 Chloride intrusion

Figure 6 presents the context between the compressive strength and the chloride intrusion as functions of time for the white and the grey concrete. Figure 7 shows the chloride intrusion in one specimen.

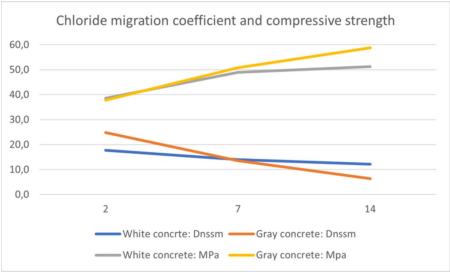

Figure 6 Chloride coefficient and compressive strength

Figure 7 Chloride intrusion in specimen

Conclusion

The white concrete resistance to chloride intrusion in the early stages of the curing phase of the concrete is stable, the resistance improves slightly over time, but there are no major changes. The white concrete has an initial resistance to chloride intrusion better than the grey. However, the grey increases it's intrusion resistance greatly from day 2 to day 14.
It does not appear that the white concrete's increase in strength over time affects the chloride migration coefficient significantly. For the grey concrete, it seems that the increase in strength corresponds to a lower chloride intrusion of the concrete.