Studying effect of addition green inhibitor on compression strength of reinforced concrete

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Abstract. In recent years the use of inhibitors in producing high-performance concrete has increased significantly to mitigate chloride and sulphate attacks. The present inhibitors in the market are toxic to the environment. Hence, the objective of the present investigation was to study a novel, eco-friendly and green waste plant (orange peel) extracts inhibitor and study its effects on compression strength of reinforced concrete. This inhibitor was added to the concrete mix with concentrations of 1\% and 3\% by weight of cement with two types of superplasticizers. Results showed that the tested penetrating type corrosion inhibitor as an admixture of the concrete samples did not impair on compressive strength, but with one of the superplasticizers showed higher (acceptable) values compared to the other type of superplasticizer due to the difference between their ability in reducing the ratio of water of the concrete samples.

1. Introduction

Corrosion of steel rebar in reinforced concrete structures is a big problem which might and cause significant human and economic losses. One of the most important reasons of corrosion in reinforced concrete is chloride attack. The main sources of chlorides are seawater and de-icing salts. Also, there are other sources of chlorides for example from gravels, sand, cement, water (being used for preparing the mixture of fresh concrete) and sometimes from (contaminated) steel rebar. In the subsistence of chloride, the protective passive stratum of steel is locally destroyed and the unprotected steel areas start dissolve. The formation of corroding products (rust) involves a substantial volume increase, i.e. the volume of corrosion products is greater than that of original steel bar. Therefore expansive stresses are induced around corroded steel bars causing possible cracking, spalling of concrete cover and loss of bond between steel/concrete (as shown in Fig. 1), and thus reducing the serviceability of concrete structures [1-8].

![Figure 1. Corrosion by chloride ions and carbonation [8]](image-url)
Among the many methods used to solve or reduce problems of corrosion in concrete, the use of corrosion inhibitors is gaining widespread acceptance due to its many advantages including ease of application, comparable lower costs and high effectiveness. Also, toxicity problems usually encountered from the use of inorganic chemical inhibitors are finding the solution via proposed alternatives of non-toxic organic chemicals or outright usage of green, environmentally-friendly extracts from natural plant materials, which are known to be rich in biocompatible organic chemicals [9]. The main purpose of this paper is to present the results of an experimental study on the compressive strengths to monitor and evaluate the effect of green inhibitor and superplasticizers of test samples prepared from concrete type XD3.

2. Materials and Methods

2.1 Materials and Samples Preparation
Portland slag cement CEM II/A-S 42.5R was used in this study conforming to the EN 197-1 [10] and it received from CRH Magyarország Kft. company in Miskolc, Hungary. Aggregates (fine and coarse) were used according standard EN 12620 [11] and it was also received from the CRH Magyarország Kft. company. Orange peels extract as a green inhibitor and two types of superplasticizers (Mapei Dynamon SR 31 and Oxydtron) were used. Tap water was used for both making and curing the specimens.

Concrete mixes were designed in accordance with the European mix design method (XD3 class) to have compressive strength C35/45 at age of 28 days. Two times three samples were prepared (with the two different plasticizers) and the two sets of three and three samples contained in 0%, 1%, 3% the green inhibitor as well as shown in Table 1. The concrete cubes so prepared for compressive strength testing had dimensions of 70x70mm. The molds were thoroughly cleaned and oiled before casting to avoid adhesion with the concrete surface. Mixing of materials was done manually after that water added to the mix with continued mixing, then the mix was put in the molds.

The specimens were taken out from the molds after 24 hours hardening, then were immersed in tap water as in Fig.2.

Table 1. The concrete mixtures (specimens) prepared for this study

| Symbol of Mix | Type of Admixture | Concentration of Green Inhibitor |
|---------------|-------------------|----------------------------------|
| A1 (Reference)| Mapei Dynamon SR 31| without                          |
|                |                   |                                  |
| B1             | Mapei Dynamon SR 31| 1% by weight of cement           |
| C1             | Mapei Dynamon SR 31| 3% by weight of cement           |
| A2 (Reference)| Oxydtron          | without                          |
|                |                   |                                  |
| B2             | Oxydtron          | 1% by weight of cement           |
| C2             | Oxydtron          | 3% by weight of cement           |

Figure 2. Curing of compressive strength specimens in tap water
2.2. Compressive Strength Test

The concrete compressive strength was measured by using a compressive strength testing machine (Kispesti Vas és Fém KTSZ) in the workshop of Institute of Ceramics and Polymers Engineering at Faculty of Materials Science and Engineering, University of Miskolc. The reported values are the average of three specimens for each age (nine for each mix).

3. Results and Discussion

Fig.3 shows the results of compressive strength test at age 28 days for each mix.

![Figure 3. Compressive strength of concrete samples after immersion in tap water for 28 days](image)

The results showed that:

1. For Dynamon SR 31 admixture in concrete there was not much reduction observed in the compressive strength. (Without this admixture the given type concrete should have compression strength of C35/45 MPa at age 28 days.)

2. By using the orange peels extract as corrosion inhibitor in conc. 1% and 3% by weight of cement, it reduced the compressive strength considerably by 10.5% for 1% addition and 13% for 3% addition, respectively. (2) For Oxydtron admixture with concrete causes reduction in compressive strength more than Dynamon SR 31 admixture in sample without green inhibitor. After using green inhibitor with 1% and 3% by weight of cement affect compressive strength with an increase 3.3% for 1% addition and 16.6% for 3% addition respectively. That’s may be due to this inhibitor works as a retarder, it retards the action or effect of tricalcium silicate (C3S) or tricalcium aluminate (C3A) and these action modifies the compressive strength at the early ages of the concrete. The increase in compressive strength after addition green inhibitor because adding inhibitor mean decreasing the amount of cement (inhibitor adding to concrete by weight of cement%), so with increasing the concentration of inhibitor leads to decreasing the cement (decreasing the hydration components because it depends on water and cement) and already causing increasing the compressive strength.

Comparing the effect of superplastizers we found that Dynamon SR 31 caused reduction in water during the hardening process of concrete more than Oxydtron and these reduction in water caused increase in strength of concrete and also decreased the porosity as a consequence of a series of chemical reactions (called hydration) of cement with water to form the binding material. The hydration reaction of ordinary Portland cement (OPC) involves four major types of hydration components, i.e. tricalcium silicate (C3S), belite (C2S), tricalcium aluminate (C3A), and ferrite or brownmillerite (C4AF). More water in the concrete means more hydration components and decrease in the capillary porosity and finally decrease in strength of concrete because the strength depends also on the capillary porosity.
4. Conclusion
From compared effect of the two types of admixtures that used in this work we noted the compressive strength in general was a little bit higher with Dynamon SR 31 than with Oxydtron, that means the superplasticizer (Dynamon SR 31) caused greater reduction of water than Oxydtron and these reduction in water caused increase in strength of concrete and also must have decreased the porosity, but at some points it also might cause some risk because at these points it may introduce the risk of autogenous shrinkage and cracking.

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