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Influence of the type of release oil on steel formwork corrosion and facing aesthetics

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HIGHLIGHTS

- The observed variations in wetting power with respect to the formwork do not appear to be significant for facing quality.
- The film thickness for vegetable-based oils stands out as a critical parameter in controlling the dusting phenomenon.
- The interface structure tends to favour protecting formwork surfaces against corrosion.
- The obtained results reveal a better resistance by vegetable oil-based films.
- The synthetic ester enhances the protective power of the film, resulting from the formation of a double soap layer.

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ABSTRACT

The quality of the concrete facings results from the implementation of release agents and the casing surface quality. It is interesting to characterize the behaviour of release agents over the lifetime of the formwork. This study is based on the many ones test physicochemical and esthetics realized on two types of surface of formwork like on three types of applications. In complement, the ageing of the casing formwork was characterized by electrochemical spectroscopy of impedance and thanks to the correlation with the aesthetic tests will allow to find from new mechanisms to the interfaces related to the studied oil's formulations.

1. Introduction

When removing formwork, two distinct elements become clearly apparent, namely the formwork itself which consists of a smooth and stiff material, and a concrete, a water-containing plastic material. From the time of concrete casting, there is an affinity between these two materials, and their interface gives rise to certain physicochemical mechanisms that are still poorly known. Once the concrete has hardened, the two elements can be separated: Such a step is commonly known as formwork removal. In the absence of an anti-adhesive separating layer (release oil), bonding would automatically occur, making its unmolding impossible without altering the facing surface [1]. Consequently, the aesthetics of these facings is directly correlated with the type of concrete/formwork interface.

In order to limit phenomena leading to the corrosion of metal form plates, metal formwork manufacturers (PERI, OUTINORD, SATECO, to name a few) have expressed interest in using new release oil mixes, which are capable of extending the formwork life cycle [2]. For this reason, release agents must be selected on the basis of the type of formwork and its compatibility with formwork skins. Such agents must be applied evenly across the entire formwork, on a clean surface and in thin layers of uniform thickness, before installing reinforcements [3].

It is noted that mineral oils remain very widespread despite their resulting environmental impact. Release agents are actually included in the category of lost lubricants, in particular through leaching into the water table from lubrication zones. Moreover, oil-based release agents cause a number of known nuisances for

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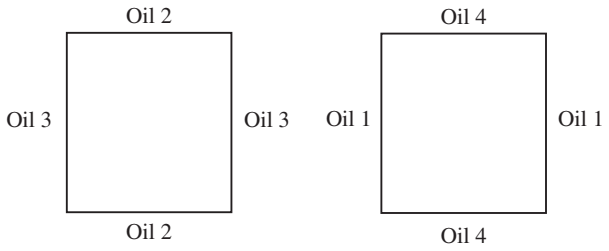


Fig. 1. Application pattern of test oils on the mould walls.

users, and related professional diseases have been catalogued by the French office of public health insurance (skin irritations by cutaneous exposure and inhalation of volatile organic compounds) [4]. To overcome these disadvantages, oils with vegetable-based formulations [5] and synthetic oils, both presumed to be less harmful to humans and the environment, have been developed.

To promote use of these oils in the concrete industry, the national union trade organization, which represents producers of concrete admixtures and mortars (SYNAD), has adopted a new charter on release oils in 2010 [6] having served to revise the year 2000 classification, so as to provide users with greater clarity, while pursuing the same objective of the enhanced use of vegetable oils.

Despite the entry of these new mix designs into the market, data are still insufficient to fully understand the specificities of their respective product families in terms of performance and use conditions. Therefore, the aim of the present study is to assess the influence of release oils on the quality of facings as well as on corrosion protection during outdoor formwork storage. The methodology adopted entails selecting four oil formulations: a vegetable oil (Oil 1), a synthetic oil (Oil 2), a mineral oil (Oil 3), and a vegetable oil associated with a synthetic oil (ester) (Oil 4).

2. Material and methods

2.1. The moulds

Eight 30 × 30 × 30 cm^3 moulds were produced by a formwork manufacturer. The volume of the moulds is of 27 l. The moulds were built with both new and used walls. Two moulds were required per test since the oils are to be applied on mould surfaces according to the following scheme (Fig. 1).

The distribution of the moulds used in these tests was carried out as follows:

- Two new moulds (see Fig. 2) for application by spraying with conic and flat nozzles.
- Two new moulds for application by spraying followed by scraping.
- Two used moulds (see Fig. 3) for application by spraying with conic and flat nozzles.
- Two used moulds for application by spraying followed by scraping.

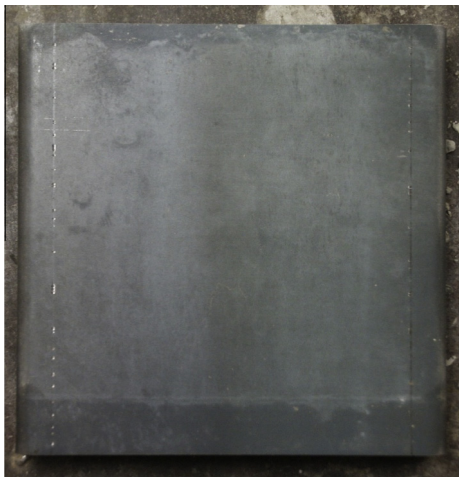


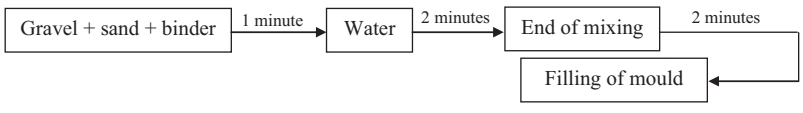
Fig. 2. New formwork surface.

Fig. 3. Used formwork surface.

2.2. The concrete

To avoid the kinds of physicochemical reactions not easily interpreted between release oil ingredients and the admixture sometimes present in concrete, a conventional concrete without any admixtures was prepared for our study. Other studies [7,8] are currently underway using various self-compacting concrete designs in order to examine interactions between chemical compounds in the oils and concrete. For our study, a 10-cm slump has been obtained using the Abrams cone. The composition of the test concrete is gathered in Table 1.

This concrete was produced at a 200 l capacity mixing plant. Mixing was carried out in accordance with the Standard NF P 18-404, entitled "Concretes: Mix design, suitability and inspection tests – Casting and storage of test specimens", which specifies the following operating procedure:



The roughness of a surface is measured by moving a pick-up lift following a direction parallel at average surface to analyze. Measurements are carried out by a roughometer Surtronic 3+. The device precision is ±0.1 μm.

The roughness values of mould surfaces were Ra = 1.30 μm for the new surface and 1.70 μm for the used surface. Ra is the most widely used international roughness parameter: it is the arithmetic average of profile deviations with respect to an average line.

The tests were conducted in the laboratory at room temperature (about 20 °C). The concrete was cast simultaneously in all moulds, with each mould being filled in two layers followed by vibration in 5 places for 10 s per layer.

It should be noted that our study has focused on aesthetic flaws encountered in the concrete facing after formwork removal [9]. The two modes of application described above were analysed from this perspective. In addition, colour variations, micro-bubbling, dusting on the concrete facing, dirtying, and dusting and