مجلة جامعة بابل / العلوم الهندسية/ المجلد 11/ العدد 5 : 2006

PROPERTIES OF CONCRETE CONTAINING PARAFFIN WAX

Tumadhir M. Al-Jabiri
University of Al-Qadissiya, College of Engineering, Civil Department

Abstract

This study was carried out to investigate the effect of adding the paraffin wax as a waterproof admixture on some properties of concrete like compressive strength, ultrasonic pulse velocity, dynamic modulus of elasticity, absorption and density. Ordinary Portland cement was used in this study, replacing partial of its weight by the paraffin wax in the mix. The results showed that the increase in paraffin wax content results in decrease in compressive strength, absorption and other properties mentioned above.

KEY WORDS: concrete, paraffin wax, waterproof admixture, permeability, compressive strength, absorption, nondestructive test.

Introduction

Durability of concrete is the most important property in many structures, especially those exposed to a risk of the external chemical attack. The external chemical attack occurs mainly through the action of aggressive ions, such as chlorides, sulfates, or of carbon dioxide, as well as many natural or industrial liquids and gases [(1)]. Concrete durability depends largely on the ease (or difficulty) with which fluids (water, carbon dioxide, oxygen) in the form of liquid or gas can migrate through the hardened concrete mass. Concrete is a porous material, therefore, moisture movement can occur by flow, diffusion, or sorption[(2)].

Permeability is a measure of the concrete's ability to resist penetration of water or other substances, some authors emphasize that the permeability of the water is the most important factor to esteem the durability under the most diverse conditions of service of a structure. As the material's permeability is lowered, the resistance to the penetration by these aggressive agents is increased. Accordingly, an effective way to improve concrete durability to ingress of harmful agents is to require low permeability [(3)]. There is a great deal of misunderstanding of the terms water permeability and waterproof. Water permeability is a most commonly thought of when discussing "high performance concrete". Waterproof is a term often used when describing the ability of a structure to hold in or hold out water. However, the problem of creating durable structures fit for their designed purpose requires a broader understanding of what exactly is meant by low permeability concrete and waterproof concrete [(4)]. The addition of the admixtures to get low permeable concrete is widely used in practice. Admixtures are chemical or mineral substances which are added to a concrete mix during its preparation, they serve to alter one, or a number of the material's wet and/or set properties. Water reducers, set retarders and accelerators, air entraining agents, and super-plasticizers are common type of chemical admixtures. Mineral admixtures are usually classified as either cementitious materials (i.e. ground-granulated blast furnace slag and lime), or pozzolans (i.e. Fly ash and silica fume)[(5)]. Many researches have been made about the use of admixtures to enhance the durability and reduce the permeability of concrete.

Paraffin wax, results from petroleum industry, is one of the waterproof admixtures, it was used, in some researches, as emulsion or apart from fine aggregate[6]. In this study the paraffin wax, which is considered as a low cost admixture in Iraq, was used as apart from cement and its effect on some properties of concrete especially the permeability was investigated.

Experimental Work

Materials and Mix Compositions

Ordinary Portland cement was used in the mix, replacing (10%, 20%, 30%) of its weight by the paraffin wax, brought from Al-Dora Refinery station, after chopping it to a very fine particles. Natural sand from Al-ekhedhir deposit and a river gravel with (19mm) maximum size conformed to IOS(No.45-1984) grading were used. ACI method for mix design (ACI200.1-91) was followed to get (20)MPa concrete compressive strength (cube specimen) with (0.6) W/C. The mix proportions were (1:2.06:2.64) (cement : sand : gravel) by weight of cement. (150x150x150)mm concrete cubes were made for all tests. Table (1) shows the constituents of concrete mixes.

Table (1) Constituents of concrete mixes.

Paraffin wax addition (%)	Cement (kg/m^3)	Coarse aggregate (kg/m^3)	Fine aggregate (kg/m^3)	Water (kg/m^3)
0	400	1056	824	240
40	360	1056	824	216
80	320	1056	824	192
120	280	1056	824	168

Mixing, Casting and Curing

The hand method for mixing was used. The sand and gravel were mixed together, then the cement with paraffin wax particles were added. The dry materials were mixed until the mix appears uniform, then the water was added and mixing continued. The concrete was cast and compacted in the cube moulds. After (24) hrs the concrete cubes were demoulded and placed in a water tank and tested at three ages: (7, 28 and 90) days.

Results and Discussion

Compressive Strength Test Results

The results obtained from the compressive strength test show that an increase in paraffin wax content leads to decrease the compressive strength of concrete **Fig.(1)**. This is mainly due to the reduction in cement content when replacing it by paraffin wax and then the W/C increase. These results are in agreement with those obtained by Al-Nassar in his study on the effect of the waterproof admixtures on the compressive strength of concrete [7]. So, as Patrick and McGrath classification [4], the addition of paraffin wax as apart of cement do not produce water permeable concrete.

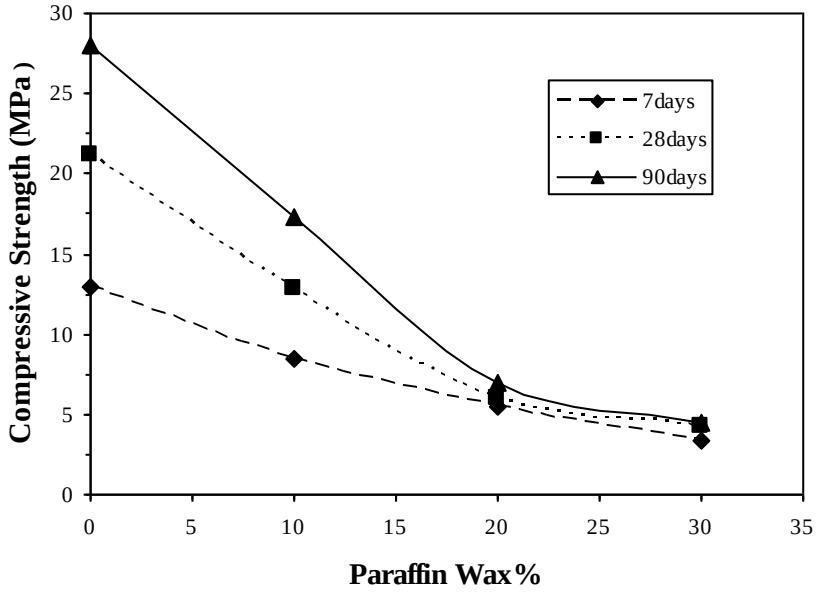

Fig. (1) Relationship between compressive strength of concrete and Paraffin wax content

Nondestructive Tests Results:

The principle of this test is that the velocity of sound in a solid material, V, is a function of the square root of the ratio of its dynamic moduluse of elasticity, E, to its dencity, ρ ,[8]:-

$$V = \left(\frac{ED}{\rho} \right)^2 \quad \text{or} \quad ED = \rho V^2$$

And $V = \frac{L}{T}$ where;

L: pulse length = specimen length.
T: time required to penetrate the specimen by the pulse.

Table(2) shows the results obtained from ultrasonic pulse velocity test and **Fig.(2)** shows the relationship between the ultrasonic pulse velocity (UPV) with the paraffin wax content. It is clearly that there is a significant reduction in UPV with increasing the paraffin wax content, this reduction confirmed the results obtained from compressive strength test. UPV of concrete without paraffin wax can be classified as excellent, UPV of concrete with addition of paraffin wax can be classified as good or satisfactory, **Table(3)** [9].

Table (2) UPV Test Results.

paraffin content %	UPV (km/sec)
0	4.84
10	4.37
20	3.96
30	3.09

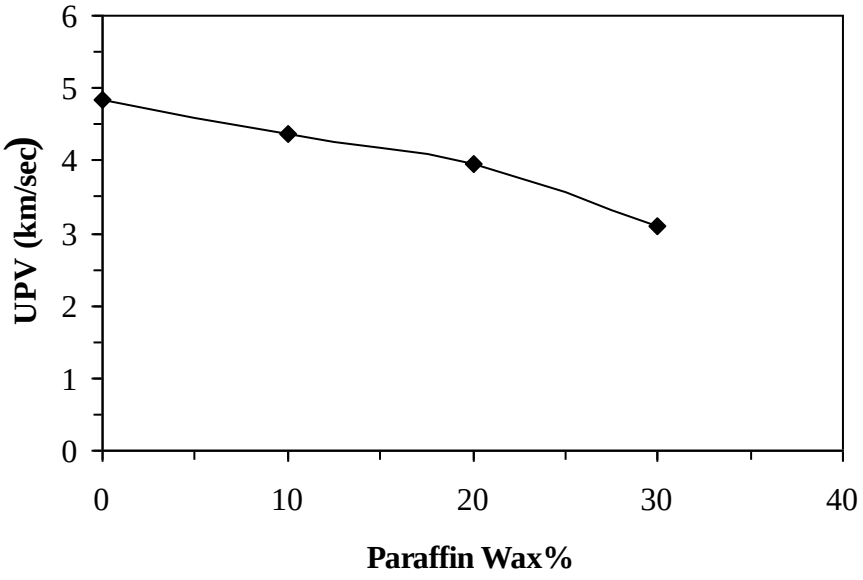

Fig. (2) Relationship between UPV and Paraffin wax content

Table (3) . Jones classification for concrete related to UPV results [9]

Concrete Quality	Velocity (km/sec)
Excellent	≥ 4.58
Good	4.57-3.66
Satisfy or Suspicion	3.66-3.05
Weak	3.00-2.14
Very Weak	≤ 2.14

From the same test results, the dynamic modulus of elasticity can be calculated. As mentioned earlier there is a direct relationship between dynamic modulus of elasticity and square of the pulse velocity, so it expects that the addition of paraffin wax has the same effect on the dynamic modulus of elasticity i.e. reversal relationship between dynamic modulus of elasticity and paraffin wax content **Fig. (3)**.

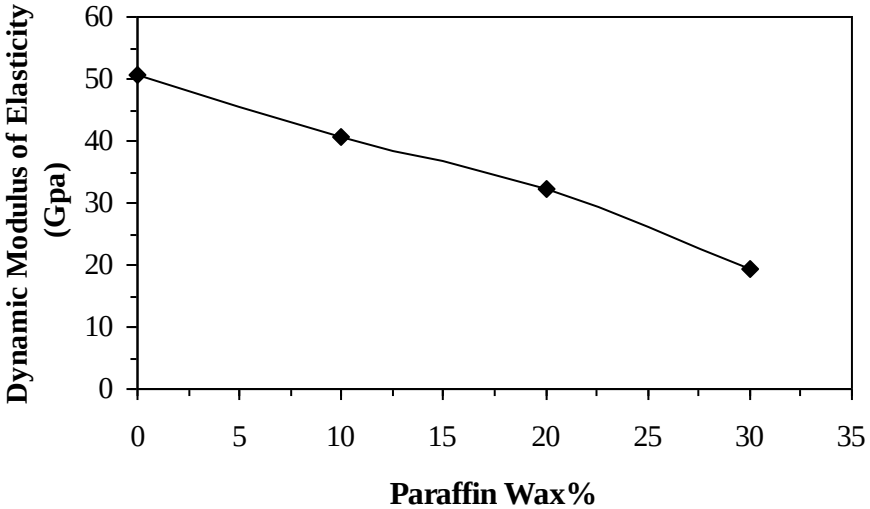

Fig. (3) Relationship between dynamic modulus of elasticity and Paraffin wax content

Absorption and Density Tests Results

Because of the impossibility to do the permeability test, the absorption and density tests adopted to be a measure for waterproofing of concrete. In these tests, the specimens have been weighted after drying it, in oven, at 110^{o}C and then weighted after immersing it in water for further (24) hrs [10]. The results obtained from these tests show that the addition of paraffin wax results in a decrease in water absorption of concrete **Fig. (4)**., generally increasing of paraffin wax content leads to decrease the density of concrete **Fig. (5)**. It can be observed that the decrease in density for the drying specimens is more than for the wet specimens. This means that some water has penetrated the concrete, but the deference between the two methods, decreases when paraffin wax content increases. As discussed earlier the paraffin wax can be used to get waterproof concrete [4].

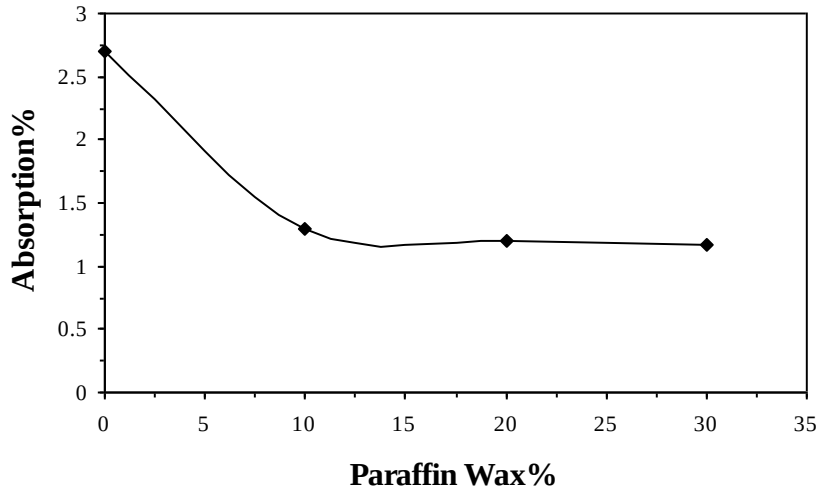

Fig. (4) Relationship between absorption and Paraffin wax content

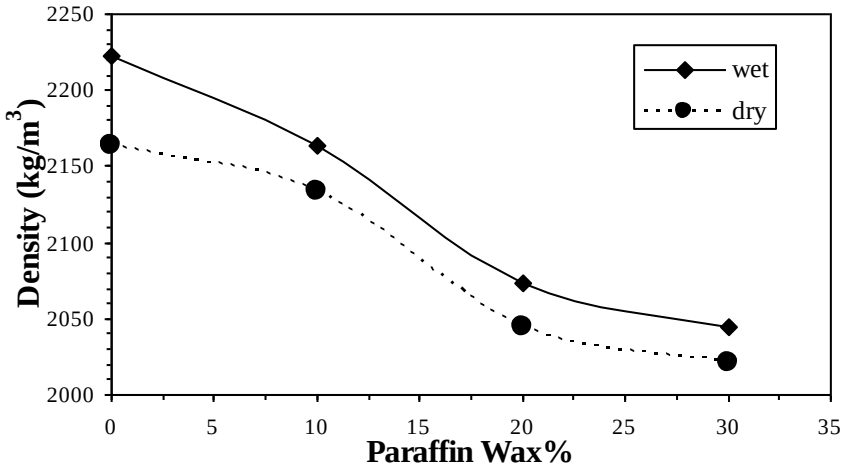

Fig. (5) Relationship between density of concrete and Paraffin wax content

Conclusion

According to the results obtained in this study, it can be concluded that the increase in paraffin wax content, added as apart of cement, results in decrease the compressive strength, absorption, density, UPV and dynamic modulus of elasticity. Paraffin wax can be used as a low cost admixture to get waterproof concrete rather than water permeable concrete,

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الخلاصة

يتناول هذا البحث دراسة تاثير اضافة شمع البرافين كمادة مانعة للرطوبة على بعض خواص الخرسانة مثل مقاومة الانضغاط , سرعة الذبذبات فوق الصوتية , معامل المرونة الديناميكي , الامتصاص والكثافة. استخدم الاسمنت البورتلاندي الاعتيادي في هذه الدراسة ويتم احلال شمع البرافين محل جزء من وزن الاسمنت في الخلطة. وقد اظهرت النتائج ان زيادة محتوى شمع البرافين يؤدي الى نقصان في مقاومة الانضغاط للخرسانة , الامتصاص والخواص الاخرى المذكورة اعلاه.