7-Conclusion

From the results presented in this paper, the following conclusions are drawn

1-Granite aggregates improved the abrasion resistance of concrete up to about 35%.

2-Incorporating 10% silica fume, as supplementary cementing materials, lowered the abrasion depth of concrete up to 15%.

3-The use of 10% S.B.R polymer in concrete mixtures showed about 20% improvement in abrasion resistance of concrete.

4-Decreasing the w/c ratio and using mechanical instruments in the finishing of the concrete floors decreased the abrasion depth of concretes.

5-There was a direct relationship between the compressive strength and the abrasion resistance of concrete specimens.

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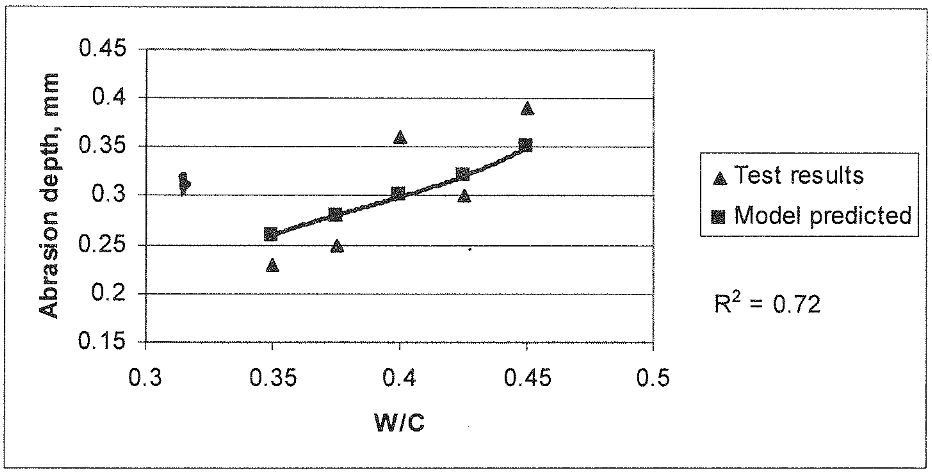

Figure (8) Relationship between abrasion depth and W/C.

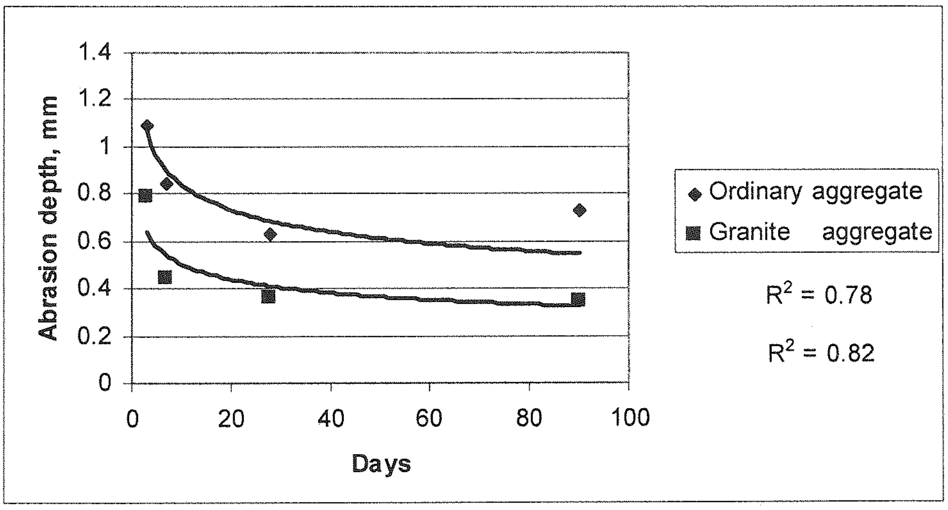

Figure (9)Relationship between abrasion depth and aggregate type.

6- Discussion

The use of granite aggregates in industrial floors and hydraulic structures improves the abrasion resistance of concrete. In fact as the content of granite in aggregates increased, the abrasion resistance of concrete was also improved and if all the aggregates were replaced by granite, this improvement could be reached about 35%. The use of silica fume and S.B.R polymer in concrete increased its abrasion resistance, too. Incorporation of 10% silica fume, as supplementary cementing material, improved the abrasion resistance of concrete up to 15%. Adding 10% S.B.R polymer in the mixtures improved the abrasion resistance of concrete up to about 20%.

This study shows that there are some interactions between the above factors and by optimization technique the final abrasion resistance can be improved up to 60%.

The W/C ratio and the finishing affected the abrasion resistance of concrete, such that lowering the W/C and mechanical finishing improved the abrasion resistance of concrete to about 35% and 25% respectively.

In this expression:
y = abrasion depth, mm
A= equal to 1 for ordinary aggregate and 0.74 for granite aggregate
B= equal to 1 for hand finishing and .79 for machine finishing
fc = compressive strength of concrete, Mpa
sf = percentage of silica fume to cement weight
R= S.B.R percent of S.B.R polymer to cement weight

In this research, three levels of abrasion resistance were defined. High abrasion resistance indicates the abrasion depth between 0 to .20 mm, medium abrasion resistance is for .21 to .45 mm and finally abrasion depth between .46 to .70 mm is designated as low abrasion resistance.

In order to show the validity of the model the results of some data obtained in experimental works and the output of the model are shown in Figs 6-9.

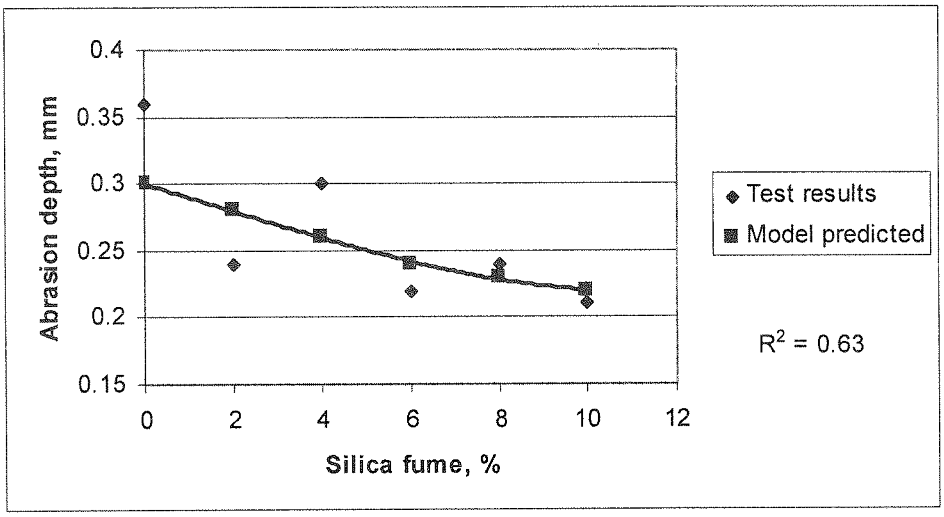

Figure (6) Relationship between abrasion depth and silica fume content.

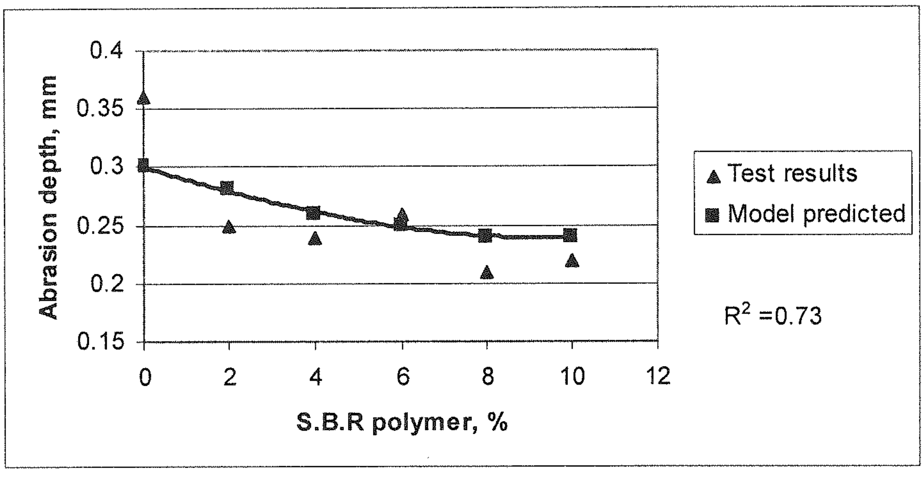

Figure (7) Relationship between abrasion depth and S.B.R polymer content.

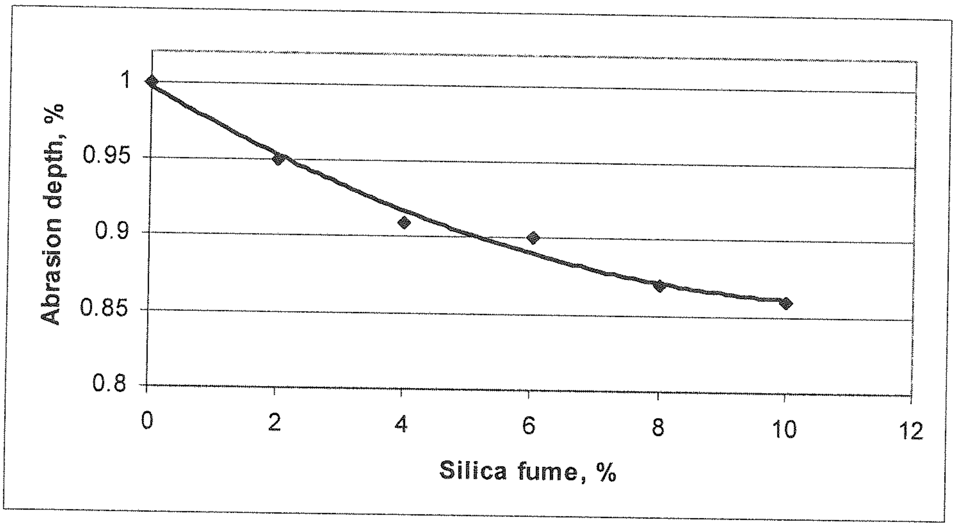

Figure (4) Improvement of abrasion resistance VS. Silica fume content.

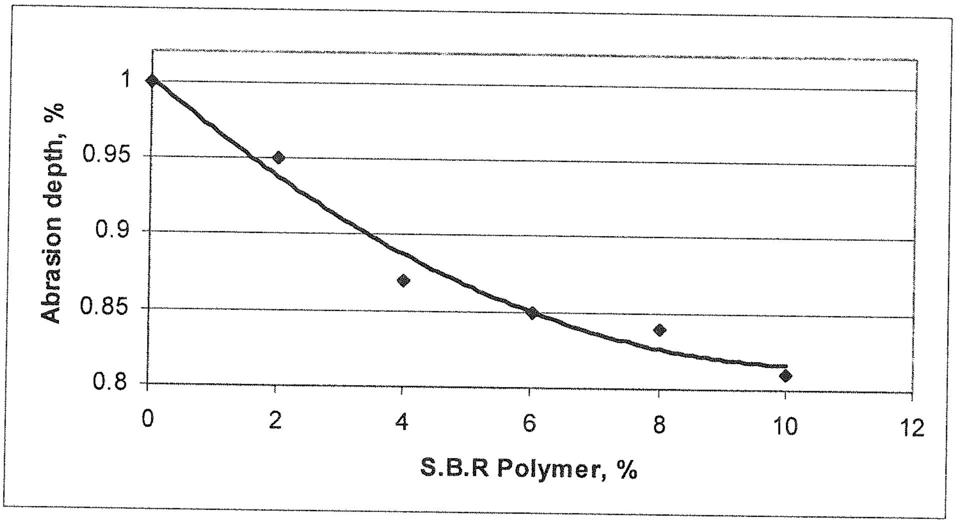

Figure (5) Improvement of abrasion resistance VS. S.B.R polymer content.

5- Abrasion model

According to the durability design and prediction of the abrasion resistance of concrete floors, a abrasion model is developed in this study. This model was adopted on experimental works. To devise this model, firstly the important parameters are related to the abrasion depth of concrete, separately. Then relationships between abrasion depth and each factor were estimated, then considering simultaneous effects, a general formula was resulted.

The parameters considered in the model are: compressive strength of concrete, aggregate type, percentage of silica fume and S.B.R polymer and finishing type. The suggested model is:

$$y = A.B.(5.82)\, fc^{(-0.684)}.\,(12sf^2-2.6sf+1).\,(-46.67R^3+20.86R^2-3.6R+1) \qquad (1)$$

granite or ordinary aggregate. The specific gravity and absorption values of the granite and ordinary aggregate were 2.66 and 0.87%, and 2.50 and 1.63%, respectively. The Los Angeles abrasion weights losses of the granite and ordinary aggregate after 500 revolutions were 14.3 and 17.6%, respectively. The natural river-bed sand with specific gravity and absorption values of 2.50 and 1.42%, respectively, was used for all ordinary aggregates. A melamine-based superplasticizer was used in the mixtures with the w/c of 0.35, to make it more workable.

3-Test program

The variable parameters in this program are summarized in Table 1.

Table (1) The variable parameters.

W/C	Aggregate materials	Percent of silica fume	Percent of S.B.R polymer	finishing
0.35,0.40,0.45	Ordinary and Granite	0 to 10	0 to 10	By hand and by machine

In above tests, the effects of each parameter and their interaction were studied. The specimens were tested at the ages of 3, 7, 28 and 90 days with revolving disk, also the compressive strengths were determined. In every test, 8 specimens for abrasion and 8 specimens for compressive strength were made.

The dimensions of the specimens for abrasion were 305x305x95 mm and for compressive strength tests were 150x150x150 mm.

4- Test results

The relation between compressive strength and abrasion resistance of concrete mixtures and the abrasion resistance improvement as a result of utilizing silica fume and S.B.R polymer are shown in figures 3 to 5.

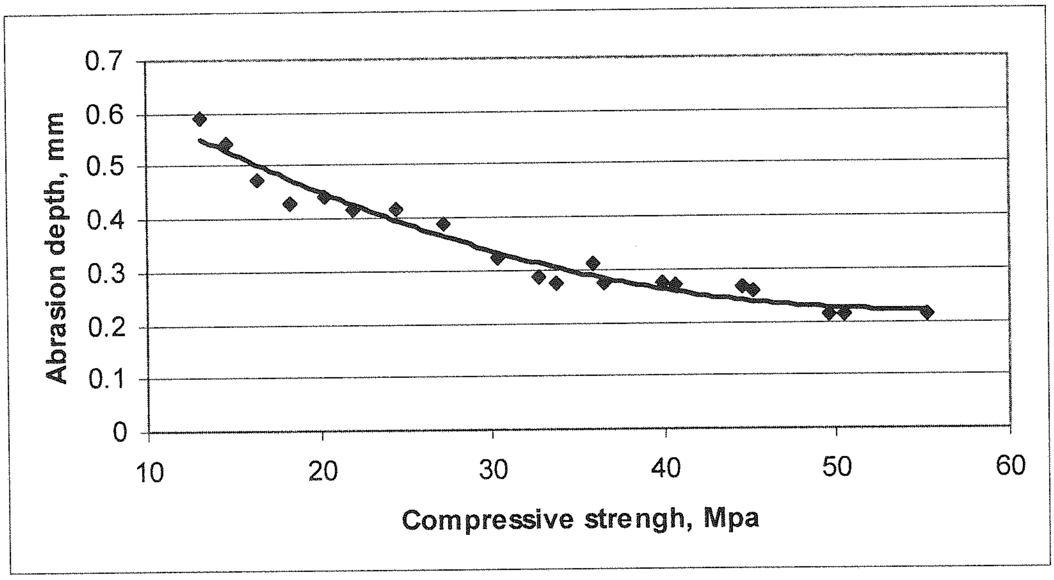

Figure (3) Abrasion depth VS. Compressive strength of concrete.

rotating-cutter method [4].

To evaluate the abrasion resistance of concrete floors, the standard test of ASTM C779-a was selected and, as shown in figures 1 and 2, the apparatus containing revolving disk system was manufactured and calibrated for the test procedures.

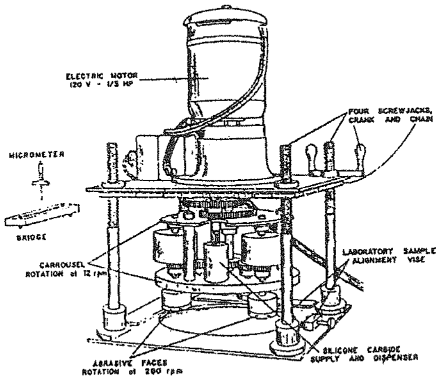

Fig (1) Revolving disk system in accordance with ASTM C 779-a.

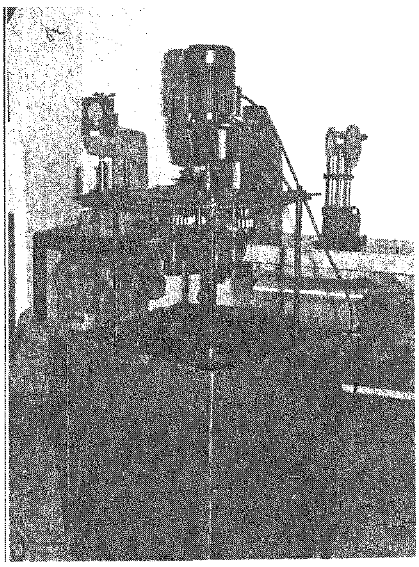

Fig (2) Manufactured revolving disk apparatus based on ASTM standard.

2-Materials and test procedures

The experimental program presented in this study consisted of testing 54 mixtures made with 2 types of aggregates, W/C ratio between .35 to .45, silica fume 0 to 10%, and S.B.R polymer 0 to 10% and surface finishing with hand and machine. In fact a special attention was given to ordinary concrete that are performing in most of industrial floors. The various mixtures were prepared with Type I Portland cements conforming to Iranian Standard A.B.A., such cements are similar to ASTM C 150 Type I Portland cements, silica fume with an SiO_2 content of 92% and S.B.R polymer were incorporated in some of mixtures. The mixtures were made with either

Investigation and Modelling of Abrasion in Industrial Concrete Floors

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Abstract

Abrasion damage in concrete slabs on the ground and hydraulic structures, which are widely used in the world, is a serious problem and may stop their serviceability. Nowadays, strength is not considered the only important factor in concrete properties, because of financial and engineering points of view; the durability of concrete in different conditions is prominent. In this study several mixtures of concrete with ordinary and granite aggregates, silica fume, S.B.R polymer and different W/C ratios were tested to evaluate abrasion resistance of concrete subjected to wearing caused by heavy traffics. The selected test was ASTM C779-a, test method for abrasion resistance of horizontal concrete surfaces. Also an rxperimental model for evaluating the abrasion resistance of concrete was suggested. The results show that the incorporation of silica fume, S.B.R polymer and also granite aggregates in concrete improve its abrasion resistance. The suggested mathematical method can predict abrasion resistance of concrete by determining the abrasion depth.

Keywords

Concrete, abrasion resistance, industrial floors, silica fume, S.B.R polymer, finishing, granite aggregates, durability, experimental modelling.

Introduction

The abrasion resistance of a concrete slab in an industrial area can be defined as the ability of the concrete surface to resist being worn away by rubbing, rolling, sliding, cutting and impact forces [1]. In industrial floors the usage of epoxies with special components and in hydraulic structures using some resins and sometimes increasing the cement content up to 600 kg per m^3 and also utilizing steel fibers have been suggested. However these methods are not cost-effective and laboratory studies are useful to find more acceptable methods in these conditions.

In this research the abrasion resistance of concrete floors, in particular the factors affecting abrasion resistance, such as W/C ratio, aggregate types, silica fume and S.B.R polymer and finishing were studied. To predict the abrasion resistance of concrete before construction a mathematical method was developed.

1-Test methods

Simulation of the abrasion-erosion of structures in laboratory scale is difficult, but the standard tests are very helpful. The suggested methods of ASTM for testing the abrasion resistance of concrete are:

a) ASTM C 418, standard test method for abrasion resistance of concrete by sandblasting [2].

b) ASTM C 779, standard test method for abrasion resistance of horizontal concrete surface [3].

c) ASTM C 944, standard test method for abrasion resistance of concrete or mortar surfaces by