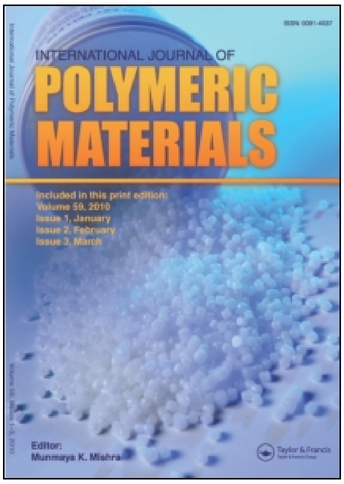

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Porosity Effect in Polymer Impregnated Concrete

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The effect of porosity on the compressive and tensile strengths of styrene-acrylonitrile copolymer impregnated concrete was investigated. The porosity change was achieved by changing water to cement ratio and adding naphthalene to the mortar mixture. Both the compressive and the splitting tensile strengths of concrete were found to be function of polymer loading, concrete matrix, pores, and interconnections between pores.

KEY WORDS Polymer impregnation, Concrete, Pore distribution, Compressive strength, Tensile strength, Radiation

INTRODUCTION

In the past, there has been found a strong correlation between the amount of polymer impregnated into the concrete and the strength of the resulting polymer concrete composites. For instance in a previous research it was found that the ratio of increase in compressive strength of polymer impregnated concrete (PIC) having a 4.3% polymer loading was about 1.1 times that of the unimpregnated sample while a 4 times increase was observed when polymer loading was raised to 6.8%.[1]

In this research the effect of porosity of concrete and thus polymer loading on strength was studied. The porosity was changed

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by two methods. (i) by changing the water-cement ratio of the mortar mixture,[2] (ii) by adding varying amounts of naphthalene to the mortar mixture.

EXPERIMENTAL

For the preparation of specimens, curing, monomer impregnation, polymerization under Cobalt-60 radiation, pore size measurement, and testing, the procedure given in a previous work[3] was followed. Water/cement ratio was changed between 0.50–0.65. The amount of naphthalene was changed between 2–10% of cement. For the specimens with naphtalene water/cement ratio was kept at 0.6. Naphthalene sublimates off during drying of specimens at 110°C at the end of curing period hence creating new pores in cement phase. For monomer styrene (70%) and acrylonitrile (30%) mixture was used.

RESULTS AND DISCUSSION

Figure 1 shows the strengths of unimpregnated samples as a function of the initial water/cement ratio in percentage. Both

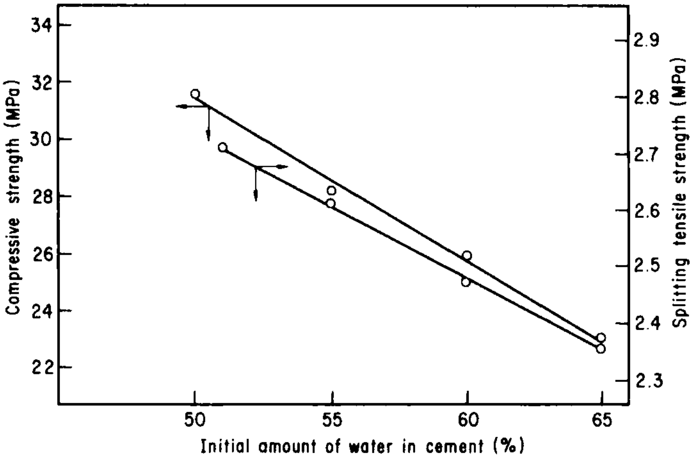

FIGURE 1 Compressive and tensile strengths of unimpregnated samples.

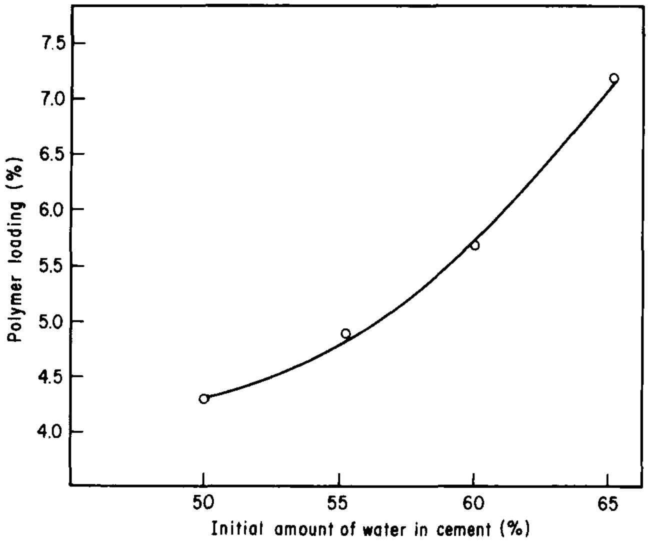

FIGURE 2 Polymer loading in concrete.

compressive and tensile strengths decrease as the amount of water increases in cement. This should be due to increased porosity in cement phase of concrete. Accordingly polymer loading in concrete increases as seen from Figure 2. The compressive and tensile strengths of impregnated samples were shown in Figure 3. It is seen that the compressive strength increases slightly from sample containing 50% water to that containing 60% water. Thus one can conclude from Figure 1 and 3 that the increase in strength due to increased polymer loading is more or less cancelled by decrease in strength due to increased water percentage, i.e. increase in pores. In the case of tensile strength the amount of polymer loaded is not sufficient to compensate the loss due to increased porosity and thus to keep the trend increasing. However in both cases the strength ratios keep increasing as seen from Figure 4. Both compressive and tensile strengths show a sharp increase after 60% water. This can be explained by noting that the differential increase in polymer loading is higher in the last samples than others. Also due to increased porosity of these samples, polymer fibers can form better interconnections and thus better network than others.

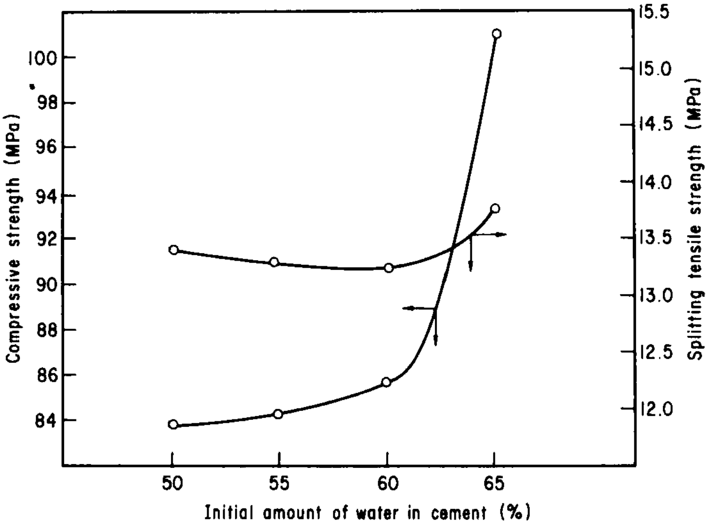

FIGURE 3 Compressive and tensile strengths of polymer impregnated samples.

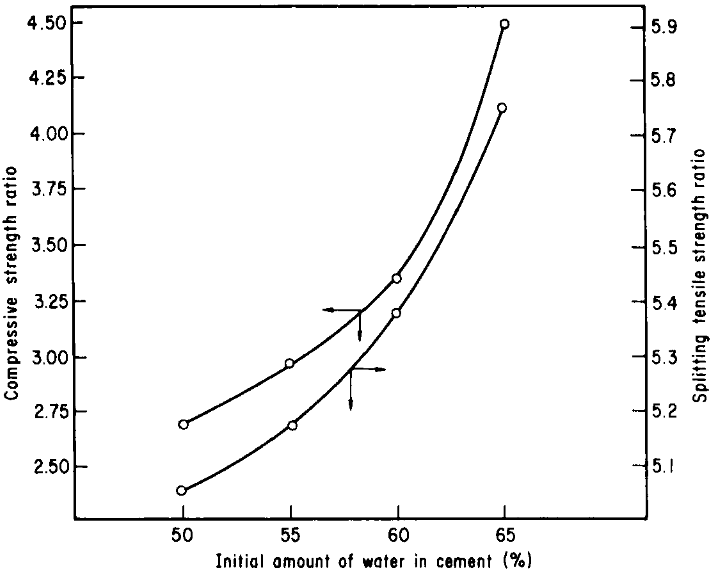

FIGURE 4 Compressive and tensile strength ratios.

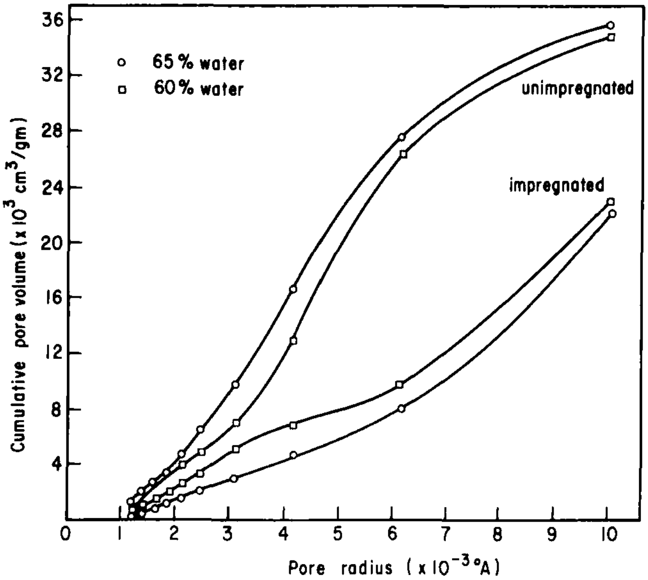

FIGURE 5 Porosity distribution.

Some samples were studied for their porosities before and after impregnation. In Figure 5 a comparison of samples with 60 and 65% water contents were given both for unimpregnated and impregnated cases. It is observed that in the case of unimpregnated samples the pore volume increases with water/cement ratio as expected. But it is interesting that after impregnation the porosity of 65% samples come out to be less than that of 60% samples. This can account for the sharp increase of strengths in Figure 3 for the case of 65% samples. Since the pore size distribution show uniform changes in unimpregnated samples i.e. there is no selective increase of certain size pores due to increase in water content, one can say that in 65% samples better interconnections between pores were provided so that monomer could reach easily the pores available, and thus a more interconnected polymer network was obtained.

The compressive and tensile strengths of unimpregnated concrete originally containing naphthalene were shown in Figure 6. It is seen that the strengths decrease with an increase in naphthalene i.e. increase in the amount of pores. Between 0 and 5% naphthalene

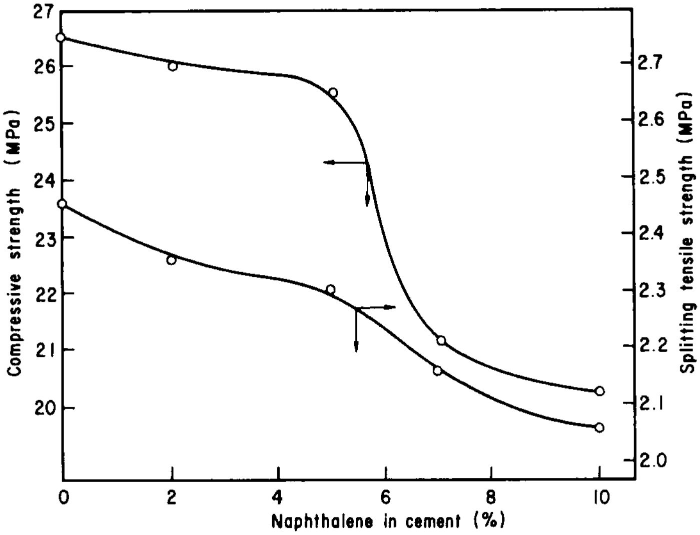

FIGURE 6 Compressive and tensile strengths of unimpregnated samples.

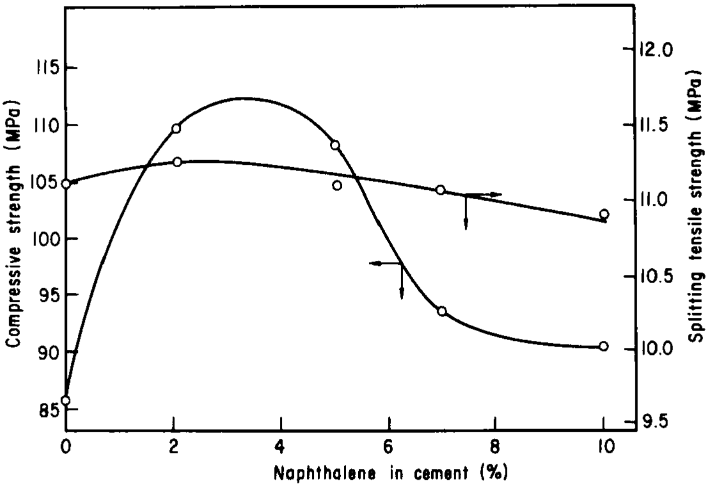

FIGURE 7 Compressive and tensile strengths of polymer impregnated samples.

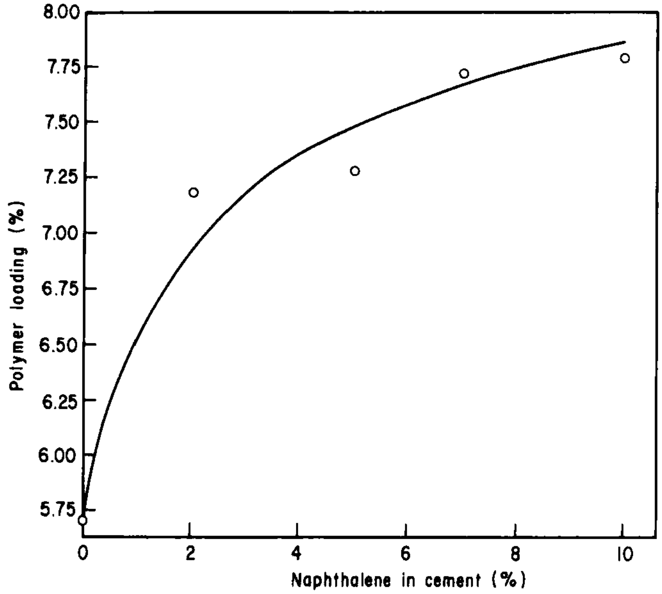

FIGURE 8 Polymer loading in concrete.

contents, the rate of decrease of strengths is quite small, but after 5% strengths decrease at a sharp rate. So it can be concluded that the pores created by naphthalene over 5%, highly facilitate the collapse of the samples when test pressure is applied. The change of compressive and tensile strengths of impregnated samples were shown in Figure 7. Both strengths show maxima around 3% naphthalene. In fact as seen from Figure 8 the rate of polymer loading is very high initially, then the rate drops after around 3% naphthalene.

The sharp decrease of compressive strength after 5% naphthalene in Figure 6 also shows up for impregnated concrete in Figure 7. The polymer load becomes insufficient to compensate the weakness due to pores generated. However the strength ratio of impregnated and unimpregnated samples keep increasing as seen from Figure 9, but at a slowing rate at high naphthalene contents. In Figure 7 it is seen that tensile strength is much less sensitive to pores than compressive strength. It can be thought that in the case of tensile strength well formed polymer network can absorb the test force (or pressure)

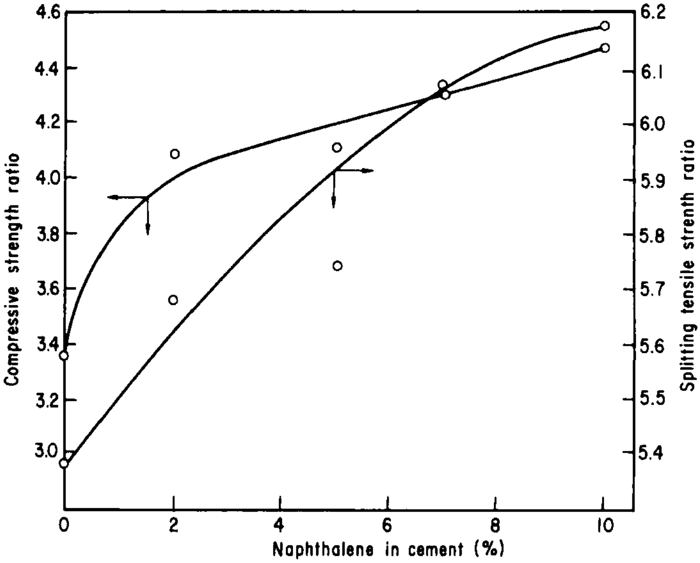

FIGURE 9 Compressive and tensile strength ratios.

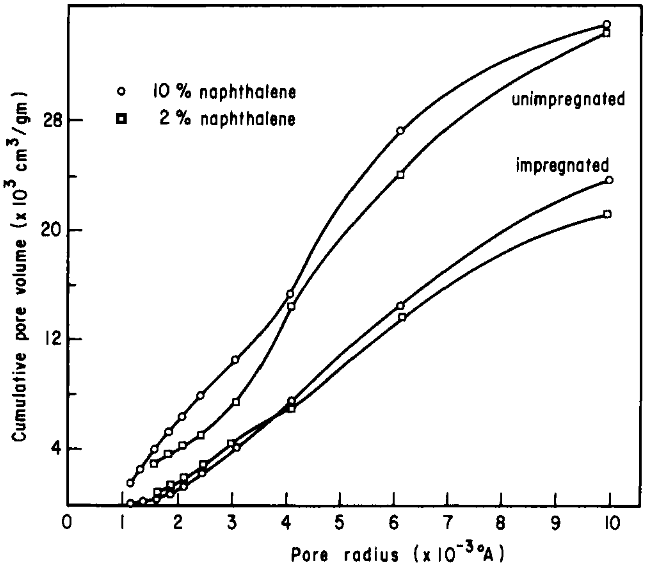

FIGURE 10 Porosity distribution.

applied and cement matrix plays a relatively smaller role. In the case of compressive strength either cement particles or polymer fibers are pushed inward to the pores while failure, therefore the presence of pores become more critical to compressive strength.

An observation that can be done in Figure 10 is that the pores in 10% naphthalene case have been filled to the largest extent as far as pores having radii between 1000 and 3500°A are concerned. So up to about to 3500°A pore size, interconnections of pores play an important role, and one gets better fillings of pores as in the case of Figure 5. After about 3500°A as the solid naphthalene particles get larger in size they create larger size pores and the polymer filling in pores becomes poorer. Since interconnections are made by tubular pores, this can be best achieved by water. For the constant period of impregnation large size pores created by large size naphthalene particles and interconnected by small diameter tubular pores can not be sufficiently filled by monomer. So impregnated 10% naphthalene samples naturally contain larger pores than impregnated 2% naphthalene samples after 3500°A.

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References

1. P. Tuğlu, M.Sc. thesis, Dept. of Chemical Eng., ODTÜ, Middle East Technical University, Ankara, Turkey, 1978.
2. D. G. Manning, and B. B. Hope, The influence of porosity and partial drying on properties of polymer impregnated mortar, in "Polymer in Concrete", American Concrete Institute, Publication SP-40, 1973.
3. G. Gündüz, B. Yeter, P. Tuğlu, I. Ahmed, *J. Mat.* 1 *Sci.*, **16,** 221 (1981).