Међународна конференција
Савремена достигнућа у грађевинарству 24.-25. април 2014. Суботица, СРБИЈА

CHANGING THE STRUCTURE OF CONCRETE AFTER EXPOSURE TO FROST

Dragan Bojović[1]
Ksenija Janković[2]
Marko Stojanović[3]
Ljiljana Lončar[4]

UDK: 666.972.53
DOI: 10.14415/konferencijaGFS2014.067

Summary: *Concrete testing can be done at micro, mezzo and macro level. Tests at the macro level are the most common and are the ultimate engineering approach, and include testing and comparison of quantities such as commpresive strength, modulus of elasticiti and the like. In this manner you can determine changes in structures of concrete. To be considered during the examination and the file structure of concrete should be seen as concrete material composed of cement stone and aggregate, that is switch to a lower level of analysis – mezzo level. Concrete exposed to freezing changes its characteristics both in terms of strength and in terms of the structure. The aim of this study is to determine how to modify the structure of the concrete after frost action. Changing the structure of concrete was evaluated qualitative and quantitative analysis of pores using a device RapidAir 457.*

Keywords: *Frost resistance, pores, RapidAir 457*

1. INTRODUCTION

Concrete as a composite material by nature is a porous material. Pores that are present in the concrete can be divided into four groups.

The first group consists of the smallest pores called by gel. Hydration of cement hydration products are formed which create quasi-layered structure [1]. Between the layers, there are areas which represent the pores of the gel. These pores have a size of 1 to 5 nm and quantity and quality of these pores can not be affected.

The second group consists of capillary pores that are in places where they were not formed hydration products. The amount of these pores depends on the applied water making concrete mixture. These pores are connected and the characteristic size of the pores is in the range of 5 to 1000 nm [2].

[1] Mr Dragan Bojović, BSCE, Institute IMS, Bulevar vojvode Mišića 43, Belgrade, Serbia, tel: +381 11 2650 322, e–mail: dragan.bojovic@institutims.rs
[2] PhD Ksenija Janković, BSCE, Institute IMS, e-mail: ksenija.jankovic@institutims.rs
[3] MSc Marko Stojanović, BSCE, Institute IMS, e-mail: marko.stojanovic@institutims.rs
[4] Ljiljana Lončar, BSCE, Institute IMS, e-mail: ljiljana.loncar@institutims.rs

The third type of pore in practice usually referred to as the entrapped air. This air occurs during mixing and placing concrete or due to subsequent allocations of water. What distinguishes this type of pore of other is their size. They are usually larger than 1mm and an irregular in shape – not spherical.
The fourth group of pores is intentionally entrained air in the concrete. The most common are obtained using air-entraining agent during the mixing of concrete and the required spherical shape with a typical size of 5 to 1250 μm.
Common to all types of the pores which occur in the concrete are formed in the cement stone and at function of the hardened cement paste and aggregate [3].
At the destruction of concrete exposed to cyclic freezing and thawing caused internal damage caused by freezing water in the concrete. This damage is always more limited at areas where concrete is greater water saturation. This damage causes a reduction of compressive and tensile strength, modulus of elasticity and adhesion of concrete for reinforcement [4,5].
Research in this area started a long time ago but with the advent of new non-destructive testing has become actual again. In addition to destructive testing in practice through a number of standards can be found and nondestructive testing by measuring the dynamic modulus of elasticity. Both approaches destructive and non-destructive tests are based on a comparison of test results at a standard sample and the samples were exposed to frost.
The behavior of concrete exposed to frost action depends on the pore structure the amount of water in the pores and temperature regime where the concrete is exposed. Pore structure is discussed in terms of quantity, type, distribution and connectivity. In current practice the resistance of concrete to freezing effects is usually evaluated by amount and distribution of pore of air entrained. The distribution of pores is evaluated through the pore spacing factor and some researchers believe that the value of spacing factor from 0.23 necessary to concrete was resistant to frost action. The method by which the resistance of concrete is determined through the characteristics of the pore is very fast and will greatly enhance the resistance of concrete to frost action. This method can be used in early ages but after 7 to 10 days after casting the concrete.

2. EXPERIMENTAL WORK

Through this experimental work are compared to the received classical destructive testing and non-destructive test to determine the amount and quality of the pores in the concrete. Destructive testing was conducted in accordance with SRPS U.M1.016 under which the test results are compared to a standard and samples exposed to frost action. Non-destructive testing is conducted so as concrete samples were recorded using the unit RapidAir 457 shown in figure 1 at 2, 4 and 6 cm from the sample surface. All tests were conducted on cube 15 cm while the non-destructive testing undertaken by the cubes cut to specified depths in all according to figure 2. After preparation of samples were made necessary recording and analysis. For each series which was treated for the purposes of this study we examined the three standard samples to destructive and non-destructive testing. With device RapidAir 457 obtained results of non-destructive testing. On the basis of this study aim was to determine the resistance of concrete to frost action and to find out what is going on in the depth of the sample with the quantity and quality of the

pores in the samples that were tested. This examination provided data on the spacing factor and the amount of pores in the concrete. The amount of the pores is determined by the size of the pores. Based on the amount of pore size were made clear diagrams of the distribution of pores in the samples that were exposed to freezing and thawing and of standard samples.
For making samples used the cement CEM II and river aggregate separated into four fractions with a maximum grain size of aggregate of 32 mm. In order to improve the properties of concrete are used as superplasticizers and air entraining agent. In all the concrete was adopted the amount of entrained air at a level of 4±0.5%. With this prescribed requirements for the amount of entrained air in fresh concrete met the requirements of as the Building code BAB87 as and European standards EN206-1.

Figure 1. Device RapidAir 457

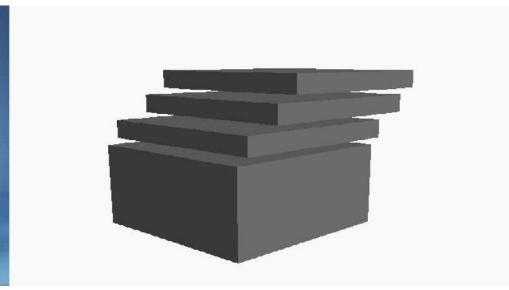

Figure 2. Recording levels of cube

3. ANALISYS RESULTS

On examination there were three series of samples. First was done destructive testing on each series. The destructive strength testing drop is varied in the range of 10 to 15% depending on the series. The largest drop of the strength of concrete had samples with the least amount of cement in mix design.
Test was carried out on three types of concrete were very close to the results. Table 1 gives the results obtained in one of the three types of concrete.

	Standard samples			Samples exposed to frost		
Depth of measuring	2 cm	4 cm	6 cm	2 cm	4 cm	6 cm
Air content	3.50	2.61	3.54	3.95	3.07	3.27
Specific surface	23.84	22.35	19.18	26.93	25.33	17.62
Spacing factor	0.197	0.240	0.243	0.165	0.197	0.275
Void frequency	0.209	0.146	0.170	0.266	0.194	0.144
Average chord length	0.168	0.179	0.209	0.149	0.158	0.227

Table 1. The average test results obtained for the RapidAir 457

In addition to the results presented in non-destructive testing on the amount and distribution of pores in samples has been carried out analysis of pore size and number. Since this is large number of results in order to better take into account here is given in the form of a diagram. The diagram for the same type of concrete is shown in Figure 3.

The diagram shows the curve for a standard samples and samples exposed to freezing and thawing.
Analysis of pore is made as to basis of the data obtained was not entirely clear what happens to the sample depth. As the device can determine the amount of pore size of the smallest from 1nm to very large pores sized over 3 mm is it for this test was very useful. The results were compared to the corresponding table but only after their picturesque views in the form of a diagram could be properly viewed.

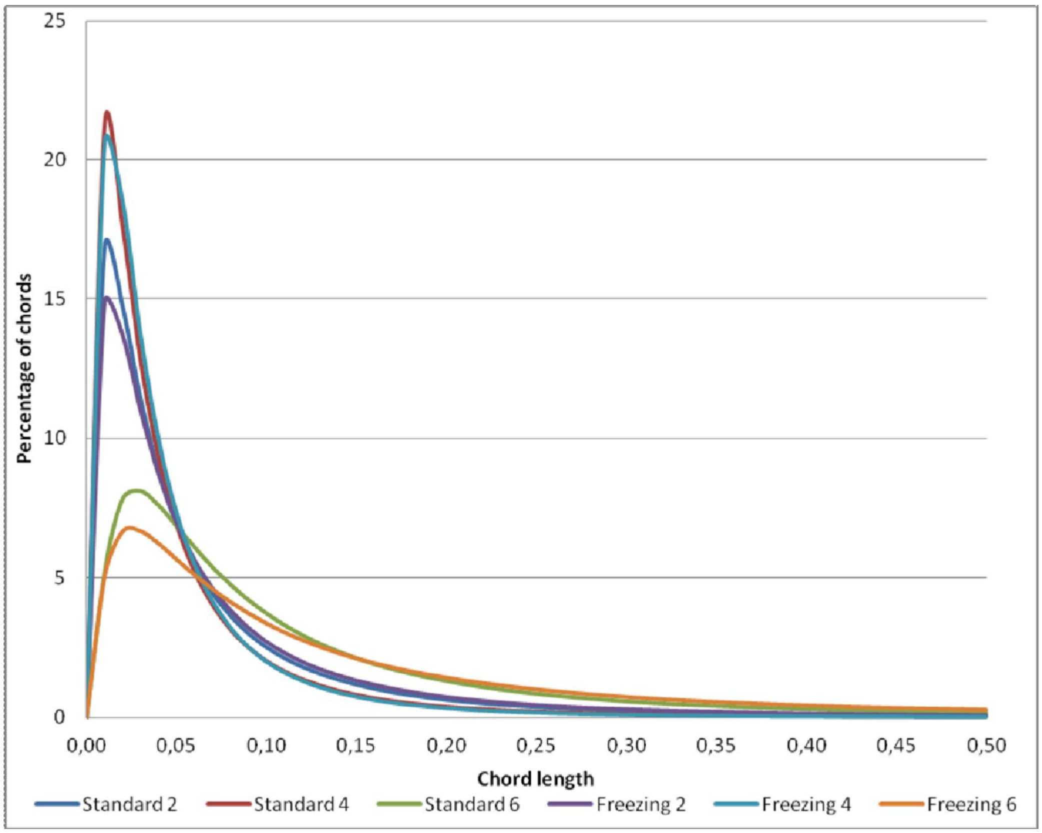

Figure 3. Pore distribution of the samples in depth

4. CONCLUSIONS

Consideration of the results showed that the new method allows a rapid and accurate determination of the resistance of concrete to frost action. The results obtained by a spacing factor of pores and conducted destructive tests in accordance with the results of international research. On the tested concretes average value of spacing factor of pores match was obtained under 0.25 as recommendations to most relevant researchers.
Based on the obtained results it can be determined that the amount of entrained air per depth is constant. Specific surface area, pore frequency of occurrence and average chord size decreases by the depth of samples as a spacing factor of pores increasing.

In addition to these conclusions was noted that all parameters except the amount of air in the concrete changes in samples that were exposed to freezing and thawing. Since these are small number of concrete on which the examination was conducted further tests are ongoing at the Institute IMS will give a better picture of the changes occurring in the structure of concrete exposed to frost action.

REFERENCES

[1] Giergiczny Z, Glinicki M, Sokołowski M, Zielinski M., Air void system and frost-salt scaling of concrete containing slag-blended cement, Construction and Building Materials, 2009, vol.23, 2451–2456
[2] Marchand J., Sellevold E.J., Pigeon M., The deicer salt scaling deterioration of concrete — an overview, Durability of Concrete, 1994, SP-145, American Concrete Institute, 1–46
[3] Pigeon M, Marchand J, Pleau R., Frost resistant concrete, Constr Build Mater, 1996, vol.10(5), 339–348
[4] Pigeon M., Pleau R., Durability of Concrete in Cold Climates, Chapman & Hall, London, 1995.
[5] Mikulic D., Gabrijel I., Hranilovic A.T., Uzelac S., Analiza pora u betonu - međulaboratorijska ispitivanja, Građevinar, 2007., vol.59(5), 387-393.

ПРОМЕНА СТРУКТУРЕ БЕТОНА НАКОН ИЗЛАГАЊА НА ДЕЈСТВО МРАЗА

Резиме: *Испитивање бетона се може вршити на микро, мезо и макро нивоу. Испитивања на макро нивоу су најчешћа и представљају крајње инжењерски приступ, а подразумевају испитивање и поређење величина попут чврстоће, модула еластичности и слично. На овај начин се не може установити промена структуре бетона. Да би се приликом испитивања разматрала и структура бетона потребно је бетон посматрати као материјал састављен од цементног камена и агрегата, то јест прећи на нижи ниво испитивања – мезо ниво. Бетон изложен дејству мраза мења своје карактеристике како по питању чврстоће тако и по питању саме структуре. Циљ овог истраживања је да се утврди како се мења структура бетона након дејства мраза. Промена структуре бетона оцењена је квалитативним и квантитативним анализом пора у бетону помоћу уређаја RapidAir 457.*

Кључне речи: *Отпорност на мраз, поре, RapidAir 457*