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BULLETIN OF THE GEORGIAN NATIONAL ACADEMY OF SCIENCES, vol. 14, no. 3, 2020

Structural Mechanics

Effect of Chemical Additives on Sloping of Concrete

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(Presented by Academy Member Guram Gabrichidze)

Concrete sliding is physical characteristic of concrete. Sliding is observed during the long-term loading conditions. In particular, sliding is the increase of deformations in concrete under the constant loading conditions. By its nature, slope deformations are conducive, although they can cause tension relaxation in the structures. Because of it the tensions are significantly reduced, which may be considered a positive issue in some cases, but relaxation may also have negative effect on pre-tensioned structures. In particular, it can occur unwanted losses of the values of pre-stretched reinforcement. The following factors are mainly influenced on slope capacities: fillers; ratio of water in concrete, age of concrete, environment relative humidity. *© 2020 Bull. Georg. Natl. Acad. Sci.*

Concrete, cement, concrete sliding, plastificator, chemical additives

The purpose of the study was the calculation of the sliding of the concrete (slope coefficients) at different relative humidity values of environment. In accordance with European standards of sliding coefficients, there were done the calculations for three different composites of concrete:

1. Concrete B-1: classic, called as base concrete, free of any chemical additives;
2. Concrete B-2: 7% of micro-silica is added to the base concrete composition;
3. Concrete B-3: 7% of microsilica and 0.5% of plastificator are added to basic concrete composition.

All three types of concrete are introduced in classic prismatic sample sizes: 10 x 10 x 30 cm. In their compositions basalt fillers and CEM II 32.5 grade cement are used [1].

Initially, all three concrete samples were tested under long-term pressure conditions. Then samples were taken to decomposition stage. Due to the experiments the compression of strength of 28 days age concrete was stated:

f_{cm} = 34.2 MPa – concrete B-1
f_{cm} = 38.5 MPa – concrete B-2
f_{cm} 46.4 MPa – concrete B-3

Sliding coefficients were calculated for the following estimated exploitation periods: t = 5, 10, 15, 20, 25, 30, 40, 45 and 50 years.

The calculations were considered due to two variants of relative environmental humidity (RH): dry climate (RH = 50%) and humid climate (RH = 80%) [2].

The results of the calculations are presented in graphic ways in Fig. 1, 2 and 3.

As the results of the calculations showed (Fig. 1, 2 and 3), sliding process for all the three types of concrete develops according the common law. In particular, the sliding decreases significantly after about 10 years of starting the modes and practically it is terminated after 20-25 years.

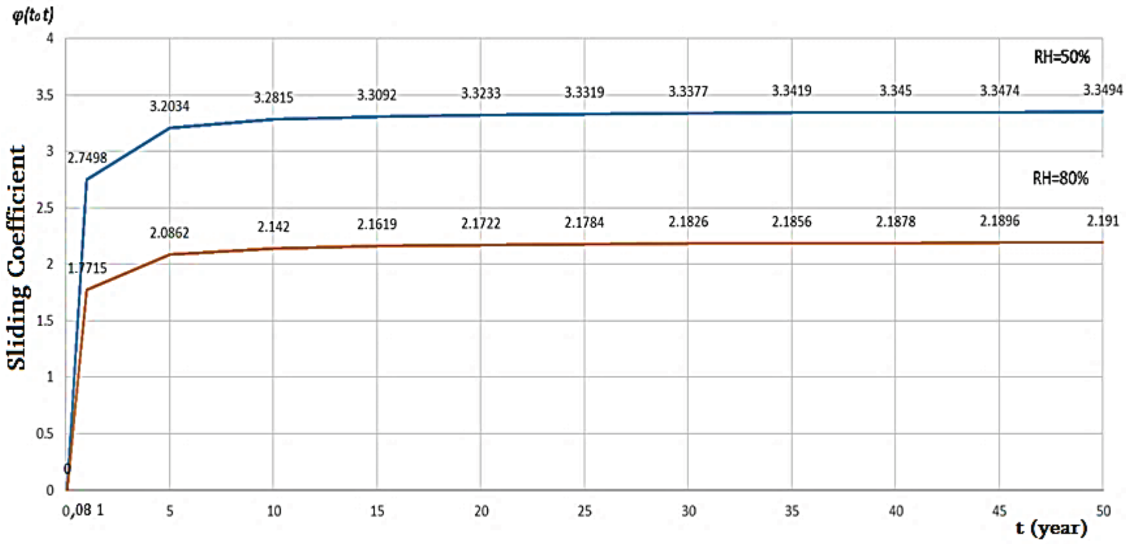

Fig. 1. Changing of sliding coefficient values for basic concrete (B-1) in time for two different relative humidity (RH): RH = 50% – dry climate and RH = 80% – damp climate.

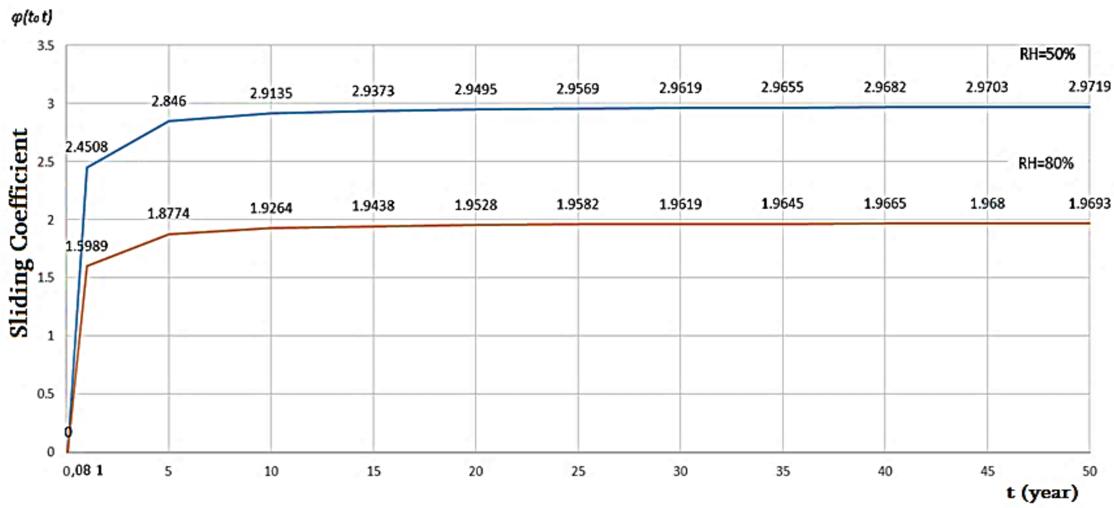

Fig. 2. Changing of sliding coefficient values for concrete with additives (B-2) in time for two different relative humidity (RH): RH = 50% – dry climate and RH = 80% – damp climate.

The relative humidity of the environment has significant influence on the value of the sliding coefficient. In dry climates (RH = 50%) the sliding coefficients are almost 1.5 times more than the values of sliding coefficients observed in humid climates (RH = 80%).

The greater is the hardness of the concrete on compression, the less is the sliding deformation. Addition of micro-silica (concrete B-2) reduces sliding coefficient by 1.1 ÷ 1.2 at first comparing to base concrete

(concrete B-1) (Fig. 1-2). The addition of micro-silica and plastificator (concrete B-3) reduces sliding coefficients by 1.6 ÷ 1.8 times (Fig. 1-3).

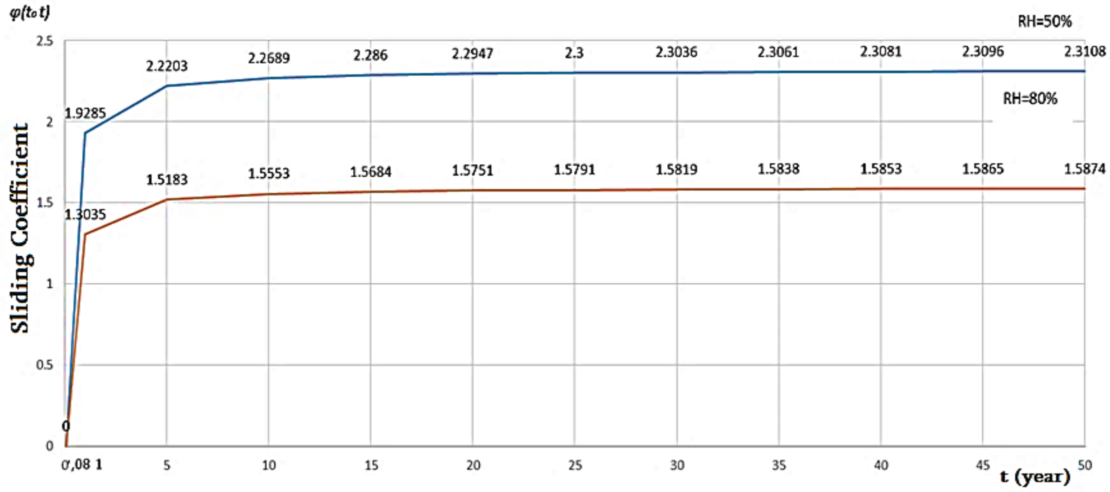

Fig. 3. Changing of sliding coefficient values of basic concrete (B-3) in time for two different relative humidity (RH): RH = 50% – dry climate and RH = 80% – damp climate.

Concrete sliding, as a physical occurrence, is directly related to the age of the concrete. The strength of the concrete also depends on the age. The concrete age strength on compression is determined by the cement type, temperature and reinforcement (solidity) conditions. According to the Eurocode – 2 (Eurocode 2: Design of concrete structures: Part 1 – General rules and rules for buildings), the average hardness of concrete of different ages can be calculated using the following relations:

$$f_{cm}(t) = \beta_{cc}(t) f_{cm}, \tag{1}$$

where

$$\beta_{cc}(t) = exp\left\{s\left[1-\left(\tfrac{28}{t}\right)^{1/2}\right]\right\}, \tag{2}$$

$\beta_{cc}(t)$ – relation coefficient of t age of the concrete;

f_{cm} – average hardness on compression for 28 days age concrete;

t – age of concrete (days);

s – coefficient of relation on the class of cement:

s = 0.20 – for the cements with hardness classes are: CEM 42.5 R, CEM 52.5 N, CEM 52.5 R (Class R);

s = 0.25 - for the cements with hardness classes are: CEM 32.5 R, CEM 42.5 N (Class N);

s = 0.38 - for the cements with hardness classes are: CEM 32.5 N (Class S).

It is natural that despite the strength values, the values of elongation modules are also related to the age of concrete. According to Eurocode 2: Design of concrete structures: Part 1-1: General rules and rules for buildings, the changes in values of elongation modulus of concrete and time can be estimated by the following expression:

$$E_{cm}(t) = \left(\tfrac{f_{cm}(t)}{f_{cm}}\right)^{0.3} E_{cm}, \tag{3}$$

$E_{cm}(t)$ და $f_{cm}(t)$ – values of concrete elongation module and compression strength with t age (days). E_{cm} and f_{cm} – values within the age of 28 days relatively.

As with the calculations of sliding coefficients, strength (hardness) and elongation module were calculated for three different composition concretes: B-1: classic, so-called Base concrete, without any chemical additive (= 34.2 MPa); B-2: base concrete composition with added micro-silica (= 38.5 MPa) and B-3: Base-concrete composition with microsilica and plastificator (= 46.4 MPa). Reports were performed on the basis of the Figs. 1-3 for the following estimated ages: t = 28 day; 1, 2, 3, 10, 20, 50, 100, 200 and 400 years [3].

The results of the report are represented graphically on the Fig. 4 and 5.

As the results of the reports have shown, the strength of concrete on compression is practically being formed about 10 years after of its molding, but the process of its reinforcement slightly lasts till about 50 years. This applies to both: classic and additive types of concrete. For example, the strength of base concrete (B-1) in the first 10 years increases approximately by 21% compared to the strength of 28-day concrete. It should be noticed that in the first year the hardness increases approximately by 16%, and the remaining 5% comes the following nine years. The strength of additive concrete (B-2 and B-3) also increases approximately with the same proportion. A similar situation is observed regarding the modification of the elongation module [4].

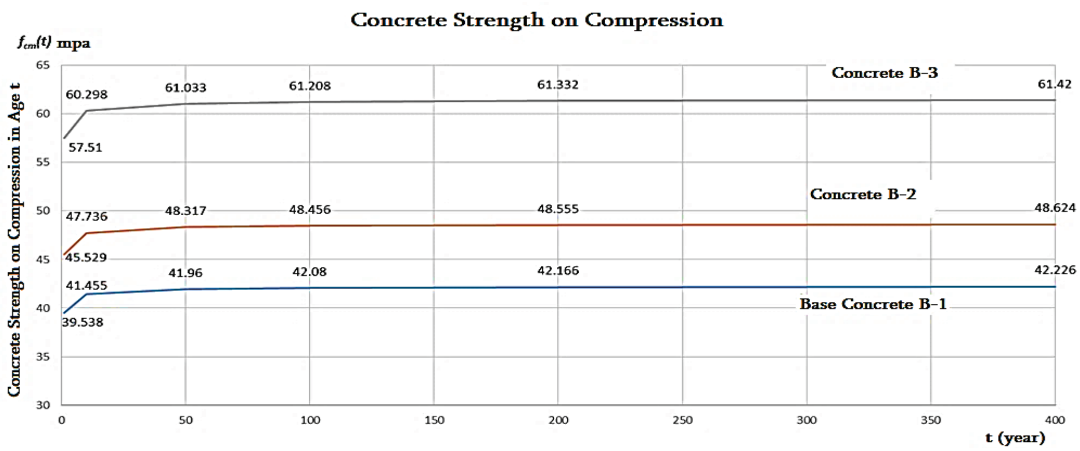

Fig. 4. Changing of the values of hardness on compression within time for base concrete (B-1), concrete with additives (B-2) and (B-3).

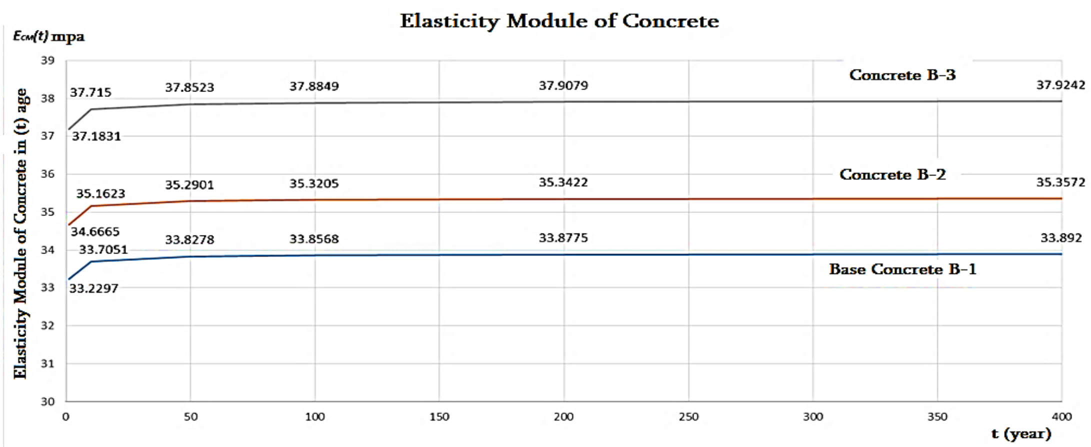

Fig. 5. Changing of the values of elongation modules within time for base concrete (B-1), concrete with additives (B-2) and (B-3).

Conclusions

Sliding process is being developed in accordance with general rules for both base concrete (B-1) and concrete with additives (B-2 and B-3). In particular, sliding decreases significantly after about 10 years of exploitation and practically is terminated after 20 - 25 years; 2. The relative humidity of the environment (RH) has significant effect on sliding coefficient. In dry climates (RH = 50%) sliding coefficients are almost 1.5 times higher than sliding coefficients observed in humid climate (RH = 80%). 3. The higher is the concrete strength on compression, the lower sliding deformations are. Addition of only micro-silica (B-2) reduces sliding coefficients by 1.1 - 1.2 times comparing to base concrete (B-1). The addition of micro-silica and plastificator altogether (B-3) reduces the sliding coefficients by almost 1.6 ÷ 1.8 times; 4. Concrete hardness on compression is practically finally formed about 10 years after molding, though the process of reinforcement slightly lasts until about 50 years. This applies to both classic and additive concrete types.

All experiments are financially supported by Shota Rustaveli National Science Foundation of Georgia. Study of Properties of Concretes (Both Ordinary and Compacted) Made of Local Building Materials and Containing Admixtures, and Their Further Introduction in Construction Operations and Road Building. Grant №DP2016_26. 22.12.2016.

სამშენებლო მექანიკა

ქიმიური დანამატების გავლენა ბეტონის ცოცვადობაზე

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ბეტონის ცოცვადობა წარმოადგენს მის ფიზიკურ მახასიათებელს, რომელიც თავს იჩენს გრძელვადიანი დატვირთვების პირობებში. კერძოდ, ცოცვადობა არის ბეტონში დეფორმაციების გაზრდა მუდმივი დატვირთვის პირობებში. თავისი ბუნებით, ცოცვადობის დეფორმაციები მილევადია, თუმცა შეუძლია გამოიწვიოს ძაბვის რელაქსაცია (შემსუბუქება) კონსტრუქციებში. ამის გამო, მათში მნიშვნელოვნად მცირდება ძაბვა, რაც, ზოგიერთ შემთხვევაში, შეიძლება დადებით მოვლენად ჩაითვალოს, თუმცა რელაქსაციას შეიძლება ჰქონდეს უარყოფითი გავლენაც წინასწარდაძაბულ კონსტრუქციებში. კერძოდ, შეიძლება მოხდეს არმატურის წინასწარი მოჭიმვის სიდიდის არასასურველი კარგვები. ცოცვადობის დაფორმაციებზე ძირითადად გავლენას ახდენს შემდეგი ფაქტორები: შემავსებლები, წყალცემენტის ფარდობა, ბეტონის ასაკი, გარემოს ფარდობითი ტენიანობა.

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Received June, 2020