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COMPRESSIVE STRENGTH AND DEFORMATIONS OF MODIFIED SAND CONCRETE

The article is devoted to the experimental investigations of deformation of drying shrinkage and the mechanical properties of modified with the polycarboxylate type superplasticizers sand concrete. It is demonstrated that fine-grained (sand) concretes for some regions, especially for Arabian countries are more preferred due to the deficit of coarse aggregate It was established that the use of modifiers (superplasticizers of new generation) can improve mechanical properties of sand concrete bringing them closer to those of conventional coarse concrete. The modified sand concrete on the characteristics of the deformative properties is similar to those of conventional normal weight structural concrete, which allows applying them to most structures and buildings. The level of long-term compressive stresses in the structures of the modified sand concrete is advisable to limit by value $\eta = |\sigma_3|/R_b \approx 0,8$. Sand concrete can replace successfully the traditional concrete because of its economical cost, its compressive strength that reaches up to 80 N/mm^2 and its high workability.

modified sand concrete, shrinkage, deformation, compressive strength

1. INTRODUCTION

It's well known, that fine-grained (sand) concretes for some regions, especially for Arabian countries are more preferred due to the deficit of coarse aggregate. For example, due to the scarcity of aggregates in the south of Algeria and the high cost of their transportation from other regions, there has been a growing interest in the use of sand-concrete [1]. Several research works [2–4] have investigated the use of sand as a substitute for coarse aggregate to make sand-concrete, which has mechanical strength comparable to conventional concretes.

In accordance to [5] fine aggregates used in concrete in Saudi Arabia (Riyadh) are either natural wadi sand or manufactured sand obtained from crushed stone. Yemen has also hundreds of miles of sand dunes. The highest dunes can be found in the desert around Marib and on the edge of the Empty Quarter (Fig. 1).

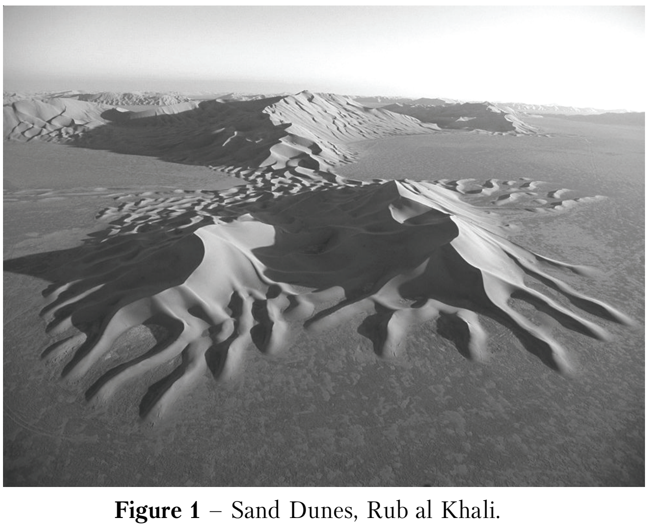


Figure 1 – Sand Dunes, Rub al Khali.

Usually sand-concrete consists of a mixture of sands, cement, one or more admixtures, additions and water. It is to be distinguished from a conventional concrete by its high proportion of sand. It is also distinguished from mortar by its cement content (low dosage of cement) and especially by its destination (sand-concrete is primarily intended for more traditional uses). This advantage becomes extremely interesting when sand-concrete can reach certain fluidity in order to improve some of their performances [4].

Research studies [6] on Riyadh sands revealed the presence of considerably large amounts of material finer than 75 m in the form of silt, clay, or limestone dust. It is evident that these materials, if present in excessive quantities, may have adverse effects on the properties of fresh and hardened concrete. In the freshly mixed state, because of their large surface area, these materials increase the water demand to produce a concrete of a desired consistency. The increase in water content leads to detrimental effects including bleeding and segregation as well as weak interfaces between granular materials [4]. Moreover, high cement content may cause severe creep and drying shrinkage [7] and may lead to classify sand-concrete as a mortar. Furthermore, clay coatings on the aggregate surface will interfere with bond between the cement paste and aggregate, thus impairing the strength and durability of concrete [8].

For these reasons sand-concrete mixes always contain a superplasticizer and a large quantity of additives (fine mineral materials). The superplasticizer is necessary for producing a flowable mix, while the addition of fine materials are required to maintain sufficient viscosity, hence reducing bleeding, segregation and settlement. However, excessive addition of fine particles can results in a considerable increase in the specific surface area of the powder, which results in an increase of water demand to achieve a given consistency [4].

On the other hand, most of superplasticizers, mainly on the basis of polymethylene naphthalene condensates promote air entrainment into the concrete mixtures while mixing. In the hardened state of concrete increased air entrainment can reduces its compressive strength. Russian scientists demonstrated [9] that air entrainment decreases significantly in case of using polycarboxylate type superplasticizers (MELFLUX 2651F). High effect of decreasing of air entrainment is achieved due to additional introduction of the grind silica sand in the composition of the concrete mix as well.

So, in this work a study on the physical and mechanical properties of modified with the polycarboxylate type superplasticizers sand concrete is presented. The main tasks of this investigation are the next: to calculate the formulation of C40 modified sand concrete, to determinate the drying shrinkage, compressive cube and prism strength of concrete as well as to identify the patterns of deforming concrete under axial compression.

2. EXPERIMENTAL PROGRAM

2.1 Materials

Ordinary Portland cement (CEM I 42.5) with a Blaine fineness 320 m^2/kg and fine aggregate: quartz sand with the fineness modulus of 1,5, packing density 1 470 kg/m^3, apparent density 2 675 kg/m^3 (Ukraine, Donetsk region) were used in concrete composition. The superplasticizer based on modified polycarboxylic ether (FM-34 from Addiment) was used as a high range water reducer. The dosage of HRWR was 0,15 % solid by mass of cementitious materials.

2.2. Mixtures proportions

The mix proportion method is based on optimizing the maximum packing mass volume of dry mixture. The materials content, kg/m^3 is: Portland cement – 728, quartz sand – 1 036, superplasticizer – 2,9*l*, water-to-cement ratio – 0,23.

2.3. Test specimens

The test specimens cast from batch were 150-mm cubes for compressive strength testing and 150×150×600 mm prisms for shrinkage measurements. The cast specimens were covered with wet sawdust and left for 24 hr. After that they were demolded and cured continuously in a curing room at a temperature of +18 °C and RH=60±5 %.

Shrinkage control strains were performed using dial indicators mounted on the test samples immediately after removal of formwork. The values of cubic and prismatic strength and the longitudinal and transverse deformation of concrete were determined in the process of testing specimens under pressure PMM-125 in accordance with Ukrainian standard.

3. RESULTS AND DISCUSSION

It was established that the shrinkage strains of the modified sand concrete at 28 days of hardening were $\varepsilon_{cs} = 37 \cdot 10^{-5}$ (Fig. 2). This is on average 20 % higher than the corresponding strains for concrete with coarse

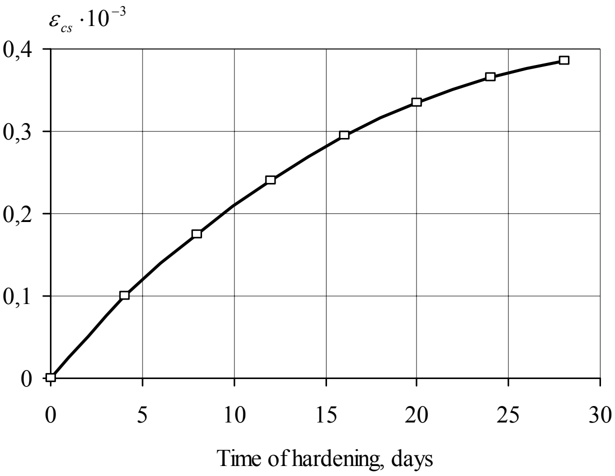


Figure 2 – Shrinkage strains of a modified sand concrete.

aggregate (crushed granite). The values of cubic and prismatic strength of sand concrete at the age of 28 days were 56,9 and 48,1 MPa respectively.

The most intensive increasing strength of sand concrete occurs in the first 7 days and reached about 75 % of the strength at 28 days (Fig. 3). The coefficient values of prism strength test at the age of 7 and 28 days were close enough in magnitude. The mean value was as follows: $k_{prism\ strength} = R_b/R \approx 0{,}86$.

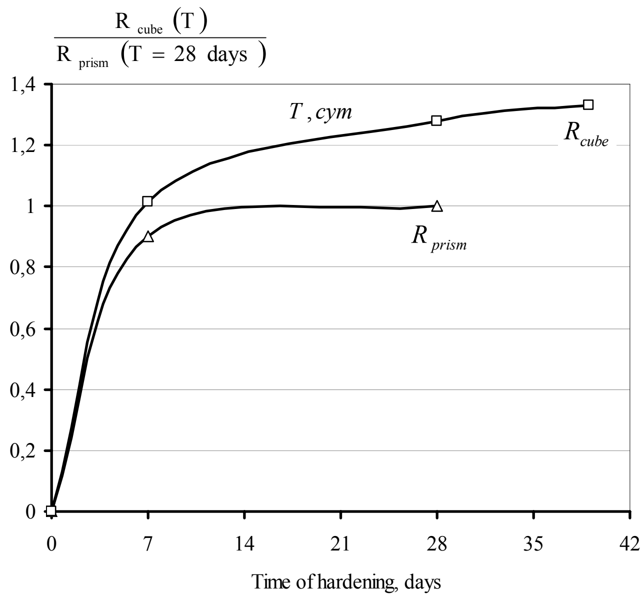
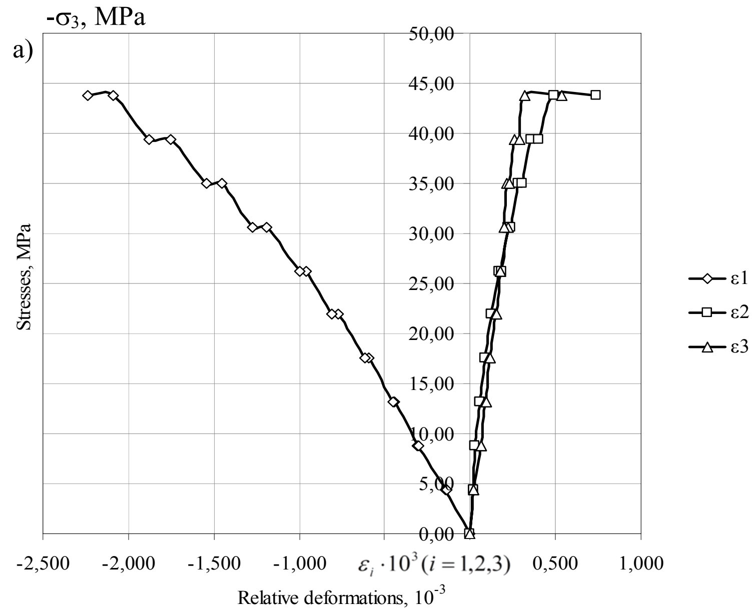


Figure 3 – The effect of concrete age on the performance of its cube and prism strength.

The average value of the initial modulus of elasticity of concrete at the age 28 days is 29,1 GPa. The coefficient of transverse strain (Poisson's ratio) is close to the value 0,2. The strain diagrams of the investigated concrete under axial compression practically at the whole range of loading close to a straight line (Fig. 4).

Some curvature to the axis of deformation observed at higher levels of loading, indicating the beginning of the process of macrocracking in the concrete structure. The maximum strain shortening (limit compressibility) of concrete upon the reaching prism strength at 7 and 28 days are 2,01 and $2{,}9 \times 10^{-3}$ respectively.

The most intensive growth of transverse deformation of concrete in the process of loading observed at the level of stress $\eta = |\sigma_3| / R_b \approx 0{,}83$ (Fig. 5). Exactly this level of loading corresponds to the upper level of the parametric process of microcrac king of concrete in the structure, which characterizes the beginning of the process of macrocracking [10].



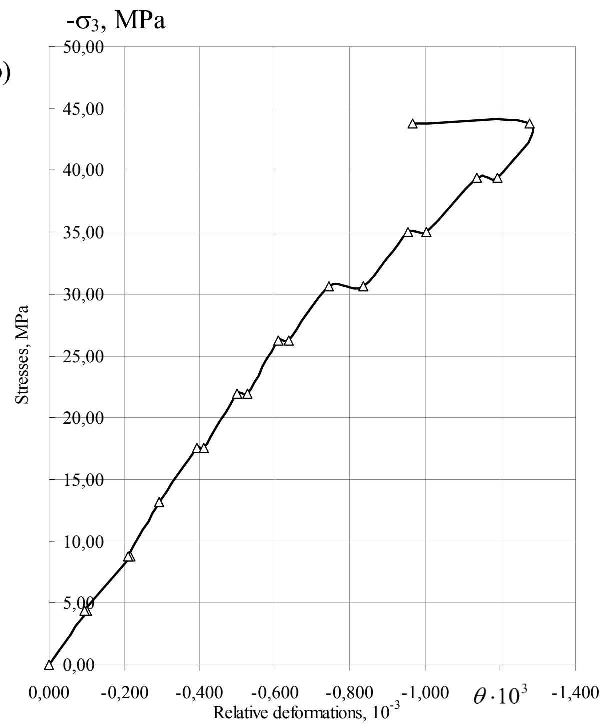


Figure 4 – Diagram of linear (a) and volume (b) strains of modified sand concrete.

CONCLUSIONS

1. The use of modifiers (superplasticizers of new generation) can improve mechanical properties of sand concrete bringing them closer to those of conventional coarse concrete.

2. The modified sand concrete on the characteristics of the deformative properties is similar to those of conventional normal weight structural concrete, which allows applying them to most structures and buildings.

3. The level of long-term compressive stresses in the structures of the modified sand concrete is advisable to limit by value of $\eta = |\sigma_3|/R_b \approx 0{,}8$.

4. Sand concrete can replace successfully the traditional concrete because of its economical cost, its compressive strength that reaches up to 80 N/mm² and its high workability.

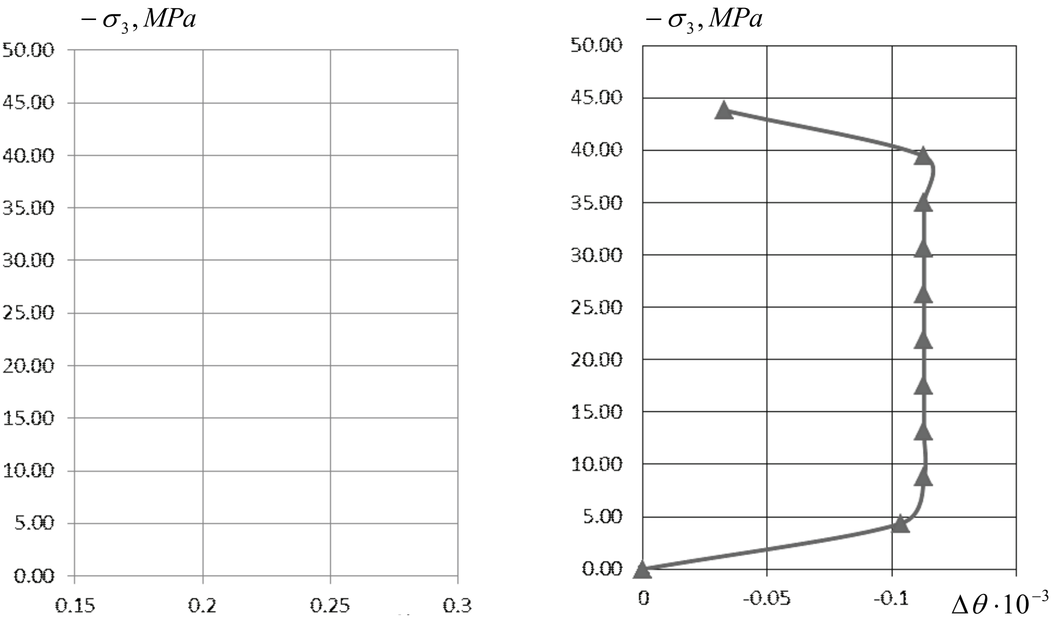


Figure 5 – Change of transverse strains (a) and the relative change in increments of volume (b) in the process of loading the samples of modified sand concrete.

REFERENCE

1. Bouziani, T. Effect of Dune Sand on the Properties of Flowing Sand-Concrete (FSC) [Текст] / T. Bouziani, M. Bederina, M. Hadjoudja // International Journal of Concrete Structures and Materials. – 2012. – Vol. 6, No. 1. – P. 59–64.
2. Reuse of local sand: effect of limestone filler proportion on the rheological and mechanical properties of different sand concretes [Текст] / M. Bédérina, M. M. Khenfer, R. M. Dheilly, M. Quéneudec // Cement and Concrete Research. – 2005. – Vol. 35, No. 6. – P. 1172–1179.
3. Rheological, mechanical and structural performances of crushed limestone sand concrete [Текст] / K. Akrout, P. Mounanga, M. Ltifi, N. Ben Jamaa // International Journal of Concrete Structures and Materials. – 2010. – Vol. 4, No. 2. – P. 97–104.
4. Incorporation of crushed sands and Tunisian desert sands in the composition of self compacting concretes. Part I: Study of formulation [Текст] / A. Rmili, M. Ben Ouezdou, M. Added, E. Ghorbel // International Journal of Concrete Structures and Materials. – 2009. – Vol. 3, No. 1. – P. 3–9.
5. Ahmed, A. E. Properties of concrete incorporating natural and crushed stone very fine sand [Текст] / A. E. Ahmed, A. A. El-Kourd // ACI Materials Journal. – July-August 1989. – Vol. 86, No 4. – P. 417–424.
6. Atta, A. H. Study of the properties of Riyadh sand used in mortar and concrete [Текст] / A. H. Atta, A. H. Mansouri // Journal of Engineering Science (Riyadh). – 1983. – Vol. 9, No 1. – P. 1–20.
7. Chang, P. K. Application of high performance concrete to high rise building in Taiwan [Текст] / P. K. Chang, C. L. Hwang, Y. N. Peng // Advances in Structural Engineering. – 2001. – Vol. 4, No. 2. – P. 65–73.
8. Neville, A. M. Properties of concrete [Текст] / A. M. Neville. – 2nd Edition. - London : Pitman Publishing Limited, 1978. – 133 p.
9. The influence of fine grained concrete components on air entrainment during its batching [Текст] / [N. M. Morozov, I. V. Borovskikh, V. G. Khozin et al] // Proceedings of Kazan State architectural and building University. – 2011. – Vol. 3, No. 17. – P. 129–133. [in Russian].
10. Berg, O. Physical basis of the theory of strength of concrete and reinforced concrete [Текст] / O. Berg. – Moscow : Gosstroiizdat, 1962. – 98 p. [in Russian].

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АЛЬ-ШАМСІ ХАЛЕД АЛІ САІД
МІЦНІСТЬ І ДЕФОРМАЦІЇ МОДИФІКОВАНОГО ПІЩАНОГО БЕТОНУ ПРИ ОСЬОВОМУ СТИСНЕННІ
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Статтю присвячено експериментальному дослідженню деформацій усадки при висиханні і механічних властивостей модифікованого полікарбоксилатним суперпластифікатором піщаного бетону. Показано, що дрібнозернисті (піщані) бетони для деяких регіонів, особливо в арабських країнах, є переважаючими в зв'язку з дефіцитом крупного заповнювача. Встановлено, що використання модифікаторів (суперпластифікатори нового покоління) дозволяє підвищити характеристики механічних властивостей піщаних бетонів, наближуючи їх до характеристик звичайних крупнозернистих бетонів. Модифіковані піщані бетони за характеристиками деформаційних властивостей близькі до характеристик звичайних важких конструкційних бетонів, що дозволяє їх застосовувати для більшості будівель і споруд. Рівень тривалих стискаючих напружень у конструкціях з модифікованих піщаних бетонів доцільно обмежити величиною $\eta = |\sigma_3|/R_b \approx 0{,}8$. Піщаний бетон може з успіхом замінити звичайний бетон завдяки його економічній доцільності, високих показників міцності при стиску, що досягає 80 МПа, і технологічності.

модифікований піщаний бетон, усадка, деформації, міцність при стиску

АЛЬ-ШАМСИ ХАЛЕД АЛИ САИД

ПРОЧНОСТЬ И ДЕФОРМАЦИИ МОДИФИЦИРОВАННОГО ПЕСЧАНОГО БЕТОНА ПРИ ОСЕВОМ СЖАТИИ

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Статья посвящена экспериментальному исследованию деформаций усадки при высыхании и механических свойств модифицированных поликарбоксилатным суперпластификатором песчаного бетона. Показано, что мелкозернистые (песчаные) бетоны для некоторых регионов, особенно в арабских странах, являются более предпочтительными в связи с дефицитом крупного заполнителя. Установлено, что использование модификаторов (суперпластификаторы нового поколения) позволяет повысить характеристики механических свойств песчаных бетонов, приближая их к характеристикам обычных крупнозернистых бетонов. Модифицированные песчаные бетоны по характеристикам деформационных свойств близки к характеристикам обычных тяжелых конструкционных бетонов, что позволяет их применять для большинства зданий и сооружений. Уровень длительных сжимающих напряжений в конструкциях из модифицированных песчаных бетонов целесообразно ограничить величиной $\eta = |\sigma_3|/R_b \approx 0{,}8$. Песчаный бетон может с успехом заменять обычный бетон благодаря его экономической целесообразности, высоких показателей прочности при сжатии, достигающей 80 МПа, и технологичности.

модифицированный песчаный бетон, усадка, деформации, прочность при сжатии

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