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Influence of geogrid on the drying shrinkage performance of concrete pavements

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Abstract

The aim of this study is to investigate the effect of geogrid on the drying shrinkage behaviour of concrete pavements. For this purpose, two categories of concrete specimens were prepared and tested by drying them within the controlled environmental conditions, for 56 days. The first category of specimens included casting and testing nine concrete prism specimens having dimensions of 75 x 75 x 280 mm. These specimens were divided into three groups. The first group included three unreinforced concrete prism specimens and taken as references. The second group consisted of three concrete prism specimens reinforced with a single biaxial geogrid layer located at 20 mm from the top of specimen. The last three specimens (third group) were reinforced with a biaxial geogrid layer placed at 37.5 mm from the top of specimen. The second category of specimens, which was suggested in this study to simulate the behaviour of concrete pavements, consisted of preparing and testing six concrete slab specimens. They had dimensions of 30 x 280 x 280 mm. The specimens of this category were divided into two groups. The first group included three unreinforced concrete slab specimens (References). The second group included three concrete slab specimens reinforced with a single biaxial geogrid layer placed at 15 mm from the top of specimen. The changes in the length of the prisms and the changes in the area of the slabs were measured and evaluated. Test results obtained illustrate that, under the controlled drying conditions, the geogrid can slightly reduce the drying shrinkage strains of the concrete pavements.

Keywords

concrete, pavements, geogrid, performance, influence, shrinkage, drying

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Influence of Geogrid on the Drying Shrinkage Performance of Concrete Pavements

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single biaxial geogrid layer placed at 15 mm from the top of specimen. The changes in the length of the prisms and the changes in the area of the slabs were measured and evaluated. Test results obtained illustrate that, under the controlled drying conditions, the geogrid can slightly reduce the drying shrinkage strains of the concrete pavements.

Author keywords: Concrete prism specimens; Concrete slab specimens; Controlled drying conditions; Biaxial geogrid; Drying shrinkage strains

1. Introduction

The early age behaviour of Portland cement concrete (PCC) pavements is significantly influenced by weather conditions. This is because the PCC pavements possess a large surface area exposed to the effect of climate changes. Temperature and relative humidity have a combined effect on the PCC pavements, especially in the drier environments or when the curing conditions of concrete being inadequate. This leads to an increase in the rate of the evaporation of concrete mix water, and therefore, the PCC pavement would be more likely to shrink.

High temperature of the concrete surface makes the concrete to lose the moisture gradually through the surface. The pore water moves towards the surface through the pore network [1]. This results in variable moisture content in space and time. In addition, the value of temperature between the top and bottom of the slab will be different. When the rate of evaporation exceeds the rate of pore water movement towards the surface, the concrete will start to shrink, which is called the drying shrinkage.

The drying shrinkage can be defined as the reduction in the concrete volume due to the influence of environmental conditions [2]. This reduction may be considered a critical situation for concrete pavements and may significantly affect the performance and lifetime of concrete roads. Sometimes the drying shrinkage leads to a generation of excessive thermal strains and stresses in the concrete, in turn, mostly leading to cracking of concrete pavements. The concrete cracking may result in reducing the effective design stress used in the pavements by up to 50% [1].

Several studies were conducted to examine the effect of temperature and relative humidity on the behaviour of concrete pavements during the early-age of their service life. For example, Asbahan and Vandenbossche [3], Zhang et al. [4], and Kim et al. [5] investigated the response of jointed plain concrete pavement subjected to environmental effects. They concluded that the slab curvature which resulted from the effect of temperature and relative humidity influences the locations and magnitude of the critical stresses in the concrete pavement. In turn, the performance of the pavement for the long term will be affected. The authors also reported that the slab curvature, which resulted from the daily fluctuations of temperature or from reversible drying shrinkage, is not significantly reduced when using dowel and tie bars.

Zhang et al. [6] theoretically studied the drying shrinkage behaviour of normal strength concrete and developed a micromechanical model using the finite element method. The model was derived based on the capillary tension created in the capillary pores of the concrete and considered the interior humidity as a driving parameter. The authors recommended that the model can be used to predict the shrinkage-induced strains of concrete at a different time and different positions. In general, these studies emphasized that the environmental loads can be critical factors in the deformation of concrete pavements and, thus, on the long-term performance of the pavement.

Several previous studies tried to address the effect of shrinkage deformation on the concrete using different reinforcement materials. Shao and Mirmiran [7] investigated the role of fibre-reinforced polymer (FRP) grids and rods on the drying shrinkage deformation of concrete pavements. They illustrated that the FRP grids could be used instead of steel reinforcement in restraining the shrinkage deformation and could be placed closer to the surface. But the cost of construction using the FRP reinforcement is in the rise.

Fibre reinforcement such as steel, polypropylene and synthetic fibres was used to restrain the shrinkage deformation of concrete. Jafarifar et al. [1]; and Ahamed et al. [8] studied the drying shrinkage behaviour of concrete pavements reinforced with recycled steel fibres. They concluded that the shrinkage strains of concrete reinforced with the steel fibres was lower than that of plain mixes. Using fibres to mitigate the shrinkage deformation of concrete pavements can be source of problems when mixing the concrete or in the workability of the concrete, especially at the high fibre percentages.

Bentz and Weiss [9], Güneyisi et al. [10]; Wei et al. [11]; and Kim and Chun [12] investigated the effect of pre-wetted lightweight fine and coarse aggregates as an internal curing technique on the autogenous and drying shrinkage behaviour of concrete. Although the use of this technique could mitigate the shrinkage deformation of cured concrete, the rate of shrinkage development was faster than the control concrete. Also, the early strength and the modulus of elasticity of the concrete were reduced.

Geogrid, which is basically used to strengthen the weak soils, has been recently utilised as a reinforcement layer for Portland cement concrete elements. This is because they have several structural characteristics such as a high tensile strength and corrosion resistance [13-15]. Siva and Agarwal [16-18] and Wang et al. [19] investigated the performance of concrete prismatic and cylindrical specimens strengthened with the geogrid. These investigations demonstrated that the flexural, compressive, and shear strength of concrete could be improved, as well as, the cracking resistance of concrete specimens could be increased. However, using geogrid products for reinforcing the Portland cement concrete elements are a new direction. So, additional research studies to find out more benefits for geogrid applications are required. In this study, the biaxial geogrid was used as a restraining layer of drying shrinkage for concrete prism and slab specimens.

2. Objective of study

The purpose of this study is to investigate the effect of geogrid on the drying shrinkage behaviour of concrete pavements by drying the specimens within controlled environmental conditions, at a temperature of 23 ± 3˚ C and Relative Humidity (RH) of 60 ± 10%. Two categories of normal strength concrete specimens were prepared and tested. They were prism and slab specimens having dimensions of 75 × 75 × 280 mm and 30 × 280 × 280 mm, respectively.

3. Properties of biaxial geogrid

The biaxial geogrid was used as a drying shrinkage restraining layer. This is because the arrangement of biaxial geogrid ribs and roughness of nodes' surface can provide an appropriate bond between the geogrid layer and the surrounding concrete [20].

The biaxial geogrid used in this study is manufactured from polypropylene composite materials [21]. It had square openings with inner dimensions of 38 × 38 mm, as shown in Figure 1. The ribs of the biaxial geogrid used were interconnected together at one point called node (junction). They had a cross section area of 2 × 3 mm measured by a digital vernier calliper gauge.

The mechanical properties of the biaxial geogrid were determined using the standard of American Society for Testing and Materials (ASTM) D6637/D6637M-15 [22]. The Single Geogrid Rib (SGR) sample was adopted in this test. In total, five SGRs were prepared and tested under a tensile force at a rate of 8 mm/min, as shown in Fig. 2(a). The instron tensile testing machine that has a capacity of 10000 N was used to test the geogrid samples. All tests were conducted at the High Bay Laboratory of the School of Civil, Mining and Environmental Engineering, University of Wollongong (UOW), Australia.

Each biaxial geogrid sample was selected from the batch and prepared according to the requirements of ASTM D6637/D6637M-15 [22]. All samples consisted of four junctions in order to provide the minimum required length and were free from any surface defects. The average length of geogrid samples, which is defined as the length of geogrid rib measured between the ends of the testing machine clamps and called initial gauge length, was 200 mm, as shown in Fig. 2(b). The testing was stopped when the geogrid rib was ruptured (Fig. 2(c)).

Table 1 lists the physical and mechanical properties of the tested biaxial geogrid samples. The tensile strength of the samples ranged between 1222 N to 1467 N with the corresponding elongation of 57 to 109 mm. These results satisfy with the requirements of ASTM D6637/D6637M-15 [22]. The average tensile strength and elongation of samples were 1341 N and 81 mm, respectively. Fig. 3 shows the tensile strength versus the corresponding strains of the five biaxial geogrid samples.

A wide tolerance before accept or reject the test results of geosynthetic products (geogrid is one of these products) is permitted by ASTM D6637/D6637M-15 [22]. This is because these products are extensively affected by environmental conditions of the laboratory and characteristics of tested geogrid samples. However, from Figure 3, it can be seen that there are differences in the results of the tensile strengths and elongations of the biaxial geogrid samples. These differences are acceptable according to the limitations of ASTM D6637/D6637M-15 [22].

4. Experimental program

4.1 Preparation of specimens

Table 2 provides details of the experimental program adopted in this study. Two categories of concrete specimens were prepared and tested. The first category of specimens that was prepared according to Australian Standards (AS) 1012.8.4 [23] included casting and testing nine concrete prism specimens with dimensions of 75 × 75 × 280 mm. These specimens were divided into three groups. The first group, which is labelled Group UP, included three unreinforced concrete prism specimens and taken as references. The second group consisted of three concrete prism specimens reinforced with a single biaxial geogrid layer located at 20 mm from the top of specimen and is named Group GP20. The last three of concrete prism specimens were reinforced with a biaxial geogrid layer placed at 37.5 mm from the top of specimen (middle of thickness) and is labelled Group GP37.5.

The second category of specimens, which is suggested in this study to mimic as much as possible the behaviour of concrete pavements, consisted of preparing and testing six concrete slab specimens. They had dimensions of 30 × 280 × 280 mm, as listed in Table 2. The specimens of this category were divided into two groups. The first group included three unreinforced concrete slab specimens (References) and is labelled Group US. The second group included three concrete slab specimens reinforced with a single biaxial geogrid layer placed at 15 mm from the top of specimen and is named Group GS. Fig. 4 and 5 show more details of the concrete prism and slab specimens.

The 30 mm thickness of slab specimens was selected in this study to minimize the wide variation of the temperature and moisture gradients the slab surfaces and the middle of thickness of the slab, which are exposed to the environmental conditions. Thus, the readings of the drying shrinkage collected from the gauge studs, which were located at the middle of the slab depth, can be considered as the average of results of the drying shrinkage for the whole slab specimen. In addition, this value of the thickness allows achieving the movement and evaporation of moisture from the slab in one direction (from the top and bottom of the slab surfaces only). This case simulates to the movement and evaporation of moisture for the concrete pavements [1].

4.2 Preparation of moulds

Nine standard metal moulds were used for moulding the prism specimens of the first category, as shown in Fig. 6. They possessed inner dimensions of 75 × 75 × 280 mm. For each prism mould, two steel slides having dimensions of 1.5 × 75 × 75 mm were cut and put inside of the moulds to achieve exactly an inner length of 280 mm. In addition, gauge studs made from stainless steel were used to be the reference points during collecting the test readings. The dimensions of studs satisfied the requirements of AS 1012.13:2015 [24] were 22.5 ± 0.1 mm of length and a diameter of 6 mm. Two gauge studs were screwed into the gauge stud holder, one at each of the end of the prism specimens. While, four gauge studs were screwed into the gauge stud holder at each side of the slab specimens.

For moulding the concrete specimens of the second category, slab specimens, six timber moulds were designed and prepared in this study, as shown in Fig. 7. They possessed inner dimensions of 30 × 280 × 280 mm. The walls of these moulds were fixed with the base using 16 screws. The inside of the moulds was covered with a 0.125 mm thick Vinyl sheet to keep the concrete mix water and to reduce the friction force between the slab and the timber moulds.

4.3 Setup of specimens

The dimensions of the biaxial geogrid layer embedded in the concrete specimens were lower than the entire dimensions of the specimens by about 15 mm for prism specimens and 40 mm for slab specimens, as shown in Fig. 8. This is because the temperature and RH gradients at the edges of concrete specimens are often regular. Thus, the variation in the temperature between the top and bottom of the concrete surface can be negligible [25].

To fix the geogrid reinforcement layer during the pouring of concrete at the required level of the slab specimens, a small wire having a diameter of 0.05 mm was used at each corner of the slab and removed after 24 hours from the casting.

All specimens were cast on the same day using ready-mixed concrete, which was supplied by Hanson Company, Australia [26]. The proportion of concrete ingredients adopted to achieve the normal compressive strength of concrete is listed in Table 3. The slump of concrete mixture, which was mixed with a 10 mm maximum aggregate size, was 150 mm. The compressive strength of the concrete, which was determined according to the test of three cylinders having a 150 diameter and a 200 mm height, was 37.6 MPa at 28 days age.

The process of pouring of concrete inside of the moulds was conducted as follows. Firstly, all moulds were cleaned and lubricated using a thin coating of mineral oil. Enough amount of concrete mixture was poured into the mould and distributed equally for making the required concrete cover. The poured concrete was lightly compacted using the table vibrator with a frequency of 50 Hz. Then, the geogrid layer was put over the concrete cover at the specified location. After that, more concrete was poured into the mould up to being filled, with the compaction using a table vibrator. Finally, the surface of the poured concrete was carefully levelled by the steel trowel. Fig. 9 shows the prism and slab moulds cast with the concrete.

5. Testing of specimens

In this study, the experimental tests conducted on the concrete specimens were achieved by curing and drying these specimens within the controlled environmental conditions. Australian Standards (AS) 1012.8.4 [23] was adopted to conduct these tests. All specimens were assembled at the same location during the whole of the curing and drying time of the specimens. This is to guarantee that all specimens would be exposed to the same environmental conditions.

The process of curing was conducted during two main stages before the specimens were dried. The first stage was performed by placing the specimens inside an environmentally controlled chamber, with RH of 95% or more, as shown in Figure 10. This stage continued for 24 hours from the casting of the specimens. The controlled chamber used in this stage was installed with two humidifiers that release a water spray. This is to ensure that the percentage of RH inside the chamber remained at 95% or more. To monitor the temperature and RH inside the chamber, two digital measuring devices were installed for this purpose.

The second curing stage of the specimens started after 24 hours from the casting of the specimens. It was conducted by submerging the specimens in the water saturated with lime. This stage continued for six days with a temperature of 23 ± 3˚ C. Figure 11 shows the two containers that included the specimens and filled with lime saturated water.

A drying stage of the specimens, which is the stage that the specimens will start to dry and shrink, started after seven days from the casting of the specimens. At this stage, the specimens were placed in a drying chamber, within the temperature and RH of 23 ± 3˚ C and 60 ± 10%, respectively. Fig. 12 shows the drying chamber.

The drying chamber, which is a fridge modified for this study to keep the temperature and RH within the required level, was installed with an air heater connected with a timer to keep the temperature at 23 ± 3˚ C. Also, an air fan having a 96 mm diameter was supplied to create air circulation around the specimens. A high accuracy sensor of RH was installed inside the drying chamber to measure the RH during the drying period. To further control the RH, especially at the early age of concrete, one kilogram of silica gel particles was prepared and spread inside the drying chamber. This stage continued for 56 days from the casting of the specimens.

6. Experimental results and discussion

Nine concrete prisms and six of concrete slabs were tested by drying them in the controlled environmental conditions, at a temperature of 23 ± 3˚ C and RH of 60 ± 10%.

The changes in the length, in one direction, of prisms and the changes in the area, in two directions, of slabs were measured over the drying time. Test readings of drying shrinkage of the specimens were collected at the total drying period of 7, 14, 21, 28, and 56 days. All results calculated herein were the average of five readings taken for each specimen for each group, which includes three specimens. These results were determined using the vertical comparator device, as shown in Fig. 13.

The analysis and evaluation of test results were conducted through dividing the findings into four intervals, which are: 7 to 14, 14 to 21, 21 to 28, and 28 to 56 days. Fig. 14, 15 and 16 and Table 3 present a summary of the experimental results.

6.1 Drying Shrinkage behaviour of prism specimens

The drying shrinkage behaviour of Groups UP, GP20 and GP37.5 were analysed and evaluated. Fig. 14 shows the average of drying shrinkage strains versus the intervals of drying shrinkage.

At the first interval, 7 to 14 days, the drying shrinkage strains of Groups GP20 and GP37.5 were greater than Group UP by about 7% and 14%, respectively. This is because the concrete at this time still had a high percentage of porosities. These porosities, spread in the concrete matrix, were still filled with the free water. This results in impairment of the bond between the geogrid layer and the surrounding concrete. As a result, the role of the geogrid reinforcement as a shrinkage restraining layer is lower. However, this situation is identical with the behaviour of drying shrinkage of concrete pavements reinforced with fibre [1].

In the following intervals, the effect of geogrid on the shrinkage behaviour of Groups GP20 and GP37.5 started to be visible. This is because the concrete matrix started gaining their appropriate hardness. It is due to progress in the process of the hydration of concrete. As a result, the property of the bond between the geogrid layer and the concrete was increased.

For intervals of 14 to 56 days, the drying shrinkage strains were reduced by about 3 to 15% for Group GP20 and 7 to 17% for Group GP37.5 in comparison with the reference (Group UP).

From the same figure, Fig. 14, the drying shrinkage behaviour of Groups GP20 and GP37.5, which differed in the locations of geogrid layer, was slightly different. For intervals of 7 to 14 and 14 to 21 days, the percentage of increase of the drying shrinkage strains of Group GP37.5 was 2% to 6% more than that of Group GP20. While, for the intervals of 21 to 28 and 28 to 56 days, the percentage of increase of the shrinkage strains for Group GP20 was 1.2% to 3% more than that of Group GP37.5. This clearly reflects the influence of location of the geogrid layer in the concrete specimens, which should be located as nearly as possible to the surfaces exposed to drying.

It should be noted that the results of drying shrinkage strains of the concrete specimens reinforced with the geogrid were generally lower, when compared with the unreinforced concrete specimens. It can say, this is because these specimens were dried within the moderate environmental conditions, at a temperature of $23 \pm 3^{\circ}$ C and RH of $60 \pm 10\%$. These conditions gradually have a low impact on the shrinkage behaviour of concrete specimens in conjunction with the progress of hardening process of the concrete.

6.2 Rate of drying shrinkage of the prism specimens

The rate of drying shrinkage of concrete prism specimens can be defined, for this study, as the quantity measurement that aims to compare the average of drying shrinkage that occurred for geogrid reinforced concrete specimens during the drying time compared to unreinforced concrete specimens.

Fig. 15 shows results of the rate of average drying shrinkage of Groups GP20 and GP37.5 compared to Group UP (reference) for each interval. In this figure, the rate of average drying shrinkage of Group UP was considered a fixed datum for comparison purposes and has a zero value. Thus, the negative sign means that the rate of average drying shrinkage of Groups GP20 and GP37.5 was greater than the reference. While the positive sign means that the rate of average drying shrinkage of Groups GP20 and GP37.5 was lower than the reference.

It can clearly be seen that, during the interval of 7 to 14 days, the rate of drying shrinkage of Groups GP20 and GP37.5 was achieved at a higher rate than the reference, about 0.0077 to 0.0147 mm/day, respectively. This illustrates that, when the concrete is still fresh, the geogrid reinforcement may contribute in increasing the rate of drying shrinkage of concrete.

The rate of drying shrinkage of Groups GP20 and GP37.5 during the intervals of 14 to 21 and 21 to 28 became lower than the reference by about 0.0001 to 0.0014 mm/day. This emphasises that the effect of geogrid reinforcement as the restraint of drying shrinkage starts when the concrete had an appropriate stiffness. While at the interval of 28 to 56 days, Groups GP20 and GP37.5 started to shrink at a slow rate because the specimens were dried within the moderate environmental conditions.

6.3 Drying Shrinkage behaviour of slab specimens

The average of drying shrinkage strains of the concrete slab specimens versus the intervals of drying shrinkage are shown in Fig. 16. Although the slab specimens generally reflected the compatible shrinkage behaviour of concrete, the drying shrinkage strains at the interval of 14 to 21 were slightly different.

However, the geogrid reinforcement proved that it has an impact in reducing the drying shrinkage strains of concrete slab specimens reinforced with the geogrid (Group GS) by about 7% more than the reference (Group US). This is clearly demonstrated at the interval of 7 to 14 days. At the end of drying period, 28 to 56 days, the results of shrinkage strains of Groups US and GS were nearly equal.

7. Conclusions

The drying shrinkage behaviour of concrete prism and slab specimens reinforced with the biaxial geogrid layer was investigated. The specimens were dried within the controlled environmental conditions, at a temperature of 23 ± 3˚ C and RH of 60 ± 10%.

The changes in the length of the prisms and the changes in the area of the slab specimens were measured and evaluated. According to the findings of the test, the principal conclusions can be drawn as follow:

1. Except of the first drying interval, 7 to 14 days, the geogrid reinforcement could reduce the drying shrinkage strains of the concrete prism specimens between 0.7% to 15% more than the reference.

2. The geogrid reinforcement could decrease the drying shrinkage strains during the early age of the specimens of Group G20. While, after 21 days of the casting, the geogrid layer in both Groups GP20 and GP37.5 showed nearly the same effect.

3. The rate of drying shrinkage of Groups GP20 and GP37.5 declined by about 2% more than the unreinforced specimens during the drying duration.

4. For the concrete slab specimens, the geogrid reinforcement could reduce the shrinkage strains by about 7 to 28% in comparison with the control specimens.

5. The concrete slab specimens were suggested in this study to simulate the behaviour of concrete pavements in providing a wide surface area exposed to the effect of environmental conditions. However, more experimental studies are required before they are adopted.

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Fig. 16. Average of drying shrinkage strains versus intervals of readings for unreinforced and geogrid reinforced concrete slab specimens

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Table 1. Physical and mechanical properties of biaxial geogrid samples.

Test measurements	Biaxial geogrid samples				
	1	2	3	4	5
Geosynthetic products	Biaxial geogrid				
Rib pitch (mm)	38 × 38				
MidRib depth (mm)	2.0				
MidRib width (mm)	3.0				
Nodal thickness (mm)	4.0				
Initial gauge length of sample (mm)	197	203	197	197	197
Tensile strength of sample (N)	1222	1467	1322	1258	1436
Elongation of sample (mm)	57	109	79	64	96
Percentage increase of elongation (%)	29	54	40	32	49
Average of tensile strength of samples (N)	1341				
Average of elongation of samples (mm)	81				
Standard deviation of the results of tensile strength (N)	96.52				

Table 2. Test matrix of experimental study.

Specimens group	Specimen Label	Number of specimens	Specimen size (mm)	Reinforcement condition	Reinforcement material	Location[a] of geogrid (mm)
Prism group	UP	3	75×75×280	Unreinforced	-------	------
	GP20	3		Reinforced	Biaxial geogrid	20
	GP37.5	3		Reinforced	Biaxial geogrid	37.5
Slab group	US	3	30 × 280×280	Unreinforced	-------	--------
	GS	3		Reinforced	Biaxial geogrid	15

a : The location of biaxial geogrid layer from the top of specimen.

Table 3. Mixture proportion of concrete [27].

Concrete ingredients	Cement (kg/m^3) general purpose type	Fly ash (kg/m^3)	Slag (kg/m^3)	Sand (kg/m^3)	Fine Sand (kg/m^3)	Coarse aggregate (10 mm size) (kg/m^3)	Water reducing admixture-PN20* (ml/m^3)	Water ($Litters/m^3$)
Dosage	164.05	65.62	98.43	339.69	687.79	829.13	1476	132.09

* Admixture-PN20 is an aqueous solution of polycarboxylate polymers and hydrocarbons [27].

Table 4. Drying shrinkage test results.

Concrete prism specimens									
Group label	Age of drying time (days)					Intervals of drying shrinkage readings (days)			
	7	14	21	28	56	7 to 14	14 to 21	21 to 28	28 to 56
	Average of readings of drying shrinkage (mm)					Average of shrinkage strains (10^{-6}) (mm/mm)			
UP	6.873	6.142	5.861	5.806	6.218	2926	1124	221	1648
GP20	7.371	6.585	6.312	6.265	6.674	3142	1094	188	1636
GP37.5	7.293	6.458	6.179	6.134	6.538	3337	1117	182	1616
Concrete slab specimens									
Group label	Age of drying time (days)					Intervals of drying shrinkage readings (days)			
	7	14	21	28	56	7 to 14	14 to 21	21 to 28	28 to 56
	Average of readings of drying shrinkage in the two directions (mm)					Average of shrinkage strains in the two directions (10^{-6}) (mm/mm)			
US	7.111	6.373	6.165	6.137	6.514	2949	834	112	1508
GS	6.910	6.222	5.923	5.902	6.282	2748	1197	80	1520