줄눈 콘크리트 포장에서 실리콘 실란트의 양생기간 및 최적 형상계수에 대한 연구

A Study on Curing Time and Reasonable Shape Factor of Silicone Sealant for Concrete Pavement

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1. Introduction

Pavement joints sealed with low-modulus sealants or field-poured sealants (silicone, rubberized asphalt...) are different from the preformed sealants, in spite of their outstanding advantages. They usually fail for several reasons, such as traffic loading, moisture-related movement, drying shrinkage or expansion for absorbing water, weather changing, etc. Among them, the most important reason is the sealant shape factor which is defined as a ratio of the sealant thickness to the joint width. Given researches have focused on the shape factor. However, according to different researchers, the shape factor are totally different in 0.5 [as references 1, 8, 9], 1.0 [3, 5, 8, 9, 11], 1.0-1.5 [1, 7], 0.5-1.0 [4], 1.0-2.0 [10], 2.0 [3, 5], etc. In general, the sealant shape factor varies and depends on many factors such as joint spacing, weathering and so on. The object of this topic is merely to propose some research results about how to determine the applicable curing time (drying time) and the most reasonable shape factor of silicone sealant for jointed concrete pavement in order to prevent joint failures.

2. Experiments

2.1 Concerned problems

As mentioned above, there are many problems needed to consider when doing sealants tests. This topic focuses on two aspects. The first problem is the curing time. It effects significantly on the time to open to traffic and whether the sealant gets full-adhesion and totally dried and is described by using the parameters of full adhesion and silicone stiffness. K-stiffness is defined as the ratio of vertical force to its movement. According to Corn Downing Brand Silicone Pavement Sealants, the curing time is 14-21 days and it is also just use for references. The question is how to design the most characteristic method to determine the reasonable curing time for sealant? The second problem is the sealant shape factor. As early concerned, small silicone depth versus a large width for in-place sealant generally reduces the internal strains and improve the elastic performance of sealant. However, large sealant depth is desirable to ensure adequate bonding of sealant to the joint face. In other words, adequate bonding force is needed to resist by adhesion-loss problem. On the other hand, sealant thickness increases will make bonding force increase and at the same time, horizontal force will raise. As a results, it is not good for joint sidewalls because it may lead to decrease the quality of pavement joints and results in some failures at concrete pavement joints sealant.

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2.2 Test model and procedure

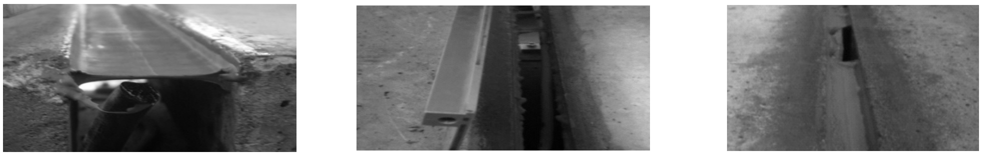
Tests are conducted by using Friction Tester and low-modulus sealant Dow Corning 890-SL Self Leveling Silicone. Curing time is determined by checking silicone stiffness and state of full adhesion. Concrete Pavement Joints width varies and depends on many factors like joints spacing, slab thickness, slab length, properties of concrete, weathering conditions like temperature, moisture, and much more. In general cases, pavement joints width is considered to be 6mm and 8mm. Joint width and thickness silicone are adjusted during the test. The forces, sealant movements, etc are recorded on computer, the relation between vertical force and vertical sealant movement has been mainly studied.

Fixed concrete slap | Free concrete slap | Friction Tester Silicone 890SL-Self Leveling Silicone | Sliding down tests

Figure 1. Test model and procedure

3. Results and analysis

3.1 Sealant failures



Case 1 | Case 2 | Case 3

Figure 2. Silicone sealant failures

Case 1 shows that no failures occur in spite of large elongation. It shows flexibility of silicone. Self-failure or internal failure of silicone is shown in case 2. In case 3, failures occur on sidewalls due to inadequate bonding between silicone and joint faces.

3.2 Working procedure of sealant

When applying the perpendicular force to silicone sealant at constant loading speed, it is observed that the vertical force rises up sharply at the beginning and reaches to the yield strength (elastic threshold) that is defined as the force or stress at which silicone begins to deform plastically. Followed by a gradual short increase because of initial strength deterioration on silicone surface which is more hardening than the other parts of sealant, the vertical force rises again. When it reaches to the ultimate strength point, sealant totally destroys due to its extreme elongation. Besides that, the horizontal movement does not change while the horizontal force slightly increases and it seems to be stable afterwards.

3.3 Curing time

Curing time is determined by the relationship between K stiffness and curing days as follows:

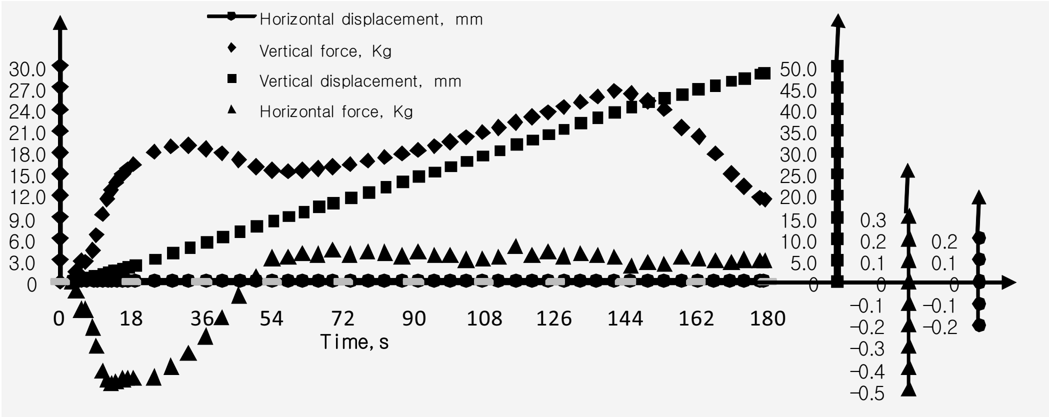


Figure 3. Silicone pavement joint sealant test at Lab, joint width of 6mm, sealant thickness of 4.5mm

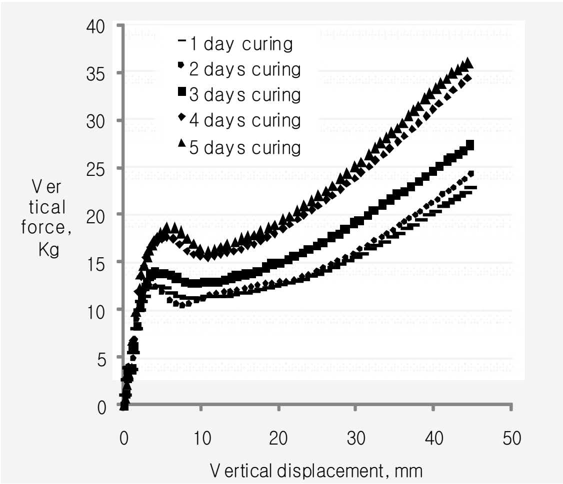
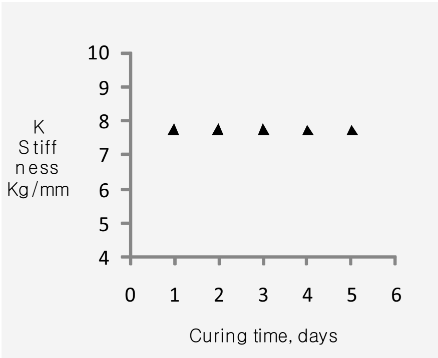


Figure 4. Vertical force and its displacement, joint width of 6mm and sealant thickness of 3mm



1 day is the most reasonable curing time for joint width of 6mm, sealant thickness of 3mm.

Figure 5. Determination of curing time

It can be said that when curing time increases, the maximum of vertical force in elastic period (yield strength) also increases. In other words, silicone strength increases along with the increase of curing time. This results in the differences in trend of the curves in figure 4. However, the K-stiffness seems not to change in elastic period. Hence, with joints width of 6mm, shape factor equals 0.5, the applicable curing time would be 1 day. This method is feasible to determine the curing time of low-modulus sealants.

3.4 The shape factor

The correlation between the vertical force and its movement of joints with 6mm and 8mm in width is as follows:

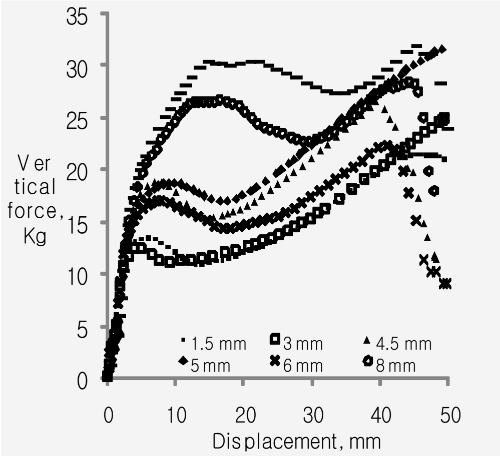


Figure 6. Vertical force and its displacement, joint width of 6mm

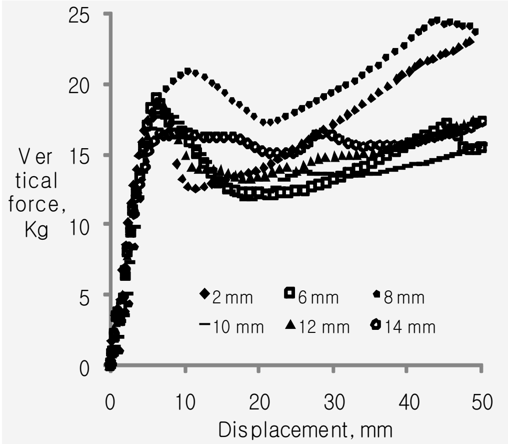
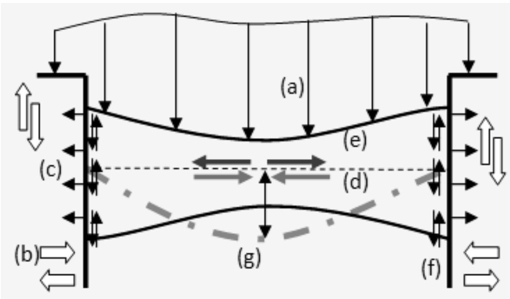


Figure 7. Vertical force and its displacement, joint width of 8mm

Based on experimental results, the K-stiffness of 6mm of joint width is slightly greater than 8mm ones at the same curing time. It is also easy to explain that, sealant acts as a beam in pavement joints, which its two heads are fixed on the surface of joint sidewalls. If it is loaded by wheel loading (a), movement of concrete slaps (b) (opening, closing, upward or downward) and much more (figure 8), the more the joints width increases, the more deformation the sealant strain will obtain. That is why the K-stiffness reduces when comparing between joints width of 6mm and of 8mm.



Joint width increases makes the deformation (g) go up and the gradual decrease of K-stiffness

Figure 8. Sealant stresses and deformation

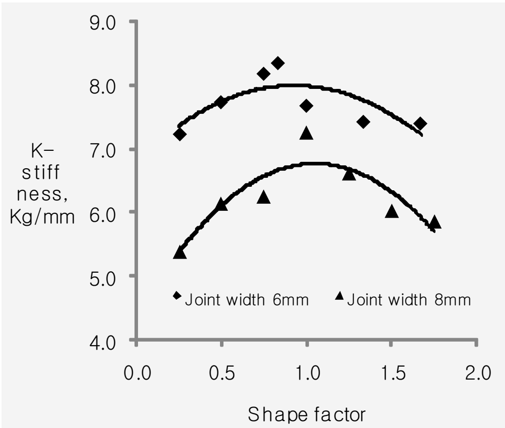


Figure 9. Determination of shape factor

According to [1] and more details in figure 8, there are a lot of stresses such as bonding stress (adhesion) (c), compression (d), tension (cohesion) (e), peeling stress (shear stress) (f), etc in sealant working procedure. Herein, this study would like to additionally mention about the sealant deformation (g). This parameter also plays an important role due to its effects on K-stiffness of pavement joints sealant. It means that, the more deformation sealant has, the more decreasing K-stiffness would be. In other words, when pavement joint width increases, the K-stiffness will drop. Most importantly, from figure 9, it can be seen that, with concrete joints width of 6mm and of 8mm, the proper shape factor would be approximate 1.

4. Conclusions

The shape factor is one of the most important characteristics affecting the failure of pavement joints sealant. The curing time also plays an important role in deciding when to open to traffic and whether or how long the sealant gets fully-adhesive and totally-dried. The topic also proposes a new method to determine curing time for silicone pavement joint sealants rather than the method from Corn Downing brand Silicone Pavement Sealants (Hand Full Test) and by which the evaluation of K-stiffness is done by using Friction Tester. In addition, the proper shape factor for concrete pavement joint sealants is different, depends on many factors and would be useful as above recommendations. In conclusion, it is requires more experiments and consideration of many real conditions to get good solutions. Hopefully, this study would have contribution to future research on pavement joints.

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