THE EFFECT OF SBR ON THE STRENGTH OF CONCRETE

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ABSTRACT

This research aims to evaluate Styrene-butadiene rubber (SBR) effect on the fresh property, compressive strength, and permeation of concrete. The mixes of SBR, added into the concrete by 5%, 10%, and 20% of cement weight, were compared to the mix of normal concrete with the same water-cement ratio. The comparison was done by comparing the properties of fresh concrete, and hardened concrete as the compressive strength, slump, water absorption, and the initial surface absorption test (ISAT) between SBR modified concrete and normal concrete. After checking the compressive strength of all samples, the results showed that the 7-day strength of SBR modified concrete showed an insignificant relationship with SBR. However, at 28-days of compressive strength, the strengths of concrete with all percentages of SBR were higher than that of normal strength. The results from slump testing showed that adding SBR affected the increase of workability of concrete. In addition, the tightness of concrete by adding SBR was confirmed through the water absorption test and ISAT test, which results showed the lower water absorption with the higher amount of SBR in concrete. However, the addition of SBR also has the limitation according to the experimental results. The optimal amount of SBR is 10% recommended in this study.

Keywords: *SBR, Strength, Slump, Water Absorption*

1. INTRODUCTION

Concrete has been used for more than 100 years because of its economy and availability [1], however, concrete becomes cracked easily because of its brittle behavior especially for the structural concrete located in coastal areas. Once it becomes cracked, the cracks would lead to many problems and reduce the service life of the concrete. Even though concrete has high compressive strength, it is quite weak in tension. Moreover, the pores inside the concrete matrix could lead to physical and chemical deterioration. On the contrary, polymers are weaker in compression but have higher tensile capacity. Other important properties are the good ability to adhere to other materials, and also have good resistance to physical and chemical attack. Thus, mixing these two materials could produce a compound that has great strength and durability [2].

Several types of polymer such as latex, redispersible polymer powder, water-soluble powder, and liquid resins can be used in concrete. After the polymer is added into concrete, the cement hydration and polymer phase formation proceed well to create a monolithic matrix phase with a network structure, in which the hydrated cement phase would be combined with the polymer phase. These two phases would be bound with aggregate to create polymer-modified concrete that has good flexibility and compressive strength [3].

Styrene-butadiene rubber (SBR) latex is one type of high polymer dispersion emulsion that is a white thick liquid and is widely used as an admixture [4]-[6]. SBR is composed of butadiene, styrene, water and it can be successfully bonded to many materials, and its water content is 52.7%. It is used to replace cement binders for improving the tensile, flexural, and compressive strength of concrete [4]. Moreover, SBR will form a latex film that improves the bond strength and mechanical properties of concrete and increases the concretes resistance to water permeability [3]. However, the effect resulted from adding SBR into fresh concrete on the most important property of concrete (compressive strength) which needs to be studied. Besides, water absorption is also an important parameter as it is a resistance indicator against carbonation migration. Meanwhile, water absorption value indirectly provides information about the porosity of concrete [1]. Therefore, this research focuses on the effect of SBR on significant properties in concrete such as strength, slump, water absorption, and initial surface absorption.

2. MATERIALS AND METHODS

2.1. MATERIALS

The water used in the experiment was normal clean water which could be found from the water tap directly. The sand used in the experiment was river sand, its properties are shown in Table 1. The sand used in the experiment was kept in one barrel in order to keep its uniform properties. The stone used in the experiment was limestone which was kept in a covered barrel to keep its constant moisture, its properties are shown in Table 1. The SBR used in the experiment was sika latex®. The Portland cement type I was also used in the study.

2.2. PROPERTIES OF COARSE AND FINE AGGREGATE

The properties of sand and stone were measured, their results are given in Table 1.

Table 1 Physical properties of sand and stone used in experiment.

Items	stone	sand
Water absorption(%)	1.06	0.92
Specific gravity	2.67	--
Unit density (Kg/m^3)	1576.6	1655.21
modulus	2.89	2.36

2.3. MIX PROPORTION

There are four different mix proportions of concrete in this experiment as given in Table 2. Mix I, Mix II, Mix III, and Mix IV contained 20%, 10%, 5%, and 0% of SBR by cement weight, respectively. The SBR solution contains SBR and 60% of water was added into the concrete mix during the mixing. Thus, these four mixes have the same water-cement ratio. The mix design was made according to the standard of ACI 211.1-91.

Table 2 Four mix proportions of concrete.

Items	Stone (Kg)	Sand (Kg)	Water (Kg)	Cement (Kg)	SBR* solution (Kg)
Mix I	995	756	91	380	190
Mix II	995	756	148	380	95
Mix III	995	756	176.5	380	47.5
Mix IV	995	756	205	380	0

*Note: the percentage of water in SBR solution is 60%,

2.4. PREPARATION OF CONCRETE SAMPLES AND TESTING PROCEDURE

The fresh concrete was mixed by using a pan mixer. Firstly, cement, stone, and sand were added to the pan mixer and followed by some amount of water. Then, the rest of the water and SBR solution were added to the pan mixer, the concrete was mixed until obtaining the proper workability. Then, each mix was tested for slump testing. The vibrating machine was used during casting. 12 concrete samples were casted in each mix, thus, 48 concrete samples were casted in total. After demolding, all concrete samples were put in a curing chamber with 30 ℃ temperature and 90% relative humidity. The compressive strength test at 7 days and 28 days was tested for all mixes according to ASTM C39. The water absorption of concrete was measured according to the standard of ASTM C642. Finally, the value of ISAT was measured following the standard of BS 1881 part 5. Each mix has 12 concrete samples which were used for compressive strength, water absorption and ISAT, 3 samples for one kind of test.

3. RESULTS AND DISCUSSION

3.1. SLUMP TESTING

The values from the slump test were increased with the increase of the amount of SBR in concrete. The slump of the controlled mix (0% of SBR) was 86mm, but the values of the other modified concrete mixes which contain 5%, 10%, 20% of SBR were 93mm, 105mm, and 137mm, respectively. These results are shown in Figure 1. The reason for the increase in slumps is that SBR has a plasticizing effect which improves the workability of concrete [1].

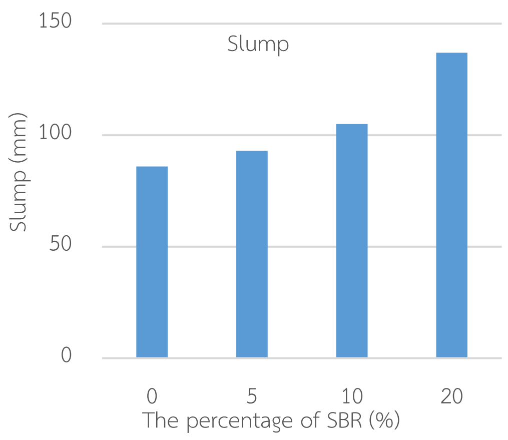

Figure 1 The slump of concrete with different percentages of SBR.

3.2. *COMPRESSIVE STRENGTH*

The average compressive strength of concrete samples at 7 days and 28 days is shown in Figure 2. The 7 days strength of concrete samples which contain 5%, 10%, and 20% SBR were 22.3 MPa, 21.9MPa, and 20.7MPa, respectively. For the control mix, the strength was 20.8MPa. By comparing the SBR modified concrete and the normal concrete, the SBR could slightly improve the compressive strength of concrete. But it did not show a clear benefit when the percentage of SBR was 20%. The reason is shown from the results of previous studies that the effect of SBR addition on compressive strength is negative at an early age because the development of polymer structure and cement hydration is in process of formation [1]. For the 28-days strength of concrete, the results were increased with the higher amount of SBR. 31.9 MPa, 33.2 MPa, and 33.5 MPa for the 5%, 10%, and 20% of SBR modified concrete. The strengths of all modified concretes were higher than that of the controlled group. The reason is that the formation of polymer film on the surface of concrete retains the internal pressure for continuing cement hydration [1]. In addition, the formation of polymer film combined with the concrete compounds will produce a tighter matrix. Even though the SBR could improve the compressive strength of concrete, the insignificant difference for compressive strength of concrete between the mix of 10% and 20% of SBR was observed. Thus, the optimal percentage of SBR in concrete is 10% because the strength of concrete did not increase significantly when the percentage of SBR was 20%.

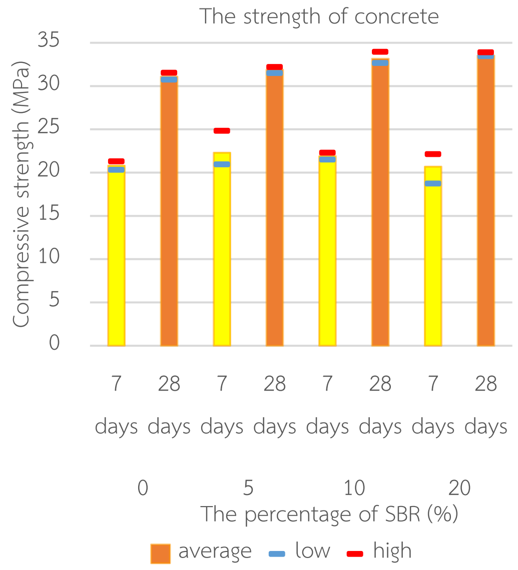

Figure 2 The strength of concrete with different percentages of SBR.

3.3. *WATER ABSORPTION TEST*

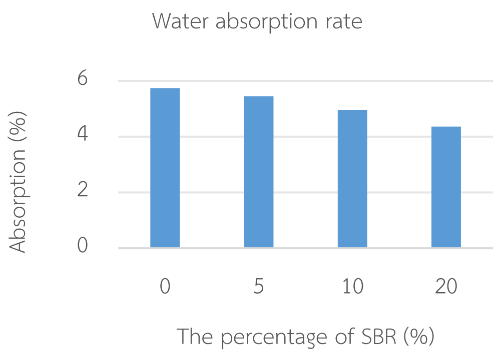

Figure 3 The water absorption of concrete with different percentages of SBR.

The average water absorption rate of concrete is shown in Figure 3. The water absorption rate of control and modified concrete were 5.7%, 5.4%, 5.0%, and 4.4% for 0%, 5%, 10%, and 20% of SBR modified concrete, respectively. It indicated that the absorption of water could be decreased with the addition of SBR, which corresponded to the higher compressive strength at 28 days in section 3.2. It could be mentioned that the more SBR contained in concrete; the lower the water absorption rate was observed. In addition, the decrease in water absorption of SBR-modified concrete could be caused by the formation of polymer film, which can prevent the movement of water inside of concrete. The polymer film makes the concrete become water-tight [1].

3.2 INITIAL SURFACE ABSORPTION TEST (ISAT)

The average results of ISAT are shown in Figure 4. These results showed a decrease of ISAT with a higher amount of SBR. That is because the formation of polymer film prevents the water from getting into the concrete. Nevertheless, the initial surface absorption of concrete was increased again when the percentage of SBR was 20%, which might be affected by the time used in the experiment (1 hour) was shorter than that of the water absorption test (24 hours). However, according to the contradictory trend of the average ISAT in 10% and 20% of SBR, this could be implied that the optimal amount of SBR is 10%.

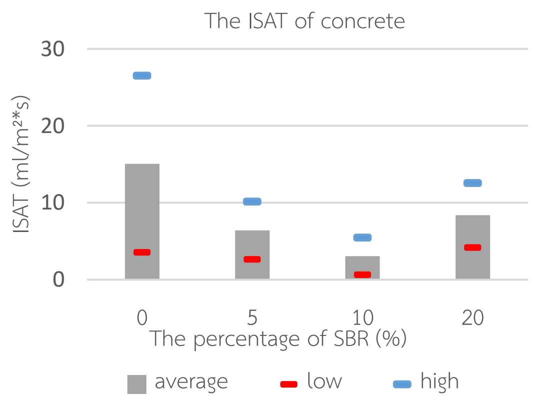

Figure 4 The initial surface absorption of concrete with different percentages of SBR.

4. CONCLUSIONS

Based on the study, several conclusions could be summarized:

1. The slumps of fresh concrete could be increased with the increase of SBR, the reason is that the SBR has a plasticizing effect which improves the workability of concrete.
2. By comparing with normal concrete, the average compressive strength at 7-day of concrete showed an insignificant increase by adding SBR, because the formation of polymer film and hydration process was in process. In the case of 28-days of average compressive strength, the addition of SBR could improve the strength of concrete more than that of normal concrete, because the formation of polymer film affected the concrete matrix. But the strength results of 10% and 20% of SBR showed insignificantly different. Therefore, the optimal percentage of SBR in concrete is 10%, because the strength of concrete did not increase significantly when the percentage of SBR was 20%.
3. The water absorption of concrete was decreased with the increase of SBR, the formation of polymer film prevented the movement of water inside of concrete. In addition, the concrete became water-tight with the addition of SBR.
4. The initial surface absorption of concrete was decreased with the increase of SBR excepting the percentage of SBR reached 20%. This showed that the concrete was becoming tight with the increasing amount of SBR in concrete. But the addition of SBR has the optimal value which is 10%.

5. REFERENCES

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