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Asphalt Dust Waste Material as a Paste Volume in Developing Sustainable Self Compacting Concrete (SCC)

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Abstract. Self-compacting concrete (SCC) mixtures are usually designed to have high workability during the fresh state through the influence of higher volumes of paste in concrete mixtures. Asphalt dust waste (ADW) is one of disposed materials obtained during the production of asphalt premix. These fine powder wastes contribute to environmental problems today. However, these waste materials can be utilized in the development of sustainable and economical SCC. This paper focuses on the preliminary evaluations of the fresh properties and compressive strength of developed SCC for 7 and 28 days only. 144 cube samples from 24 mixtures with varying water binder ratios (0.2, 0.3 and 0.4) and ADW volume (0% to 100%) were prepared. $MD9_{40}$ and $MD9_{50}$ showed a satisfactory performance for the slump flow, J-Ring, L-Box and V-Funnel tests at fresh state. The compressive strength after 28 days for $MD9_{40}$ and $MD9_{50}$ was 36.9 MPa and 28.0 MPa respectively. In conclusion, the use of ADW as paste volume should be limited and a higher water binder ratio will significantly reduce the compressive strength.

INTRODUCTION

The development of Self Compacting Concrete (SCC) has started since 1986 in Japan. It was invented due to the gradual reduction of skilled workers that caused problems in the production of durable concrete structures by adequate compaction during the placement of concrete. Therefore, SCC is the alternative solution to produce durable concrete structures that can be compacted into every corner of a formwork without requiring any vibrating tools [1].

SCC is a concrete that has very high workability that allows it to flow and consolidate under its own weight during the fresh state without the need for vibration tools. Furthermore, it also has excellent filling ability, passing ability and stability from segregation [2]. Nowadays, researchers are taking advantage of waste materials and using them as replacement material for cement, aggregates, sand or filler materials in SCC [3]. On the other hand, utilizing waste materials in the development of SCC is becoming one of the most efficient solutions to reduce environmental problems especially for waste related to landfill problems [4]. Besides that, utilizing waste materials in SCC will also give rise to more efficient technologies and optimize the use of resources which can contribute towards a nation's sustainability and growth.

Previous research has utilized powder waste as a replacement for some of the constituent materials in SCC. Some of them have utilized disposed waste marble powder, kaolin waste, roof tile powder, granite powder, basalt powder, rice husk ash and limestone powder material to increase the rheological effect in SCC [5-12]. Generally, the powder materials used in SCC are less than 0.125 mm in size as they are the most efficient [2]. However, different types of powder waste have resulted in a wide range of mix possibilities and therefore, there is a considerable gap when it concerns the improvement of the mix design for various applications and requirements [12-13].

Therefore, this paper presents the potential use of Asphalt Dust Waste (ADW), which has particle sizes less than 0.125 mm, as part of the paste materials to improve the rheological properties of SCC during its fresh state. This research contributes significantly in reducing local waste generated through asphalt road construction in Malaysia. In

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conclusion, the results from $MD9_{40}$ and $MD9_{50}$ showed a very good performance in the fresh state as well as the hardened state for developed ADWSCC.

EXPERIMENTAL

Constituent Materials

The constituent materials used in this research are Local Ordinary Portland Cement type 1 according to MS EN 197-1, CEM I 42.5 N, course aggregates measuring 12 mm, fine aggregates measuring 4 mm and ADW. The constituent materials were air dried prior to mixing except for cement.

Mixed Proportion

The performance of SCC in its fresh and hardened state depends on the proportion and types of constituent materials, water binder ratio (w/b) and high range water reducing admixture [215]. This research developed four series of mix design designations, which are $MD4_{0\text{-}100}$, $MD5_{0\text{-}100}$, $MD6_{0\text{-}100}$, and $MD7_{0\text{-}50}$ as shown in Table 1 and Table 2. The proportions of constituent materials are based on the total volumetric ratio (TVR) concept. The $MD4_{0\text{-}100}$, $MD5_{0\text{-}100}$ and $MD6_{0\text{-}100}$ are designed with 25% cement, 60% aggregate, 15% sand and an increasing amount of ADW ranging from 20% to 100% by volume of course aggregate. The amount of superplasticiser SIKA 2044 was fixed at 3% and the water binder ratios of 0.2, 0.3 and 0.4 were used for $MD4_{0\text{-}100}$, $MD5_{0\text{-}100}$, $MD6_{0\text{-}100}$ respectively. Finally, the mix design for $MD9_{0\text{-}50}$was modified to 25% cement, 50% aggregate, 50% sand from volume of aggregate and ADW ranging from 10% to 50% by total volume of coarse aggregate and sand. The modifications of mix design $MD9_{0\text{-}50}$ are based on reducing the amount of granular materials (aggregate and sand), a w/b ratio of 0.3, 2% of superplaticiser SIKA 2044 and an increased amount of ADW as a paste material.

TABLE 1. Proportion mixed design for$MD4_{0\text{-}100}$, $MD5_{0\text{-}100}$and $MD6_{0\text{-}100}$

Weight(kg)	**Percentages of Asphalt Dust Waste**					
	0%	20%	40%	60%	80%	100%
Cement	288	288	288	288	288	288
Aggregate	801	801	801	801	801	801
Sand	240	240	240	240	240	240
ADW	0	126	253	379	505	632
w/b	For ($MD4_{0\text{-}100}$ - 0.2) , ($MD5_{0\text{-}100}$ - 0.3) and ($MD6_{0\text{-}100}$ - 0.4)					
Superplasticizer	(3%)					

TABLE 2. Proportion mixed design for $MD9_{0\text{-}50}$

Weight(kg)	**Percentages of Asphalt Dust Waste**					
	0%	10%	20%	30%	40%	50%
Cement	288	288	288	288	288	288
Aggregate	668	601	534	467	401	334
Sand	400	360	320	280	240	200
ADW	0	79	158	237	316	395
w/b	0.3					
Superplasticizer	2%					

RESULTS AND DISCUSSIONS

Fresh State Conditions

Fresh states properties of SCC were initially evaluated. The performance of SCC in its fresh state was measured in terms of slump flow diameter, J Ring test, V-funnel test and L-box test. The slump flow values for $MD4_{0\text{-}100}$, $MD5_{0\text{-}100}$, $MD6_{0\text{-}100}$, and $MD9_{0\text{-}30}$ are less than 550 mm except for $MD9_{40\text{-}50}$. However, $MD4_{0\text{-}100}$, $MD5_{0\text{-}100}$, $MD6_{0\text{-}100}$ and $MD9_{0\text{-}30}$ obtained values close to 500 mm slump flow and may possibly achieve a higher flow by increasing its w/b ratio, sand to aggregate ratio and the amount of superplasticiser SIKA 2044. Finally, the adjusted mix, $MD9_{40\text{-}50,}$ consisted of a w/b ratio 0.3 and 2% of SP. $MD9_{40}$ is based on a volumetric ratio of 25% cement, 30% aggregates, 15% sand and 30% ADW. Meanwhile, $MD9_{50}$ refer to a volumetric ratio of 25% cement, 20% aggregate, 12.5% sand and 37.5% ADW. Table 3 shows the details of the fresh state properties of $MD9_{0\text{-}50}$.

TABLE 3. Fresh state properties of $MD9_{0\text{-}50}$

	$MD9_{0}$	**$MD9_{10}$**	**$MD9_{20}$**	**$MD9_{30}$**	**$MD9_{40}$**	**$MD9_{50}$**
Slump flow	400 mm	420 mm	410 mm	405 mm	675 mm	705 mm
SF for T_{500}	-	-	-	-	3 s	3 s
J Ring flow	-	-	-	-	650 mm	700 mm
JR T_{500}	-	-	-	-	3 s	3 s
VF T_{5s}	-	-	-	-	40 s	27 s
VF T_{5m}	-	-	-	-	45 s	34 s
L Box $_{(H2/H1)}$	-	-	-	-	0.95	0.94
L Box T_{20}	-	-	-	-	3 s	2 s
L Box T_{40}	-	-	-	-	5 s	4 s

Compressive Strength of ADWSCC

A total of 144 cube samples (100mm x 100mm x100mm) were measured for compressive strength on day 7 and day 28 as shown in Figure 1.On average, MD4, MD5 and MD9 have a compressive strength of more than 30 MPa. This also shows that some of these proportions have the potential to be used as self compacting concrete. However, the proportion ratio between constituent materials, w/b ratio and amount of superplasticiser SIKA 2044 need to be adjusted to improve the fresh state properties of SCC [2].

The compressive result from $MD4_{0\text{-}100}$, $MD5_{0\text{-}100}$ and $MD6_{0\text{-}100}$ showed that ADW can be optimized between the range of 20% to 60% from the total volume of aggregates. However, the modified mix proportion of $MD9_{0\text{-}50}$ has shown gradual degradation in terms of compressive strength with the increasing amount of ADW used. This diminution may be due to different matrix proportions in the design of constituent materials used.

According to the results obtained, the reuse of ADW material as a paste material in high volume from the amount of granular materials is part of a contribution towards sustainable development. The development of SCC has greatly reduced energy consumption, labour cost, faster construction, better surface finishes as well as produced a thinner concrete section [2].

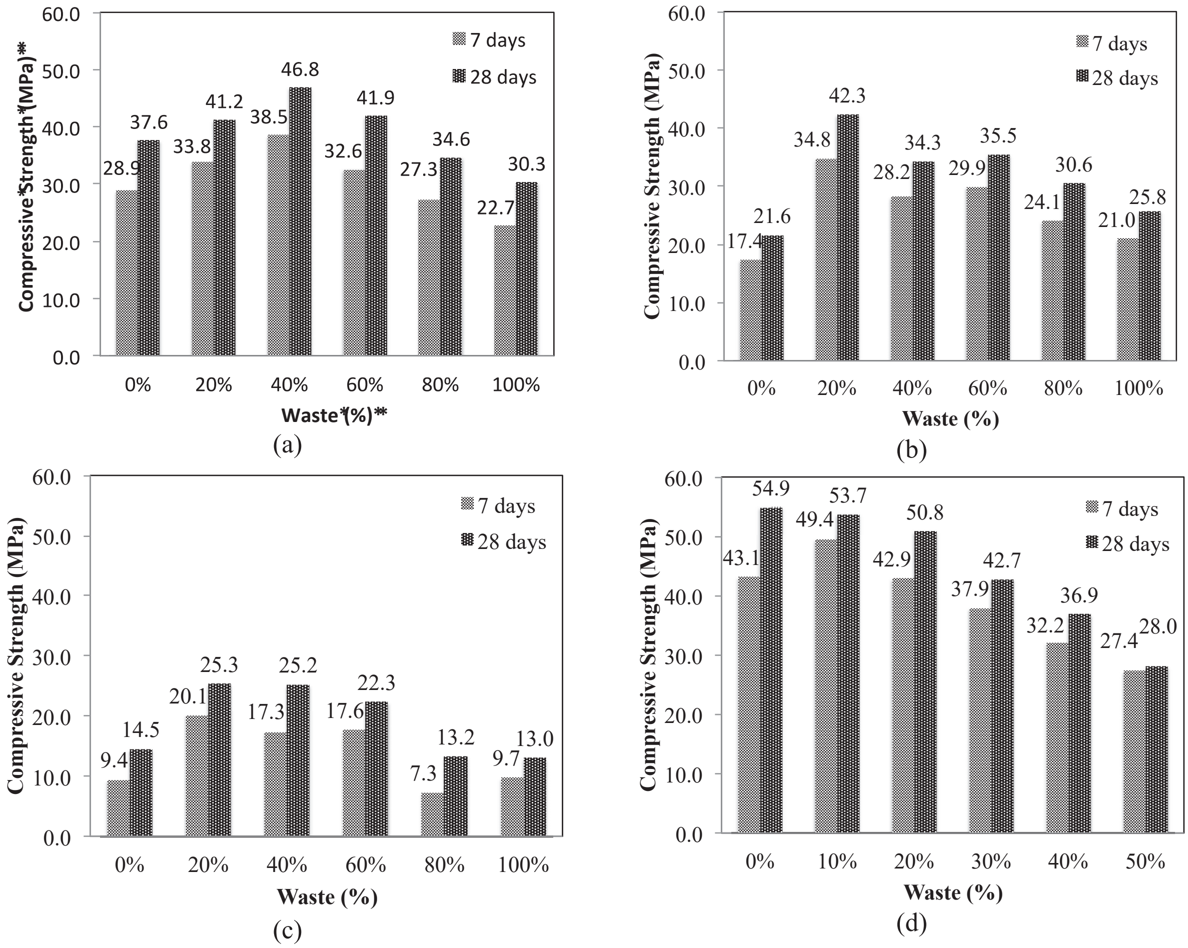

FIGURE 1. Compressive test for 7 and 28 days; (a) MD4, (b) MD5, (c) MD6 and (d) MD9

CONCLUSIONS

In this research, the use of ADW as a paste material in production of high slump concrete and SCC was successful. ADW has the ability to increase packing factor between granular materials and also improve workability in concrete mixture. However, utilizing w/b ratio 0.4 and superplasticiser 3% have draw back the compressive strength of MD6 concrete mixture. Therefore, further research on various granular ratios with differences w/b ratio and percentage of superplasticiser should be conducted to obtain an economical mix design ratio. Furthermore, the compressive strength also should be evaluated more than 28 days to study the effect of ADW in hardened concrete in longer duration.

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