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Research paper

Prediction of Sound Absorption Coefficient for Double Layer Rubberised Concrete Blocks

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Abstract

Nowadays rubberised concrete is used to support construction sustainability and contribute to a better development of efficient construction material, in particular by using waste rubber tyre. The use of rubber in block pavement is one of the actions in order to reduce the noise from tyre-road interaction and hence able to reduce pass by noise pollution. In this paper, the influence of waste rubber tyre as the replacement for aggregate on the sound absorption coefficient of double layer rubberised concrete blocks was investigated. Non acoustics and acoustics experimental investigations were carried out on a series of block with thickness of 80 mm with facing layer (FL) of block varies in thickness from 10 to 40 mm. FL and bottom layer consist of concrete mixture containing waste tyre rubber granules (RG) of 5 mm to 8 mm and 1 mm to 4 mm, respectively as replacement of natural aggregate within the range of 10-40%. The ratio for cement: aggregate: sand was 1: 1.7:1.5 and water to cement (w/c) ratio of 0.47. Noun acoustics parameters include density, compressive strength, water absorption and porosity. Acoustic parameters investigation of specimens of double layer block showed that concrete pavement blocks have maximum sound absorption located at low frequency of 500 to 700 Hz. This indicates that it is suitable for application of mitigation of low speed traffic condition. A model was developed to predict the maximum sound absorption coefficient of the double layer block pavements which included the percentage of rubber content, thickness of FL and porosity as statistically significant predictor ($p < 0.05$). This would benefit the road engineers in managing traffic noise management as the sound absorption coefficient is the key important element in reducing tyre/road interaction noise.

***Keywords**: Sound Absorption Coefficient; Double-Layer Concrete Block; Rubberised Concrete; Concrete Paving Blocks; Tyre/Road Interaction*

1. Introduction

Traffic noise remained an annoying noise to people living in most cities in the world. Perhaps it due to the increase of the number of vehicles to accommodate for the transportation of human supplies. Even though newer vehicles are designed to produce lower noise levels, the increase in vehicle density has kept traffic noise as a major setback in the improvement of the quality of life (1). According to most recent research, the problem of traffic noise has led many people living near major roads have high chances of dementia (2). The use of pavement with low noise emission characteristics is one of the actions mostly applied all over the world to curve this situation. Low noise concrete pavement block (CPB) is even better as it durable against chemical spills involving fuel, hydraulic fluid, and other materials. Also, its provide a low-maintenance, flexible structure, durable to weather and organic solvents resistant, and aesthetics. Its modular nature make it is easy to remove, reuse and replace for the case of settlement (3). Depend on its strength, CPB applicable to many pavement uses such that for low-speed road area (speed up to 60 km/hr), heavily-trafficked urban streets, port facility loading terminals, and on airfield taxiways at the international airport.

The key characteristic of low noise block pavement is the sound absorption coefficient α which is the capability of block to absorb sound. The values are in the range of $0<\alpha<1$ with of 1.0 being the perfectly absorbing sound and 0 is perfectly reflecting sound. Generally, normal concrete has α relatively low value of 0.05–0.10. Past research by Sukontasukkul and Chaikaew (4) found that adding rubber causes sound absorption coefficient increased due to void present in microstructure of concrete. There are two reasons of void present in microstructure of concrete by: i) mixture lack interaction bonding between tyre particle and cement (5, 6); ii) due to hydrophobic nature of rubber that could repel water and results in porosity once the concrete hardened (7). Similarly, the void in pavement structure can absorb sound created by road-tyre interaction (8). According to Peeters and Kuijpers (9), α value of greater 0.3 would minimize horn effect which occurs in the range of 500 Hz to 2500Hz.

The research presented in this paper focused on exploratory evaluation of effect of RG composition on non-acoustical properties, and prediction of its acoustical performance of the sound absorption coefficient. The objective of the research presented in this paper is to evaluate the effect of rubber granules (RG) composition on non-acoustical parameters of double layer rubberised concrete paving block (DRCPB) and to evaluate the relationship between maximum sound absorption coefficient and non-acoustical parameters. This was accomplished through laboratory test of acoustic characteristics of DRCPB and assessment of relationship between optimum sound absorption and non-acoustical properties through the multi-regression analysis. Further, the important empirical modelling is the determination of the block with maximum sound absorption in effective frequency and will be used for future work of the determination of the pass by noise reduction.

2. Literature Review

Researches have conducted on the physical properties and strengths of CPB with the application of crumb rubber or RG from waste tyre as aggregate replacement (4, 10-14) Ling et al.,(15), researches had focused on development of single block layer pavement. While Ling et al (10) used the crumb rubber for replacement of fine aggregate (11-13, 16) treated RG replacement for coarse aggregate at FL of double layer block. In general, the compressive strength of concrete pavement block would reduce (10-13, 16) but increase the flexural strength and skid resistance (4, 10). Specifically Ling et al.(10) found that 15% replacement as fine aggregate and w/c=0.5, CPB achieve the target compressive strength of 30 MPa. This proves that CPB has a great potential to be used according to traffic volume and types of applications.Only little research showed the information of acoustic performance on rubberised CPB (10, 13). Double layer with fine aggregate replacement in FL demonstrated lower sound absorption coefficients than without facing layer over the entire frequency range (100–1600 Hz). This was attributed to the fact that CPBs without facing layer contribute a higher porosity may due to the large sized pore surface, resulting in lesser frictional losses within the pore structure. Meanwhile, frequency spectrum of sound pressure level due to traffic varies according to speed of traffic. For low speed the peak is usually at 500 to 700 Hz while for high speed sound pressure level is dominantly high at 900 to 1100 Hz. Shatanawi (17) suggested that the maximum absorption coefficient is recommended to occur at a frequency of approximately 500 to 700 Hz for low traffic speed and at approximately 900 to 1100 Hz for high speed traffic. While Tian et al. (18) stated that maximum sound absorption coefficient depends also on the mixture characteristics and the thickness of the specimen, with thickness of 80 mm produced a maximum absorption for concrete pavement.

Further, it is suggested that rubber usage in block pavement is the only solution to mitigate traffic noise for roads with high and continuous traffic flows (19, 20). The development of poro-elastic is one example of rubber application in block which essentially consisting of a hard aggregate of small stones and sand particles, a soft aggregate of RG from recycled tyres and a binder of polyurethane. In this research, a series of double layer block containing different percentage of RG, sand, gravel and cement as a binder has been looked and their relation between sound absorption coefficient with non-acoustical properties has been further examined.

3. Methodology

3.1. Materials

The main composition of concrete paving block are cement, fine and coarse aggregate. Cement was ordinary Portland cement (OPC) Type I complying with ASTM C150 (ASTM, 2002) to ensure that the block has enough strength with compressive strength value of cement at 28 day not less than standard value of 45MPa. The composition of cement is shown in Fig. 1. Fine aggregate used were natural aggregates (sand) and RG of size1 – 4 mm while coarse aggregate were crushed granite with nominal size less than 10 mm and RG of and 5 – 8 mm (Fig. 2). The material properties of natural fine and coarse aggregate were listed in Table 1 while the chemical properties of RG is shown in Table 2. RG were produced from mechanical shredding of waste tyre rubber (Fig. 2(d) and 2(e)). Besides main composition, a high-range water-reducer - superplasticizer of Glenium C380 was used to produce concrete that able to flow easily while maintaining high plasticity for periods longer than conventional concrete. This superplasticizer is free of chloride, and has been formulated to comply with the requirements of ASTM C494 (ASTM, 2013) for Types A and F admixtures.

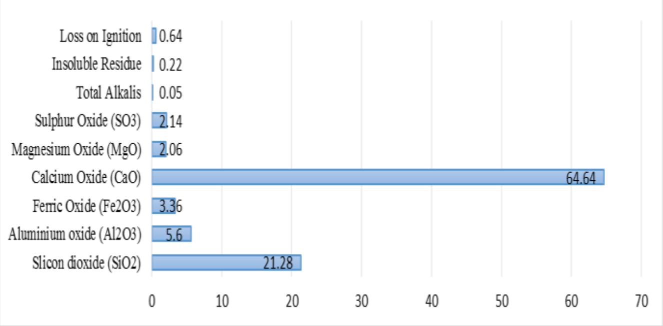


Fig. 1: Chemical Compositions of Ordinary Portland Cement

Table 1: Density, Specific Gravity and Water Absorption

Aggregate Type	Density (kg/m3)	Specific Gravity	Water Absorption (%)
Coarse Aggregate	2493.75	2.50	0.49
Fine Aggregate	1645.88	1.65	0.70

Table 2: Density and chemical composition

Density:	1.103 g/cm3
Chemical composition:	
SBR	48%
Carbon black	47%
Extender oil	1.9%
Zinc oxide	1.1%
Strearic acid	0.5%
Sulfur	0.8%
Acccelerator	0.7%


(a) cement (b) natural sand (c) coarse granite (d) fine RG (e) coarse RG

Fig. 2: Main composition in block pavement

3.2. Method of fabrication

DRCPB specimens were fabricated by mix proportion of cement: aggregate: sand of 1: 1.7: 1.5 and water cement (w/c) ratio of 0.47. Two concrete mixes were prepared; Mixture I (in FL) consist of natural fine aggregate, natural coarse aggregate (granite) and coarser RG(5-8 mm) (Fig. 3). The RG replaced the coarse aggregate (granite) by means of 10, 20, 30 and 40 % by weight. Mixture II for bottom layer consist of natural coarse aggregate (granite), natural fine aggregate and fine RG(1-4 mm). The fine RG replaced the fine sand), also by means of 10, 20, 30 and 40 % by weight. The DRCPB were fabricated in steel mould with internal dimension of 200 mm in length, 100 mm in width and 80 mm in depth.

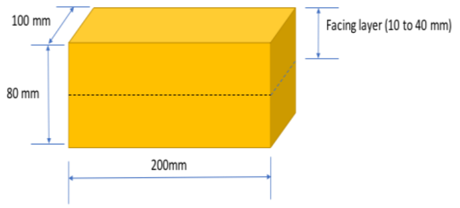


Fig. 3: Illustration of double layer rubberised concrete paving blocks specimen series

320 numbers of CPB Specimen were made for non-acoustic parameters testing such as water absorption, porosity, density and compressive strength, i.e 5 specimen for each percentage of RG and thickness. An 80 mm depth was selected so that the DRCPB can receive high traffic loading. This was also based on the work by Tian et al. (2014) that maximum absorption coefficient was achieved by using thickness of specimen 80mm. There were four specimen series with the percentage of RG varied with 10 % (DRCPB (10)), 20 % (DRCPB (20)), 30 % (DRCPB (30)) and 40 % (DRCPB (40)) (Table 3). In each series, FL thickness were varied with 10, 20, 30 and 40 mm (Fig. 3). In each specimen, concrete mixture II were poured into the steel moulds and compacted on a vibrating table for 5 seconds. Then, subsequently, Mixture I concrete mix was poured on top of the concrete in the steel moulds then compacted for another 5 seconds to obtain uniform mix and avoid segregation. Another 16 double-layer cylindrical rubberised concrete specimens with 99.5 mm in diameter and 80 mm thickness were prepared for acoustical testing. DRCPB Acoustical samples were casted in thin cylindrical PVC sleeves to ensure a snug fit. Both non-acoustical testing and acoustical testing specimens were removed from the moulds after 24 hours of casting and cured in air at room temperature approximately 27 °C and 65 % relative humidity for 28 days until tested.

Table 3: Mix proportion for specimen series

Specimen series (RG percentage)	**FL**	**Mixture Series***	**Cement (kg/m^3)**	**RG size (mm)**	**RG (kg/m^3)**	**Aggregate (kg/m^3)**	**Sand (kg/m^3)**	**No of non-acoustical testing specimens**	**No of Acoustical testing specimens**
DRCPB (10)	10, 20, 30 and 40 mm	I	489	5–8	43.0	733.5	733.5	80	4
		II	489	1–4	52.6	831.3	660.1		
DRCPB (20)		I	489	5–8	75.3	660.2	733.5	80	4
		II	489	1–4	105.0	831.3	586.8		
DRCPB (30)		I	489	5–8	107.6	586.8	733.5	80	4
		II	489	1–4	157.6	831.3	513.4		
DRCPB (40)		I	489	5–8	150.6	489.0	733.5	80	4
		II	489	1–4	210.0	831.3	440.1		

*Mixture I – FL: Mixture II – bottom layer

Fig. 4: DRCPB and cylindrical samples

3.3. Non-Acoustics and Acoustic Performance Testing

Non-acoustic testing on DRCPB specimens including water absorption, porosity, density and compressive strength were first tested. The compressive strength tests were conducted in accordance with BS EN 1338 (BS EN, 2003) specification. The effective air voids test was performed according to ASTM D 7063 (ASTM, 2011) by using a CoreLok device, which is usually used for testing the porosity of compacted asphalt concrete samples. Densities and porosities of DRCPBs were measured according to the standard procedures stated in ASTM C642 (ASTM, 2006). Detailed information for the physical and mechanical performance testing can be found in Jusli et al. (13).

Sound absorption of DRCPB was measured according to ASTM E1050 (ASTM, 2010) by using impedance tube. In this test, the parameter measured is only limited to the acoustic or sound absorption coefficient (α). The acoustic absorption coefficient was measured in a range from 100 to 1600 Hz and follows ASTM E1050 specification. An average of three samples of specimens was taken. It is known that the frequency of noise from the tyre-pavement interaction concentrates within the range of approximately 600–1,250 Hz. Therefore, the input sound frequency of the standing-wave tube was controlled in the range of approximately 125–2,000 Hz, and the evaluation was based on the acoustical performance of the DRCPB material in this frequency range.

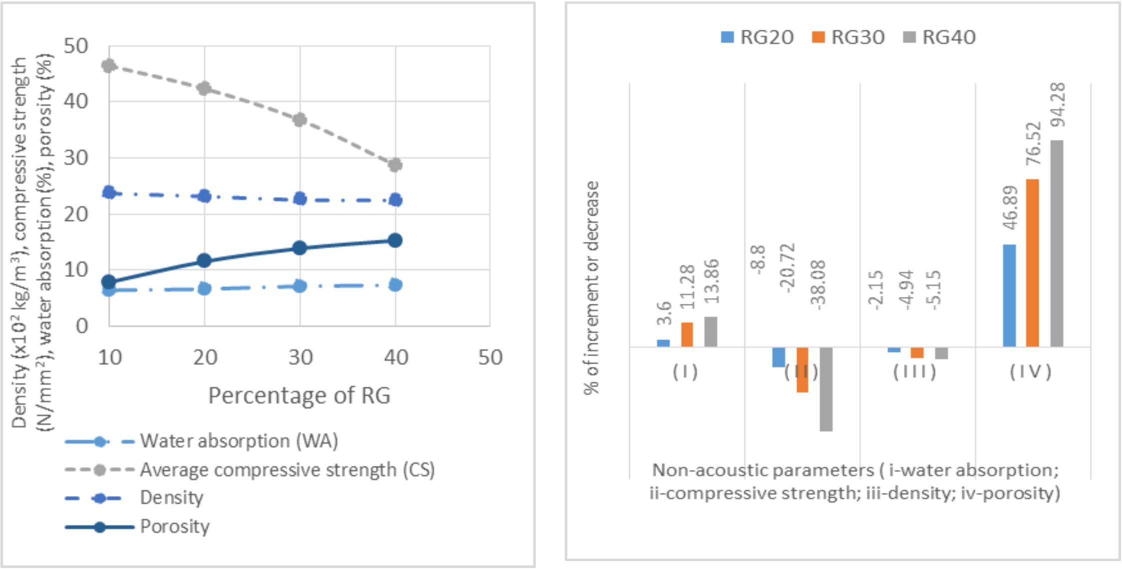
3.4. Non-Acoustical Parameters and Its Relation with Sound Absorption Coefficient

The effect of percentage of RG on non-acoustical parameters were evaluated. The maximum sound absorption coefficients and it frequency position were analyzed for each specimen. The correlation of maximum sound absorption with each non-acoustical parameter were then determined, in order to investigate the possibilities of influence of non-acoustical parameters to sound absorption coefficient. Then, multiple regression analysis was used to estimate a predictive equation of sound absorption with the help of Microsoft excel. Multiple regressions give the opportunity to establish the evidence that one or more independent variables cause another dependent variable to change (21). In so doing, the analysis establishes the relative magnitude of the contribution of each predictor variable. It also offers the opportunity to examine what proportion of the variance in the outcome variable is explained by each predictor variable and or / their combined effect as in (22).

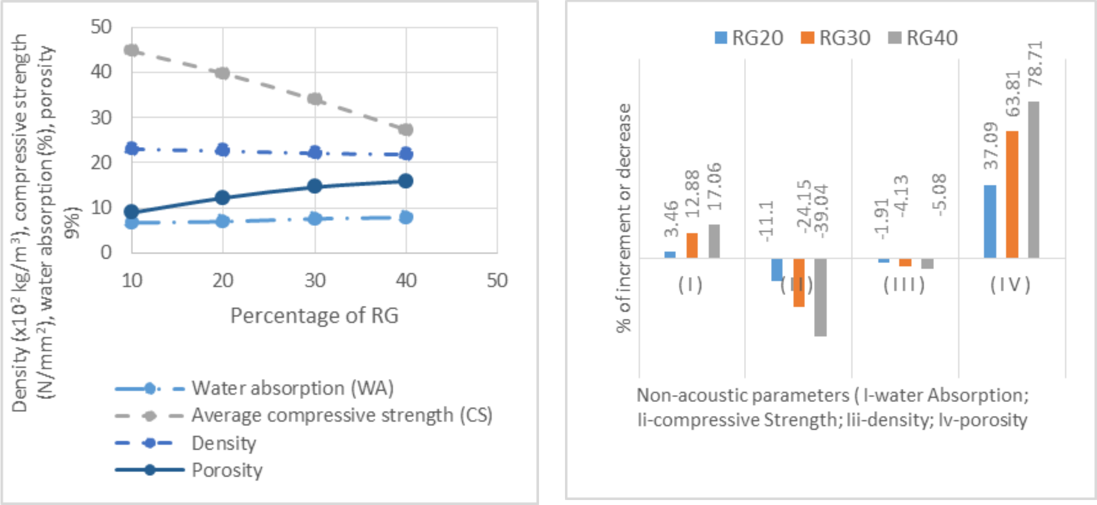
4. Results and findings

4.1. Non-Acoustical Properties

The effect of RG content on non-acoustic parameters such as water absorption, porosity, density, and compressive strength of the DRCPBs specimens are demonstrated in Fig. 5. The percentage of increment/decrement on these parameters were calculated based on minimum parameter at the condition of 10% RG content with a thickness of 10mm.



(a) FL 10 mm



(b)FL 20 mm

Fig. 5: Effect of RG on non-acoustic parameters values and % of increase or decrease for each FL thickness

Table 4: Correlation between parameters

	Thickness	% RG	water absorption	compressive strength	density	porosity
thickness	1					
% RG	0	1				
water absorption	0.60	0.77	1			
compressive strength	-0.24	-0.95	-0.89	1		
density	-0.65	-0.72	-0.97	0.85	1	
porosity	0.25	0.94	0.89	-0.95	-0.87	1
maximum sound absorption	0.49	0.84	0.96	-0.93	-0.93	0.91

4.2. Effect of Percentage RG On Water Absorption.

For each thickness, it is noticeable that the water absorption increases as the percentage of the RG rises. It is believed that replacement of higher coarse tyre rubber particles tend to create more voids as rubber particles have a tendency to trap air during concrete mixing. The percentage increment is maximum for 30 mm moved from of 4.31% to 17.51%, indicating a rise of about 13% when 30% of the coarse aggregate was substituted with RG aggregates in FL and 30% fine RG replaced with fine aggregate at bottom layer. The relationship between RG content and percentage increase in water absorption was found to be linear. It was found that 98.21% of the variation in water absorption can be explained by RG content.

4.3. Effect of Percentage RG on Porosity

The effect of RG content on porosity that can be seen in Fig. 5 in general is that the porosity increases as the percentage of the RG rises. The porosity increased about 94%, 79%, 67% and 62.5% from base line of 10% RG content for thickness 10, 20, 30 and 40 mm respectively when 40% of the coarse aggregate was substituted with RG aggregates in FL and 40% fine RG replaced with fine aggregate at bottom layer. It is caused by the addition of rubber to concrete led to the presence of large gaps in the interface in rubber/cement matrix as explained by Pelisser et al. (23) through scanning electron microscopy (SEM) of cement matrix.. The relationship between RG content and percentage increase in porosity was found to be polynomial of second order. It was found that R^2 are 0.9978, 0.9997, 0.994 and 0.9959 for 10, 20, 30 and 40mm thickness respectively. These are significantly high correlation meaning that for all thickness of FL more that 99% of the variation in porosity can be explained by RG content.

4.4. Effect of RG On Density

The density of the specimen of DRCPBs obtained are decreases as the RG content increases. In average, the density of thickness 10 to 40mm FL was lowered by about 5% when 40% of the coarse aggregate was substituted with RG. It was generally agreed that the low specific gravity of RG contribute to the reduction of concrete blocks density. Furthermore, the unit weight of the mixtures was reduced with the increasing rubber content due to increases air content. Siddiquw and Naik(24) mentioned that the non-polar nature of rubber particles may tend to entrap air if their rough surfaces increase, which in turn increases the air content and reduces the density of the concrete mixtures. The relationship between RG content and percentage increase in porosity was found to be linear. It was found that 98.21% of the variation in water absorption can be explained by RG content. This result also confirms the findings from Ling (25) where the increased of rubber content in a mixture, has systematically reduced the density.

4.5. Effect RG on Compressive Strength

As expected, the compressive of all the rubberised concrete blocks demonstrated a decreasing tendency with increasing of rubber content (Fig. 5). The compressive strength decreased about 38%, 39%, 40% and 36% from baseline of 10% RG content for thickness 10, 20, 30 and 40 mm respectively when 40% of the coarse aggregate was substituted with RG aggregates in FL and 40% fine RG replaced with fine aggregate at bottom layer. In the case of 30mm series mixtures, the increase in rubber content from 10% to 40% resulted in a substantial decrease in the compressive strength from 43.72 MPa to 26.27 MPa which is equivalent to about a 40% reduction of strength. The possible reasons for this strength reduction can be attributed to the reduction of the quantity of the solid load-carrying material with increasing rubber content. This results further agrees with findings from Ling (25) where the compressive strength of rubberised concrete blocks is systematically reduced with the increased of rubber content. Moreover, she suggested that the rubber substitution used in concrete blocks should not exceed 10% volume for structural and 40% volume for non-structural applications. It can be noticed that compressive strength of 30.00 N/mm2 to 48.70 N/mm2 are satisfactory for light and heavy traffic situations in which it could be achieved if 10% to 30% RG contents are used.

4.6. Sound absorption characteristics

Fig. 6 and 7 indicate that thickness of FL does influence the maximum acoustic absorption and it frequency. The higher percentage of RG and the thicker FL enhance the effectiveness of DRCPB to absorb sound. According to Sandberg and Ejsmont et al. (19) maximum sound absorption coefficient for normal concrete is 0.02 while in this study maximum sound absorption recorded was 0.34. Generally, the thicker specimen has higher maximum sound absorption at higher frequencies. However, sound absorption coefficient has only one peak although the block has two layer which is in contrast with Tian et al. (18) findings. This is because in this research the two layer were casted together while the bottom layer is still not hardened while Tian et al. (18) samples were a two hardened layer glued together to become a composite layer. It was also obtained that all specimen has the maximum absorption at the low frequency range (500 -700 Hz).

4.7. Correlation between Maximum Sound Absorption Coefficient and Non-Acoustic Parameters

Table 4 shows correlation between all parameters. By taking into consideration of relation between maximum sound absorption coefficient and thickness, percentage of RG, water absorption, compressive strength, density and porosity, it was found that except thickness, all parameters has high relation with maximum sound absorption coefficient (magnitude >0.8). The thickness of FL has moderate relationship with maximum sound absorption. High negative correlation between maximum sound absorption with density (-0.93) and compressive strength (-0.93). Low density lead to low compressive strength of DRCPBs, consequently low density was found enhancing the effectiveness in terms of maximum sound absorption due to more porosity. The relationship between maximum sound absorption and decrease in density was found to be systematically in 2nd order of polynomial with R^2 are 0.91 (Fig. 8). It high correlation that 91% of the variation in maximum sound absorption coefficient can be explained by density. For water absorption and porosity**,** the higher the water absorption the higher the porosity and thus the higher the sound absorption. Fig. 9 shows the relationship between porosity and maximum sound absorption coefficient. It observed that sound absorption value higher than 0.25 can be obtained if the porosity is more than 15 % with thickness of more than 20 and RG between 30 to 40%. A 15% to 30% porosity can be defined as porous block. Fig. 9 also indicates the increase of porosity from 10% to 15% for 30 and 40mm thickness. According to Sandberg and Ejsmont (26), porosity effectively reduces the air pumping effect, thereby reducing the tyre-pavement interaction noise. The relationship between maximum absorption and increase in porosity was found to be systematically in 2nd order of polynomial with R^2 is 0.90. This shows that 90% of the variation in maximum sound absorption coefficient can be explained by porosity.

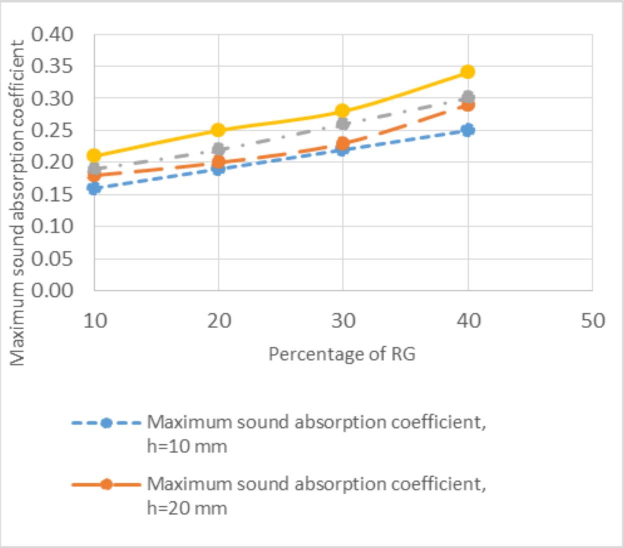


Fig. 6: Effect of percentage of RG on maximum sound absorption

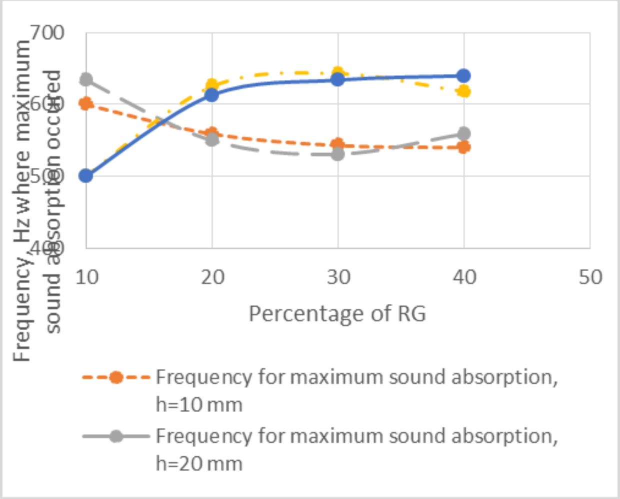


Fig. 7: Frequency of sound that maximum sound absorption occurred

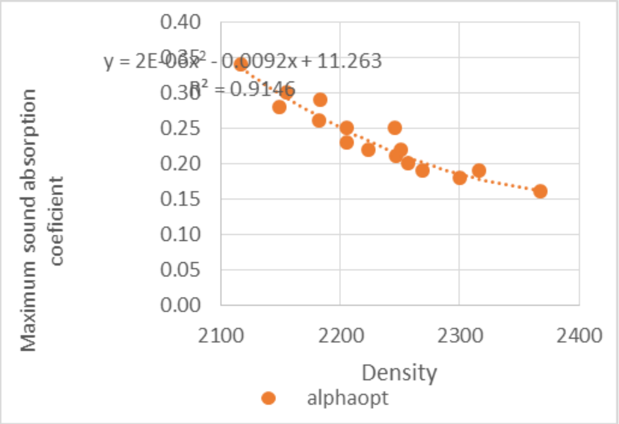


Fig. 8: Relationship between maximum sound absorption and density

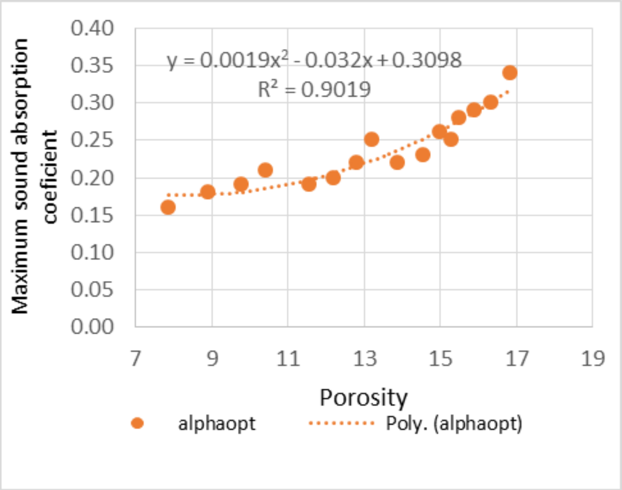


Fig. 9: Relationship between maximum sound absorption coefficient and porosity

4.8. Prediction of Sound Absorption Coefficient for Double Layer Rubberised Concrete Paving Blocks

The assessment of acoustic performance is further carried by examining the data obtained in Fig.s 5 to 7. The model that estimate the maximum sound absorption was developed based on these experimental results. By considering the results of correlation analysis, all non-acoustic parameter (thickness, % RG, water permeability, compressive strength, density, and porosity) were taken into account as the predictor variables (independent variables). The criterion variable (dependent variable) was optimum sound absorption of DRCPBs. Tables 5 shows summary of the results for the regression analysis on the first trial. The R-square (R^2 = 0.99) which is the coefficient of determination shows that there is strong correlation between the criterion variable (maximum sound absorption) and the predictor variables (thickness, % RG, water permeability, compressive strength, density, and porosity). However, by referring to the probability p, only thickness , % RG and porosity have significant predictor to the maximum sound absorption as it value < 0.05. Thus by only taken into consideration of these predictors, a new model was obtained as shown in Table 6.

The new model shows R^2 = 0.98 which is the coefficient of determination shows that there is strong correlation between the criterion variable (optimum sound absorption) and the predictor variables (thickness, % RG, and porosity). The table also demonstrates that the adjusted R^2 = 0.970. Using the analysis of variance (ANOVA) and the adjusted R^2, the following conventional statistical report was extracted (adjusted R^2 = 0.8970 $F_{3,12}$ = 239, $P < 5.76*10^{-11}$). As $P < 5.76*10^{-11}$, it implies that the model is statistically significant. The parameter estimate the coefficients of the predictor variables in the regression equation. Subsequently, Model 1 equation for predicting the optimum sound absorption was derived:

Table 5: First trial of model 1 regression

	Coefficients	*SE*	*t Stat*	*P-value*
Constant	0.053	0.700	0.076	0.941
FL thickness	0.003	0.001	2.623	0.034
% RG	0.010	0.002	3.691	0.007
Water absorption	-0.009	0.023	-0.409	0.694
Density	0.005	0.003	1.791	0.116
Compressive strength	-8.3E-05	0.000	-0.392	0.706
Porosity	-0.019	0.005	-3.415	0.011

Table 6: Final model summary

Regression Statistics	
Multiple R	0.99
R^2	0.98
Adjusted R^2	0.97
Standard Error	0.01
Observations	16

ANOVA					
	df	**SS**	**MS**	**F**	**Significance F**
Regression	3	0.03	0.01	239.24	5.76E-11
Residual	12	0.00	0.00		
Total	15	0.03			

	Coefficients	**SE**	**t Stat**	**P-value**
Coeficient	0.157	0.022	7.200	1.09E-05
FL thickness	0.003	0.000	10.396	2.35E-07
% RG	0.006	0.000	7.410	8.16E-06
Porosity	-0.011	0.003	-3.111	0.009

Maximum sound absorption of specimen =0.157 + 0.003* FL thickness + 0.006*RG-0.011*porosity (1)

Equation 1 shows a strong correlation based on the combination of results for the four series thickness with R^2 values of 0.89, respectively. By using these equations, the sound absorption of rubberised concrete blocks at 28 days can be predicted, provided that the percentage of rubber used is within the tested range. In order to validate this approach, proposed Equation 1 was used to predict the sound absorption coefficient of a set of thickness 10 mm to 40 mm of 10% to 40% RG replacement. The predicted values were plotted and compared with the experimental values. Fig. 10 shows that the predicted sound absorption coefficient values appear to be consistent with the experimental values. Thus, Equation 1 can be used for predicting acoustic performance for the purpose of traffic noise mitigation.

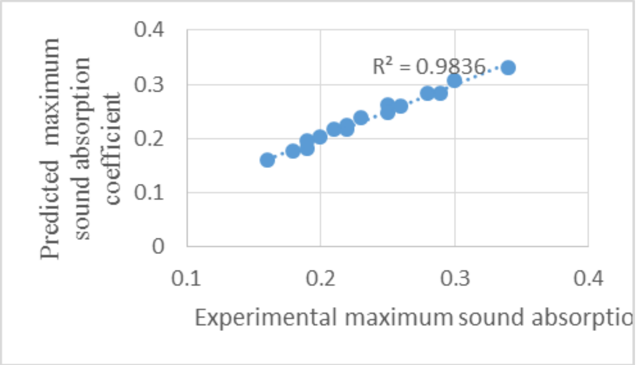


Fig. 10: predicted vs experimental for optimum sound absorption

5. Conclusion

Non-acoustic parameters of concrete pavement blocks were affected when RG was used as a partial replacement for coarse aggregate in top layer and as fine aggregate in bottom layer. Decrease in density and compressive strength was observed when part of the aggregate was substituted with RG. But the water absorption of the DRCPBs increased as the RG increased. Comparison between the current study and the previous studies shows non acoustic properties of RG concrete reduced, whether the RG aggregate is used as coarse or fine aggregate in the concrete mix. It is suggested that the rubber substitution used in concrete blocks should be in the range of 10% to 30% RG to obtain compressive strength of 30.00 N/mm^2 to 48.70 N/mm^2 which represents satisfactory for light and heavy traffic situations.

Acoustic parameters investigation of DRCPB specimens showed that concrete pavement blocks have maximum/peak of sound absorption located at low frequency of 500 to 700 Hz. This indicates the suitability for application of mitigation for low traffic speed condition. Non acoustic parameters can determine the acoustic characteristic of specimen, thus, a model was developed to predict the maximum sound absorption of the DRCPBs. The effect of rubber content, thickness of FL and porosity on the prediction was statistically significant ($p < 0.05$). The model is only capable of predicting the optimum sound absorption of double layer rubberised concrete block with a mix proportion of cement: aggregate: sand of 1:1.7:1.5; and if the FL thickness, the % RG composition and the curing condition used are within the tested ranged.

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