3.35	48	5.1	3.5
2.36	30	0.4	3.1
1.18	24	0.4	2.7
0.425	15	0.9	1.8
0.3	15	0	1.8
0.075	27	13	0.6
Sum	1193.1	99.9	99.4

Table 2 Laboratory Test Result of Stated Materials

Materials	Asphalt	Sand	Gravel	PC	FA	QD
Specific gravity	1.02	2.5	2.78	3.15	2.35	2.65
Penetration	66.7	-	-	-	-	-
Viscosity	50	-	-	-	-	-
Softening	49.5	-	-	-	-	-
Gravel of Binder	60/70	-	-	-	-	-

Table 3: Schedule of Aggregates used for Blending

Sieve No. (mm)	Aggregate A (Gravel)	Aggregate B (Sand)	Specification Limit	Mix Proportion (0.62A+0.38B)
25.4	98.9	100	100	99.32
19	97.6	100	90-100	98.51
13.2	95.2	91.1	70-75	73.64
9.5	91.3	43.3	50-75	73.06
6.7	83	16.8	40-60	57.84
4.75	61.4	8.6	35-55	41.85
3.35	21.8	3.5	30-50	14.85
2.36	13	3.1	26-48	9.24
1.18	3	2.7	22-40	2.89
0.425	0.9	1.8	19-30	1.24
0.3	0.2	1.8	9-19	0.80
0.075	0.1	0.8	3-7	0.29

Table 4: Mix design properties for Unmodified Asphalt Concrete

Binder %	G_{mb}	Stability (N)	Density (kg/m^3)	Flow (mm)	Gmm	VMA (%)	Air Void (%)
4	2.181	20360	2181.3	5.95	2.313	20.66086	5.706874
4.5	2.259	29505	2258.9	8.05	2.389	17.82342	5.441607
5	2.274	31815	2274	9.45	2.405	17.27776	5.446985
5.5	2.290	36730	2290.4	9.45	2.413	16.69572	5.097389
6	2.194	27145	2194	10.5	2.3	20.18795	4.608696

Table 5: Mix Design Properties of Asphalt Concrete Modified with Mineral Fillers @ Optimum Asphalt content for heavy traffic

Void Fillers (%)	Stability (N)			Flow (0.25mm)			Density (kg/m^3)		
	PC	GD	FA	PC	GD	FA	PC	GD	FA
0.0	8315.02	8315.02	8,315.02	12.132	12.132	12.132	2002.107	2002.107	2002.107
0.5	12049.8	9072.14	11,606	9.189	10.9188	10.81296	2306.337	2200.884	2179.18
1.0	12993.2	11697.9	12,514.23	8.1	10.5188	9.282598	2321.754	2279.18	2384.416
1.5	13531.3	12613.7	13,447.52	7.83	8.8748	6.86105	2338.498	2294.416	2409.63
2.0	14343.4	14520.4	11,677.32	7.133	10.8771	10.10774	2340.074	2360.963	2213.698
2.5	15777.8	10977.4	10,019.21	7.062	10.8988	10.2003	2402.112	2213.698	2110.243
3.0	17355.5	8768.9	9,096.82	6.85	12.132	11.0021	2522.031	2010.243	2010.987

Table 6: Summary of Results for Dynamic Modulus, Tensile Strain and Fatigue @ Frequency of 0.1 Hz.

Modifier (%)	Dynamic Moduli (N/mm^2)			Tensile Strain (ε_t)			Load Cycles to Failure (N_f)		
	PC	QD	FA	PC (εt)x10^{-5}	QD (εt)x10^{-4}	FA (εt)x10^{-4}	PC	QD	FA
0.00	1,010.34	1,010.34	1,010.34	18.9942	18.9942	18.9942	11,983,650	11,983,650	11,983,650
0.50	1,026.29	1,017.12	1,030.76	16.9844	15.8064	16.9468	12,999,450	12,600,000	12,500,000
1.00	1,080.73	1,029.94	1,090.71	16.0396	13.7636	14.9424	13,010,720	12,400,000	12,850,000
1.50	1,121.58	1,099.88	1,138.31	14.9466	10.9506	13.9302	13,026,690	12,600,000	13,700,000
2.00	1,143.79	1,137.40	1,093.45	12.9232	8.9222	14.7244	13,059,820	14,100,000	12,600,000
2.50	1,171.59	1,067.60	1,057.51	10.9154	9.9174	16.0154	13,063,430	11,200,000	12,100,000
3.00	1,182.90	1,010.05	1,010.81	8.8998	14.9076	16.9712	14,004,180	9,600,000	11,200,000

Table 7: Summary of Results for Dynamic Modulus, Tensile Strain and Fatigue @ Frequency of 1.0 Hz.

Modifier (%)	Dynamic Moduli (N/mm^2), (E*)			Tensile Strain (ε_t)x10^{-5}			Load Cycles to Failure (N_f)		
	PC	QD	FA	PC	QD	FA	PC	QD	FA
0.00	1,010.34	1,010.34	1,010.34	14.660	14.660	14.660	10.9994510	10,9994510	10.9994510
0.50	1,096.29	1,007.12	1,030.76	13.821	13.806	14.468	12.9836225	11,8700366	11,2205978
1.00	1,124.73	1,029.94	1,040.71	12.761	12.763	14.024	13.4301072	12,9903356	13,0106305
1.50	1,135.58	1,039.88	1,138.31	11.433	10.950	11.724	13.6102669	13,1002006	13,6304869
2.00	1,143.79	1,137.40	1,063.45	10.022	9.922	13.530	13.9205982	14,2108840	13,2008257
2.50	1,171.59	1,067.60	1,057.51	09.915	11.717	14.915	14.0006343	13,1109680	12,4909864
3.00	1,182.90	1,060.05	1,055.81	08.999	12.907	16.971	14,5108418	11,0110001	11,5113749

Figure 1: Variation in Dynamic Moduli (Stiffness) Against Filler Content (%) for 0.1Hz

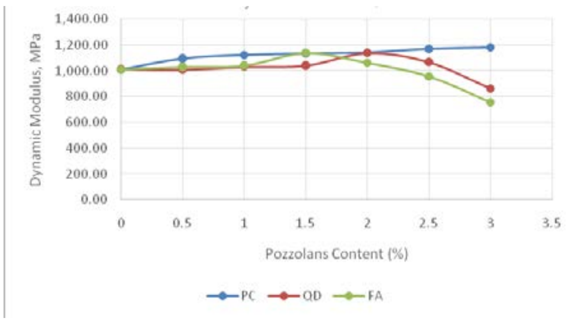


Figure 2: Variation in Tensile Strain against Filler Content (%) for 0.1Hz

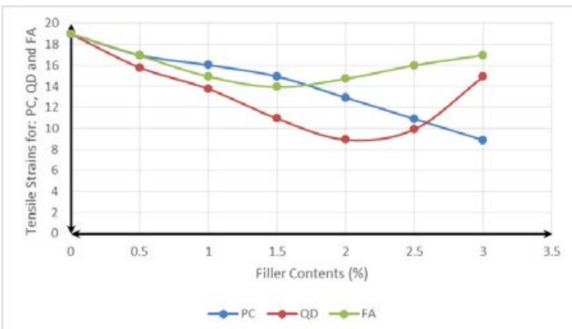


Figure 3: Variation of No. of Load Cycle to failure against Filler Content (%) for 0.1Hz

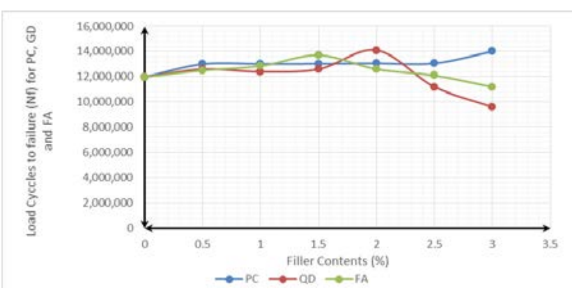


Figure 4: Variation of Dynamic Moduli (Stiffness) against Filler Content (%) for 0.1Hz

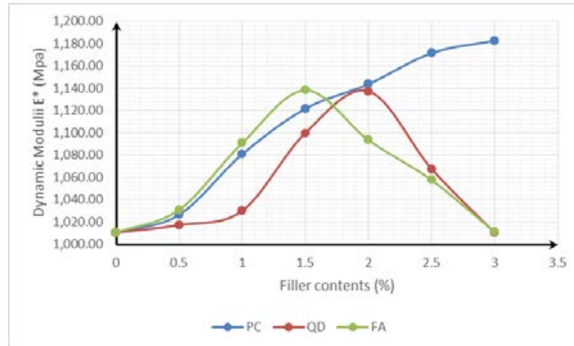


Figure 5: Variation in Tensile Strain against Filler Content (%) for 1.0Hz

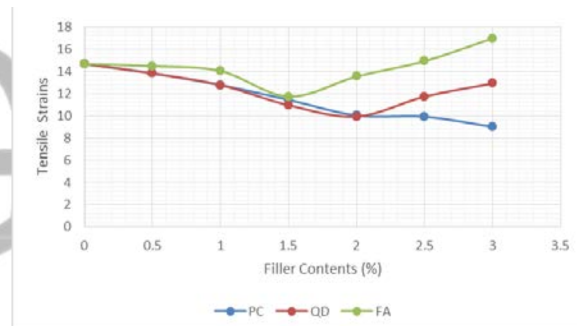
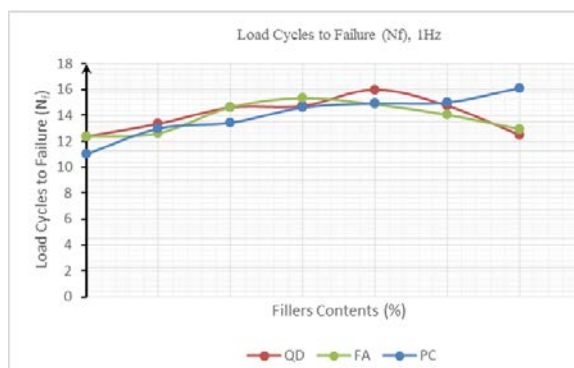


Figure 6: Variation of No. of Load cycle to failure against Filler Content (%) for 1.0Hz



4.0 DISCUSSION

- **Dynamic Modulus**

➢ For Portland cement (PC) it is observed that upon the addition of Portland cement filler content unto the HMA concrete, it increases the dynamic modulus/stiffness of the HMA concrete, also at the same time the material gain density and also increase stability of the HMA (see Table 6 and Figure 1).

➢ For quarry dust and fly-ash

Dynamic modulus/stiffness increases upon the addition of both filler content up to 1.5% and 2.0% respectively by weight of aggregate. However, further addition of the mineral filler content reduces stiffness of the HMA. This is because the filler content became move than the aggregate bearing load causing it to loss stability and stiffness of the HMA concrete (see Table 6 and Figure 1).

- **Tensile Strain**

➢ Studies have shown that tensile strains negatively affect fatigue life of hot mix asphalt concretes. Therefore, increased levels of tensile strain will automatically reduce the pavement life during use. From the foregoing, results show that the introduction of Portland cement (PC) at varying amounts of filler,0.5% – 3.0% into the asphalt concrete mixtures reduced the tensile strains linearly from 0.5% to 3.0% at loading frequency of 0.1 Hz (see Table 6 and Figure 2). That is to say, the Portland cement filler content keep reducing the void in the HMA concrete, ensuring that no crack is initiated at the bottom of the HMA concrete making the HMA to gain stiffness and stability.

➢ For Quarry Dust and Fly-ash

Upon addition of both filler content, reduce void in the HMA concrete up to a peak of 1.5% and 2.0%, further addition increased tensile strain at the bottom of the HMA concrete, causing the HMA concrete to loss stability and stiffness as a result of fillers being more than the aggregate bearing load.(see Table 6 and Figure 2).

- **Fatigue Crack**

➢ From Table 6 and Figure 6, it is evident that the repetition of load cycle to failure (N_f) of the asphalt concrete showed different character, of set values for the various fillers. Fatigue expressed as number of load repetitions to failure increased with increasing Portland cement (PC) content up to 3.0%.

However, for Quarry Dust (QD) and Fly-Ash (FA) fatigue life increased with increasing filler content to a maximum peak of 2.0% QD filler content and 1.5% Fly-Ash filler content, eventually starts to decrease upon addition of 2.0%, 2.5% and 3.0% for both filler content. The same trend was observed for 1.0Hz frequency.

5.0 CONCLUSIONS

The conclusions from the study are as follows:

i. The dynamic modulus/stiffness obtained from the modified HMA concrete significantly improved upon addition of Portland Cement (PC), Quarry Dust (QD) and Fly-Ash (FA) filler content.

ii. For tensile strain, upon the addition of Portland Cement (PC) content cause a reduction in tensile strain levels, thereby causing an increase in fatigue life of the pavement synonymous with HMA concrete. While that of quarry dust and fly-ash behaves similar to that of PC up to a peak of 1.5% and 2.0% filler content respectively.

iii. For fatigue crack upon addition of Portland cement (PC) filler content, increases the fatigue life of the pavement. Quarry Dust and fly-ash increases fatigue life of the pavement to a peak of 1.5% and 2.0% both filler content. However, further addition of the fillers increases fatigue crack of the pavement.

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