Research & Reviews: Journal of Engineering and Technology ISSN: 2319-9873

Evaluation of the Effect of Moisture, Fines Content and Plasticity in the Fill Materials (G3) used for Roadwork in Tanzania Study Area Pwani Region

Joseph Stephen Gimonge*, **Siya Rimoy**

Department of Transportation and Geotechnical Engineering (TGE), College of Engineering and Technology, University of Dar es Salaam, Dar es Salaam, Tanzania

Review Article

Received: 17-Aug-2022, Manuscript No. JET-22-72076; **Editor assigned:** 19-Aug-2022, PreQC No. JET-22-72076 (PQ); **Reviewed:** 02-Sep-2022, QC No. JET-22-72076; **Revised:** 03-Jan-2023, Manuscript No. JET-22-72076 (R); **Published:** 11-Jan-2023, DOI: 10.4172/2319-9873.12.1.001

***For Correspondence :** Joseph Stephen Gimonge, Department of Transportation and Geotechnical Engineering (TGE), College of Engineering and Technology, University of Dar es Salaam, Dar es Salaam, Tanzania;

Email: jostev07@yahoo.com

Citation: Gimonge JS, et al. Evaluation of the Effect of Moisture, Fines Content and Plasticity in the Fill Materials (G3) used for Roadwork in Tanzania Study Area Pwani Region. RRJ Eng Technol. 2023;12:001.

ABSTRACT

Tanzania roadwork construction activities must adhere established guidelines of standard specification and pavement and materials design manual established by the ministry of work. The construction of fill layer requires the materials which constitute CBR equal or more than 3%, having minimum compaction of 90% and with maximum Swelling Index of 2%. Tests of gradations and plasticity properties are disregarded during the classification. This situation has resulted into the use of soil with high water susceptibility during the construction due to lack of control on the plasticity and the percentage of fines content. Tanzania comprises three climatic zones of dry, moderate and wet; the established guidelines had omitted the division of climatic zone during classification the fill material requirement. The study to evaluate the effect of fines content, plasticity and moisture change in the fill materials has been undertaken. The investigation test conducted comprised soil specimen having fines content to the proportional of 5%, 10%, 45%, 60% and 80% sampled from Pwani region. Each sample were investigated at three climatic zones whereas dry, moderate and wet with 75% of OMC, 100% of OMC and 125% of OMC respectively. The effects were investigated through resilient modulus (Mr) and strength (CBR) parameters. The laboratory results and analysis revealed that fines content and plasticity are detrimental to the performance of fill layer. CBR is inversely proportional to the fines content and PI. The Mr values are increased when the fines content increases up to optimal content of fines, and the soil structure with most fined grains has poor performance when exposed to the wet condition. The findings might have a great implication in the roadwork construction industry in Tanzania and other countries with similar characteristics. For instance, the ministry of work might utilize the findings by adding the fine content and plasticity limit. Roadwork construction specification urged to include the limit of fines content and plasticity. Also, the classification must be separated based on climatic zone. The minimum compaction effort must be improved from 90% to 93% together with CBR value from 3% to 5%.

Keywords: California Bearing Ratio (CBR); Resilient modulus; Fines content; Fill material; Moisture content; Plasticity index; Compaction

INTRODUCTION

The pavement structure is composed of subgrade, pavement layers and surfacing. The subgrade layer plays as the foundation of the pavement structure on which all other layers are built on. It must be properly designed and protected to ensure the long life of the pavement. The subgrade layer is usually consists of the *in situ*, fill, lower improved subgrade, and upper improved subgrade. Researchers have categories fill material in groups and minimum specifications requirements such as the California Bearing Ratio (CBR), Liquid Limit (LL), Plasticity Index (PI), Swelling Index (SI) and Grading Limits his study focused on the evaluation of the performance to the established requirement of fill material (G3) used for roadwork in Tanzania [1].

The main objective of the study is to evaluate the effect of moisture content, PI, and fines content in the fill material used for roadwork practice. The study has been undertaken to review the causes of premature deformation caused by the fill layer. Uneven settlement, permanent deformation and other distress have been experienced in Tanzania, whereby the contributed factors are associated with the subgrade deformation. Lack of an adequate engineering solution, difficulties in specifying, testing, and interpreting laboratory and field tests, geological set up, and stratification have accelerated the structural failure of the pavement roadbed, fill layer and improved subgrade [2-5].

LITERATURE REVIEW

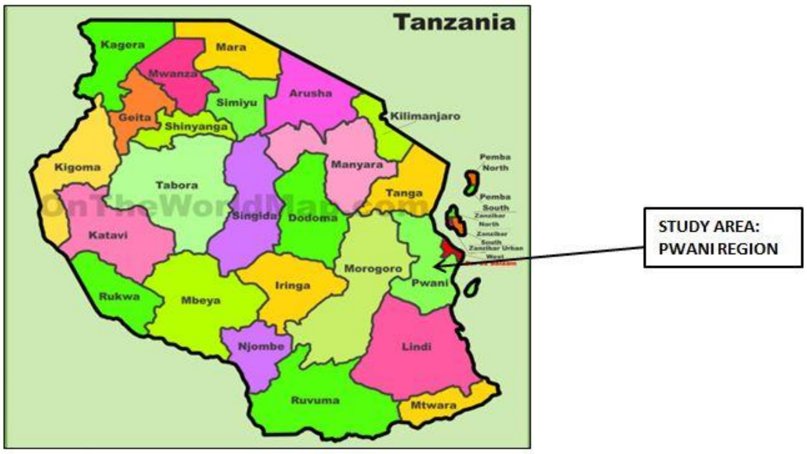
The studies by Elliott, Dennis, Qiu nd, Gao, et al. have stated that fill layer contribute the occurrence of uneven settlement and rutting to the pavement in great extent compared with others factors. The permanent deformation associated with fill layer is a difficult point to ascertain in the field of highway engineering but has affected the road performance by deteriorating the stiffened of other pavement structures to withstand the vertical strain of other layers. Gao et al. found that through the construction of micro piles between subgrade and pavement layer, the deformation at the toe of the slope, the shoulder, and the center of the roadbed was reduced by more than 96%.

METHODOLOGY

The soil test samples were collected from the borrow pit used for fill layer. The preference for selection was based on soil with CBR values ranging between 3 to 7 (G3). The experiments exercise undertaken was based on empirical and mechanistic empirical method which examines the performance CBR and Mr values. The Mr value was opted to characterize the effect of moisture under variation of fine content [6].

The borrow pit sampling exercise was conducted according to the standard procedures stated in the field testing manual established by ministry of Work. The fill material representative were collected from four (4) borrow pits, namely Lulanzi, Pangani, Viziwaziwa and Miwaleni located in Pwani region. Pwani region is located along the coast zone of Indian Ocean in Tanzania. It possesses moderate climatic condition. The Figure 1 below indicates the geographic location of Pwani region attempted for soil sampling used for investigation [7].

Figure 1. The Map of Tanzania indicating the study area.



The soil properties tests founded meet the standard specification for roadworks. The sample identification was classified based on the amount of fines in the soil specimen [8]. The sample identifications used are shown to the Table 1 below.

Table 1. Illustrate the sample identification number.

S/N	Sample label	Explanation
1	LUL/80/FLM	Fill material sampled from the Lulanzi borrow pit constitute 80% of fine content (original sample)
2	PAN/21/FLM	Fill material sampled from Pangani borrow pit constitute 21% of fine content (original sample)
3	LULPAN/45/FLM	Fill material sample obtained by blending Lulanzi and Pangani borrowed sample by 50/50 proportional. The material constitutes 45% of fine content.
4	LUL/60/FLM (a)	Fill material obtained by reducing the weight of fine content through sieve analysis test. (a), (b) and (c) constitute 60%, 10% and 5% of fine content respectively.
5	PAN/10/FLM (b)	
6	PAN/05/FLM (c)	
7	MIW/21/FLM	Fill material sampled from miwaleni borrow pit constitute 21% of fine content (original sample)
8	VIZ/42/FLM	Fill material sampled from viziwaziwa borrow pit constitute 42% of fine content(original sample)

Method for investigation the effect of moisture variation to the fill material

Evaluation of effect of moisture variability in the fill layers has been investigated. The corresponding test used for investigation is resilient modulus. The fabricated samples were prepared at three moisture conditions in the base from optimum moisture content. Since the standard specifications specify that, the lowest moisture content required for earthwork activities is 75% of the optimum moisture content. The amount deviation of ± 25% from Optimum Moisture Content (OMC) and 100% at OMC have been used as a representative to investigate the effect of moisture variability to each sample [9].

Systematic steps used to undertake the investigation fill material

Step I: Determination of the soil characteristics: The soil properties test undertaken by using empirical method. The tests conducted comprise of sieve analysis, compaction, CBR and waterberg limit. Table 2 indicates type of test undertaken.

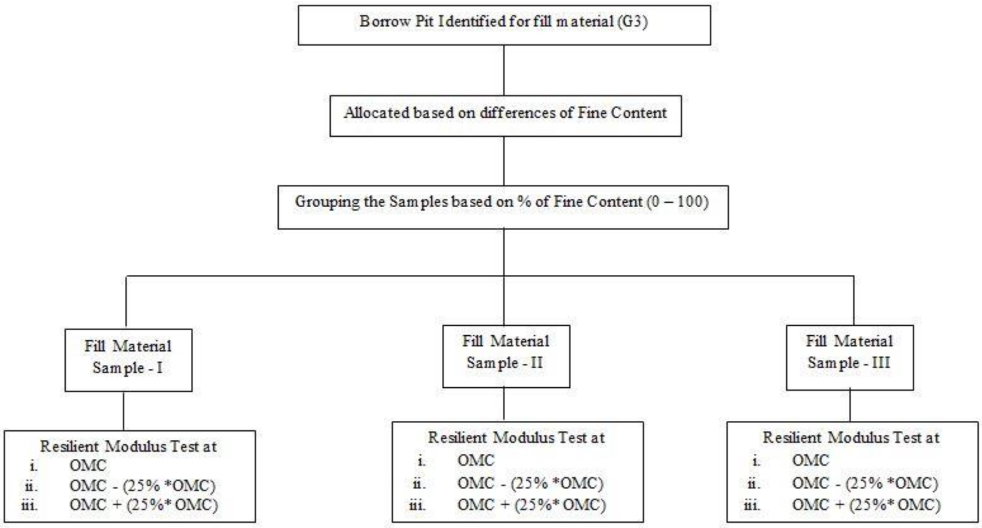
Table 2. Indicate type of soil properties tests conducted.

SN	Soil characteristics	
1	Moisture content	Natural moisture content
2	Waterberg limit test	Liquid limit (%) Plastic limit (%) Plasticity index (%) Linear shrinkage
3	Sieve analysis test	Gravel fraction, percent retained above sieve 4.75 mm (%) Coarse fraction, percent retained above sieve 0.075 mm (%) Fine fraction, percent passing sieve 0.075 mm (%) Evaluate GM and GC
4	Soil classification	USCS classification

5	Compaction Test	Optimum Water Content (OMC) (%) Maximum Dry Density (MDD) gr/cm^3
6	CBR Test	Soaked CBR testing at 93% of MDD Swell index (%)

Step II: Identified soil matrix for undertaking the resilient modulus for fill material: The soil matrix used to undertake the resilient modulus tests indicated in Figure 2 herein below.

Figure 2. Represent the soil index.



Step III: Determination the effects due to variation of moisture content: The assessment regarding the effect of moisture has been opted to the range of +25% and -25% from OMC. This has been adopted to fit the range of ± 25% as indicated in the standard specification. The tests of resilient modulus (Mr) were conducted according to AASHTO T307-99, 2017, and were undertaken at Tan roads central materials laboratory through the use of the UTM -130 installed equipment. Table 3 illustrates the procedure attempted to investigate the effect of moisture and fines content to the fill material specimen [10].

Table 3. Illustrate the procedure used to investigate the effect of moisture and fines content.

Sn	Testing	Sample group	Moisture condition	Moisture state	Test no.
1	Resilient modulus for subgrade (Fill material)	A	OMC	Moderate	1
			(OMC+25% × OMC)	Wet	2
			(OMC−25% × OMC)	Dry	3
2	Resilient modulus for subgrade (Fill material)	B	OMC	Moderate	4
			(OMC+25% × OMC)	Wet	5
			(OMC−25% × OMC)	Dry	6
3	Resilient modulus for subgrade (Fill material)	C	OMC	Moderate	7
			(OMC+25% × OMC)	Wet	8
			(OMC−25% × OMC)	Dry	9
4	Resilient modulus for subgrade (Fill material)	D	OMC	Moderate	10
			(OMC+25% × OMC)	Wet	11
			(OMC−25% × OMC)	Dry	12
5	Resilient modulus for subgrade (Fill material)	E	OMC	Moderate	13
			(OMC+25% × OMC)	Wet	14
			(OMC−25% × OMC)	Dry	15

6	Resilient modulus for subgrade (Fill material)	F	OMC	Moderate	16
			(OMC + 25% × OMC)	Wet	17
			(OMC – 25% × OMC)	Dry	18

RESULTS AND DISCUSSION

The soil engineering properties were conducted based on laboratory tests procedure of Central Materials Laboratory (CML) 1.2 – 14, 1.7, 1.9 and 1.1, of 2000 affiliated from BS 1377, 1990. The summary of soil index has been submitted in the Table 4 below.

Table 4. Show the summary of soil properties.

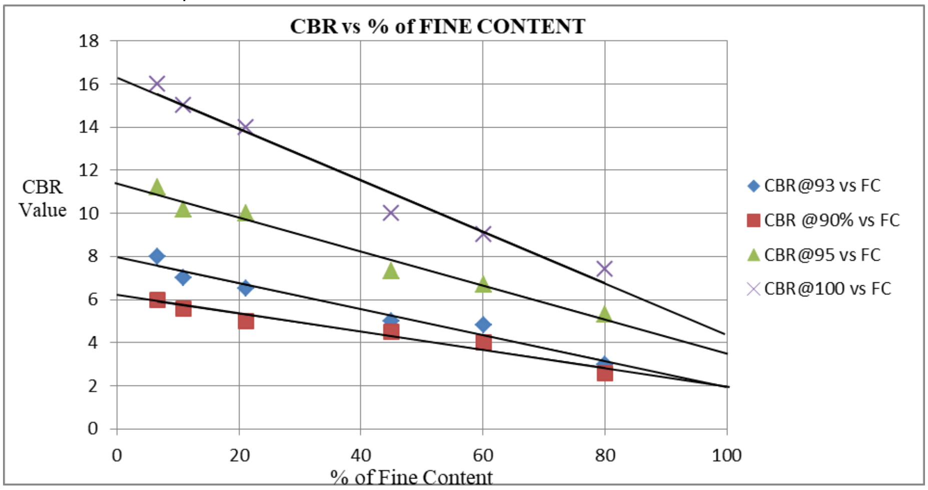
SUMMARY OF SOIL INDEX AND STRENGTH PARAMETERS																							
Borrow pit name	Sample No.	Atterberg Limits				Grading Modulus	Grading % passing											BS Compaction heavy		4 days Soaked CBR Value (%)			
							Sieve size (mm)											MDD	OMC	90%	95%	100%	Swell
		LL(%)	PL(%)	PI(%)	LS(%)		20	14	10	6.3	5	2	1.18	0.6	0.43	0.212	0.15	0.075	(kg/m³)	(%)	A	B	C	(%)
Lulanzi	LUL/80/FLM	51	21	30	13	0.3	100	100	100	100	100	100	97	94	90	86	82	80	1752	14	3	6	7.4	1.52
	*LUL/60/FLM	46	17.4	28.6	11	0.6	100	100	100	100	100	100	94	89	80	71	63	60	1817	11.2	4	7	9	1.24
Lulpan	*LUP/45/FLM	43	16	27	12	0.78	100	100	100	100	99	97	92	83	80	64	55	45	1874	9.6	5	7	10	2.91
Pangani	PAN/21/FLM	36.4	13.2	23.2	10	1.45	100	100	99	97	96	86	70	57	49	42	32	21	1888	7.8	5	10	14	1.441
	*PAN/10/FLM	30.3	10.1	20.2	8	1.6	100	100	99	97	96	84	67	51	42	34	23	11	1920	6.2	6	10	15	0.91
	*PAN/05/FLM	22.3	9.7	12.6	6	1.7	100	99	99	96	95	83	65	49	40	31	19	7	1966	5.5	6	12	16	0.6
Miwaleni	×MIW/21/FLM	21.1	12	9.08	7	1.4	100	98	97	95	94	86	79	64	50	39	26	21	1895	11.1	6	9	16	0.79
Viziwa ziwa	×VIZ/42/FLM	31.3	15.2	16.15	9	0.9	100	100	100	100	100	100	98	83	72	61	46	32	1880	9.2	9	13	23	1.58
CBR type A=62 blows 3 layers of BS light; CBR type B=30 blows 5 layers of BS heavy; CBR type C=62 blows 5 layers of BS heavy.																							
Note: *represent samples obtained from laboratory; × indicate untested samples for M_r																							

Evaluation of the relationship of CBR versus fines content

The study revealed that any increase of fine content in the soil structure affect the CBR value in the linear trend line. Increase of the fine content decreases the CBR value and decrease the fine content the CBR value is upgraded. Figure 3 represents the relationships of CBR at 90%, 93%, 95% and 100% of MDD versus the percentage of fines content [11-

15].

Figure 3. Relationship between CBR with fluctuation of fines content in the soil structure.

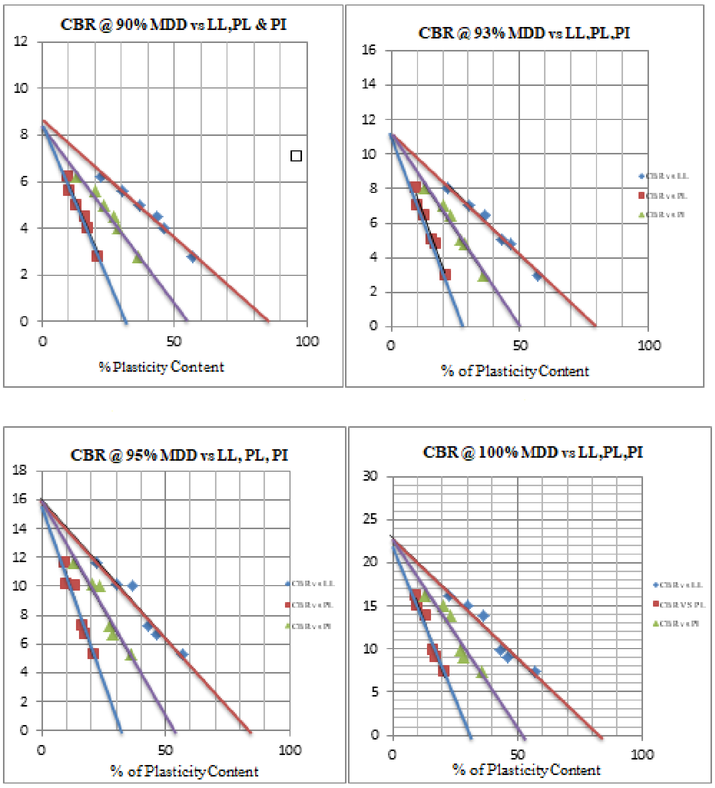


The CBR values founded to change according to the compaction energy employed. At 0% of fines content (0% passing sieve size 0.075 mm) and 100% of compaction has resulted the maximum CBR value compared with 90% of compaction. This implies that the highest CBR is achieved at highest degree of compaction [16-19]. Thus, the CBR value to the compaction of 95%>compaction of 93%>compaction of 90%. This observation is founded the same with the study undertaken by Inan, et al. that with an increase in fines the CBR value tends to decrease and vice versa.

Relationship between CBR versus liquid limit, plastic limit, and plasticity index

Any increment of LL, PL and PI decreases the CBR value and vice versa. Figure 4 represent the simple linear relationship between CBR as dependent variable at (90%, 93%, 95% and 100%) of MDD against plasticity parameters as independent variable.

Figure 4. (a). CBR @ 90% MDD *vs*. LL, PL and PI; (b). CBR @ 93% MDD *vs*. LL, PL, PI; (c). CBR @ 95% MDD *vs*. LL, PL, PI; (d). CBR @ 100% MDD *vs*. LL, PL, PI.



It is noted that the rate of change of CBR against LL, PL and PI is not same. The rate of change of PL lead at the highest followed by LL and PI. The graphs showed that at maximum value of LL, PL and PI have resulted low CBR value and at minimum values of plasticity parameter the CBR value is improved. Thus, it can be concluded that all plasticity parameters influence the performance of CBR. Also, the graphs revealed that degrees of compaction affect CBR in great extent compared with plasticity parameters. By neglecting effect of LL, PL and PI (at 0% of plasticity content), the CBR value of 8.2%, 11%, 16% and 23% at compaction of 90%, 93%, 95% and 100% respectively were obtained (Table 5). This implies that, the maximum compaction result high CBR and minimum compaction result low CBR. Thus, plasticity parameters and compaction are vital factors to be considered to adhere good strength of the fill layer [20]. The observation was founded to be the same as the study undertaken by B Shirur, et al.

Determination of the relationship between M_r, fines content and moisture content

Table 5. Indicates the summary of the resilient modulus result of the fill material.

Borrow pit name	Sample no.	% of fine content Passing 0.075	BS compaction heavy MDD (kg/m³)	OMC (%)	Strength CBR 4 days soak (%) A	B	C	Swell (%)	% MDD A	B	C	CBR at 93 %	M_r at OMC (Mpa) at 93%	M_r at dry (Mpa)	M_r at wet (Mpa)	Dust ratio
Lulanzi	LUL/80/FLM	80	1752	14	3	6	7.4	1.5	90	96	100	3.1	38.55	61.42	20.29	0.9
	LUL/60/FLM	60.1	1817	11.2	4	7	9	1.2	89	97	99	4.8	40.82	60.6	27.89	0.8
Lulpan	LUP/45/FLM	45	1874	9.6	3	5	8	2.9	89	93	99	5	42.86	60.23	39.95	0.6
Pangani	PAN/21/FLM	21.2	1888	7.8	4	6	13	1.4	90	93	96	6.8	46.63	47.55	43.35	0.4
	PAN/10/FLM	10.9	1920	6.2	5	7	14	0.9	89	92	99	7	38.55	40.35	36.44	0.3
	PAN/05/FLM	6.7	1966	5.5	6	8	16	0.6	89	93	99	8	34.25	36.66	32.14	0.2
CBR type A=62 blows 3 layers of BS light.																
CBR type B=30 blows 5 layers of BS heavy.																
CBR type C=62 blows 5 layers of BS heavy.																

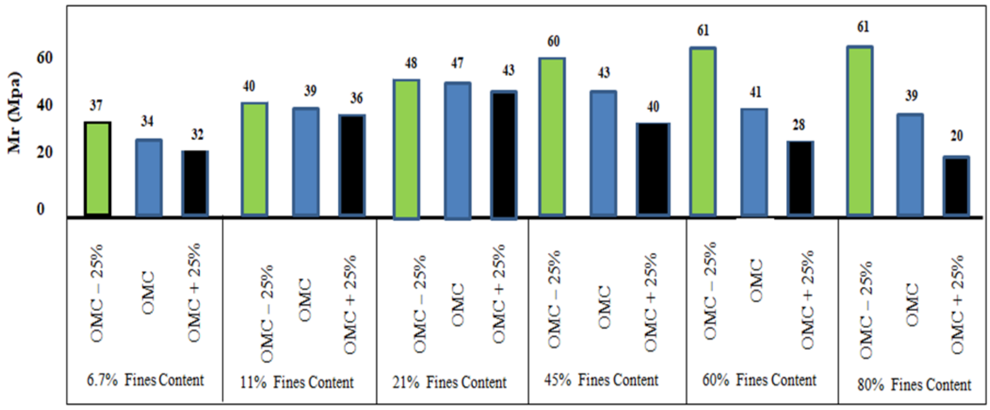
It is observed that the highest M_r value achieved is 61 Mpa to the specimen with fine content of 60% and 80% at the moisture content of 75% of OMC. The lowest Mr value obtained is 20 Mpa achieved in the specimens with fine content 80% at the moisture content of 125% of OMC. The study by Albert, et al. has proposed that the effective Mr used for subgrade and fill layer through the method described in the AASHTO T294-92 shall be equal or greater than 30 Mpa. The stated Mr should be acted as lowest value for fill layer throughout the pavement life despite of seasonal variation of moisture content to the fill layer.

The M_r of 20 Mpa and 28 Mpa obtained at fine content of 80% and 60% at moisture content of 125% of OMC were founded unsatisfactory to withstand the stiffness of the fill layer. Although, these samples have resulted highest Mr in dry condition but have poor performance when exposed to the wet condition. Excessive of moisture content in the specimen result unsatisfactory resilient modulus. The rate of change of M_r is dependent with the amount of fines content in the soil specimen. For the specimen with fine content ranging between (45%-80%), the rate of decrease of M_r is higher compared with the specimen with fines content ranging between (6%-44%). From Figure 4, the analysis for the rate of change of M_r is presented below.

- For the specimen with fines content of 21%, the rate change of M_r is 2.1% and 9% with moisture change from (75%*OMC to OMC) and (OMC to 125%*OMC) respectively.
- For fine content for 45%, the rate change of M_r is 28% and 7% with moisture change from (75%*OMC to OMC) and (OMC to 125%*OMC) respectively.
- For fine content of 60% the rate change of M_r is 33% and 32% with moisture change from (75%*OMC to OMC) and (OMC to 125%*OMC) respectively and
- For fine content, 80% of the rate change of M_r is 39% and 49% with moisture change from (75%*OMC to OMC) and (OMC to 125%*OMC) respectively.

The changes of M_r depend on the climate condition, environment, and drainage factors. The amount of fines content in the aggregate plays the most critical factor during assessment the extent of weakness due to seasonal change. For aggregate with FC ≤ 45% the weakness is satisfactory, for aggregate with 45% ≤ FC <60% the weakness is between moderate to high, and for aggregate with FC ≥ 60% the weakness is higher. For aggregate with fine content below 50% can perform satisfactorily if there will be small suction of moisture to the fill layer, but for material with fine content greater than 50% small suction of moisture could result in the poor performance of the fill layer which will subsequently affect the overall pavement performance (Figure 5). The study was founded on the same studies undertaken by Drumm, et al.

Figure 5. Variation of M_r values due to fluctuation of moisture and fines content.



Correlation of CBR and M_r by using USCS soil classification group and Correlation Factor (CF)

Based on the soil properties test result, the soil samples are divided into Group I, Group II and Group III. Group I consist of LUL/80/FLM soil type having Clayey with high plasticity (CH), Group II consisted of LUL/60/FLM and LUP/45/FLM soil type having clay with low plasticity (CL) and Group III consisted of PAN/21/FLM, PAN/10/FLM and PAN/05/FLM soil type having clay or silt in the sand (SC). The correlation has been discussed in the Table 6.

Table 6. Correlation of CBR and Mr by using USCS soil classification group and Correlation Factor (CF).

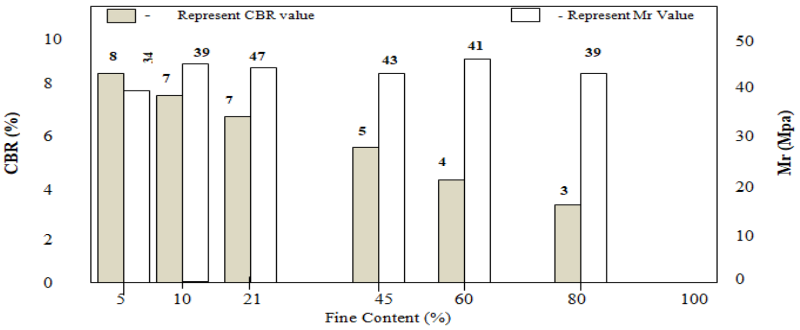
Group no.	Soil classification (USCS)	Sample no.	Fine content (%)	Soaked CBR at 93% of MDD (%)	M_r (Mpa)	Correlation between CBR and M_r Values	Correlation Factor (CF)	Average
I	CH	LUL/80/FLM	80	3	38.55	M_r=(12.85) * CBR	12.85	12.85
II	CL	LUL/60/FLM	60.1	4.8	40.82	M_r=(8.5) * CBR	8.5	8.535
	CL	LUP/45/FLM	45	5	42.86	M_r=(8.57) * CBR	8.57	
III	SC	PAN/21/FLM	21.2	6.5	46.63	M_r=(7.17) * CBR	7.17	5.65
	SC	PAN/10/FLM	10.9	7	38.55	M_r=(5.51) * CBR	5.51	
	SC	PAN/05/FLM	6.7	8	34.25	M_r=(4.28) * CBR	4.28	

From the result above, it was observed that the soil sample of group I having CH soil type has the highest average correlation factor of 12.85 which correlates M_r=(12.85) * CBR between Mr and soaked CBR value. For the soil sample Group II exhibit CL has a lower average correlation factor of 8.535 compared to the soil group I of CH. The correlation of M_r=(8.535) * CBR between Mr and soaked CBR value.

For the soil sample group III exhibit SC have the lowest average correlation factor of 5.65 compared to group I and group II. The correlation of Mr=(5.65) * CBR between Mr and soaked CBR value. The average correlation factor for group I having CH soil type was founds to be highest followed by Group II having CL soil type and finally with group III having SC soil type (Figure 6).

Performance of CBR and M_r due to variation of fines content

Figure 6. Performance of CBR and Mr due to variation of fines content.



The fine content at 5%, 10%, 21%, and 45% shows the acceptable performance of CBR ranging from 5%-8% while the M^r is ranging between (34–47 Mpa) medium to high result. But any incremental of fine content above 45%, the CBR provide poor performance but the M_r possess good performance. This implies that the aggregate with fine content greater than 45% during the repeated loading test brings a small magnitude of cumulative permanent strain and the absence of void between soil particles. The aggregate with low fine content in the soil structure contains a high percentage of air voids. During the repeated loading test, it result high permanent strain which provide low resilient modulus for fill layer. The aggregate specimen with low fine content resulted low water susceptibility soil behaviour which resulted high CBR value meanwhile the aggregate specimen with high fine content result high water susceptibility soil behaviour which result low CBR value. The sample with fine content between (5-60) resulted in a good performance of CBR and M_r. This analysis found the same with the studies undertaken by Lakshmi, et al.

Experimental results revealed that fine content, plasticity index, moisture content and degree of compaction have a definitive effect to the strength and stiffness of the fill layer. Degree of compaction showed more impact compared with other factors. The soil specimen compacted above 95% result higher strength and stiffness rather than compacted at 90% despite incorporation of other factors. The increment of fine content in the soil specimen influence CBR performance and behaviour of water susceptibility. The specimen with most fined grained soil is highly affected compared with the least fines content. Excessive of moisture content from OMC condition exhibit the decrease of stiffness. However, finding observed that decrease of moisture content from 100% to 75% of OMC during compaction resulted good performance of M_r.

The Plasticity Index (PI) show detrimental contribution to the strength of the soil specimen. The specimen with PI more than 45% resulted low CBR value. The control of PI has been insisted as elaborated in the literature review and incorporated in various specifications. The specification has classified that the requirements for fill material are; maximum PI ≤ 45%, maximum liquid limit ≤ 90% and SI ≤ 3%. The Kenya specification has classified that the requirement for fill material is; the CBR ≥ 5%, SI ≤ 3%, PI ≤ 50%, and the layer shall be constructed at 95% of MDD.

The effect of variation of moisture has been studied. The results show that the soil type of clayey with high plasticity (CH) are most influenced than low plasticity (CL) and clay of silt in sand type (SC). The suction of moisture in the pavement fluctuates due to changes of environment climatic condition. Since has divided the Tanzania into three climatic zones aimed to select suitable material that will fit respective climatic zone. Unrestrained seasonal change behaviour have resulted occurrence of differential movement and seasonal crack to the pavement layer.

The correlation of CBR and M_r has been observed by comparing the correlation factors value. The soil type CH observed to have high correlation factor than soil type CL and SC. The soil with least fine content founded to have good performance on CBR with unsatisfactory M_r value and specimen with high fine content have unsatisfactory CBR with satisfactory M_r at dry condition (Table 7).

Table 7. Indicating an improved classification for selection of fill material.

Type of test	MoW 1999 and MoW 2000	Recommendation		
		Dry zone	Moderate zone	Wet zone
CBR	CBR ≥ 3% at 90% MDD	CBR ≥ 5% at 93% of MDD	CBR ≥ 5 % at 93% of MDD	CBR ≥ 7 at 93% of MDD
Swell	≤ 2%	≤ 2% at 93%	≤ 2% at 93%	≤ 2% at 93%
Plasticity Index	-	PI ≤ 45	PI ≤ 45	PI ≤ 40
% Passing 0.075 mm	-	Max 55%	Max 55%	Max 50%

The amendments undertaken above are in line with the test results obtained and pavement material design manuals from other specification include Kenya, Namibia, South Africa, Ethiopia, Somalia, Sri Lanka and Australia.

CONCLUSION

Effect of PI and fines content on the strength of the fill layer

It was noted that fill material type constitute more than 55% of fine content (% passing 0.075 mm) and having PI greater than 45% are more sensitive to change the overall pavement performance while exposed to variation of moisture content. Controlling of fines content and plasticity index during classification of fill material is significant for the performance of the pavement life.

Effect of variation of moisture content and fines content on the stiffness of the fill layer

Variation of moisture in the soil specimen from dry to moderate and moderate to wet sides founded affect the stiffness of the fill layer. The magnitudes of consequence depend with the amount of fines content in the soil specimen. The soil structure constitutes fines content greater than 55% had resulted higher rate of change of M_r compared to the soil specimen with fines content lower than 55%. However, satisfactory result of Mr had been noted while tested at dry side followed by moderate side. But the soil samples with 60% and 80% fines content had resulted M_r lower than 30 Mpa at wet sides which is unacceptable for roadwork construction.

Assessment of correlation between CBR and stiffness of the fill material

The correlation of CBR and Mr has been observed by using the correlation factors value. The soil type of clayey with high plasticity (CH) composed high correlation factor followed by soil type clayey with low plasticity (CL) and finally with soil type silt or clayey in the sand (SC).

The soil with least amount of fine content founded has good performance on CBR but resulted low M_r value. The soil type constitute high fines content resulted low value of CBR but resulted satisfactory Mr at dry and moderate sides. But the M_r to the wet sides results unsatisfactory performance.

Determination of an improved classification approach for selection of fill material

From the result analysis it has founded that, CBR value of 3% is attracting great amount of fines content, thus improving the CBR above 3%, it reduce the percentage of fines content in the soil specimen. The determination of an improved classification will be comprises the climatic condition, improve of CBR value from 3% to 5% and classification based of percentage of fines content to the soil specimen.

RECOMMENDATION

The following recommendation is suggested to improve the requirement for the selection of fill material.

- Additional restriction must be provided through the Standard specification by including the limit of plasticity index (PI) and fines content.
- Tanzania has been divided into three climatic zone due differences to the amount of rainfall. The selection of fill material must be categorized based on the climatic zones as recommended in Table 8.
- The Ministry of Works through the road authority is advised to increase the minimum CBR value from 3% up to 5% and degree of compaction from 90% up to 93% as indicated in the Table 8.

ACKNOWLEDGEMENT

My gratefully acknowledges should firstly be to the Almighty God. Then, secondly to Tanzania national roads agency (Tan roads) worked under ministry of work Tanzania for funding and the guidance of the other authors in the accomplishment of this study. I dedicate this paper to department of transportation and geotechnical engineering, college of engineering and technology at the university of Dar es Salaam.

REFERENCES

1. B Shirur, et al. “Establishing Relationship between CBR Value and Physical Properties of Soil. IOSR J Mech Civ Eng. 2014;11:26–30.
2. Drumm EC, et al. Subgrade resilient modulus correction for saturation effects. J Geotech Geoenviron Eng. 1997;123:663–670.
3. Gao X, et al. Analysis of Deformation Characteristics of Filled Subgrade Treated by Micro-Pile. Adv Civ Eng. 2021;1-8.
4. Jayasekera S, et al. Some relationships between shrink swell index, liquid limit, plasticity index, activity and free swell index. Aust Geomech. 2003;38:53-58.

5. Khasawneh, et al. Permanent Deformation Behavior of Cohesive Subgrade Soils Classified as A-4a and A-6a. Mater Today Proc. 2020;33:1762–1768.
6. Korde, et al. A Study of Correlation between CBR Value and Physical Properties of Some Soils. Int J Emerg Technol Adv Eng. 2015;5:237–239.
7. Lakshmi SM, et al. Establishment of Correlation between CBR and Resilient Modulus of Subgrade. Int J Civ Eng. 2019;6:44–49.
8. Majidzadeh K, et al. Rutting Evaluation of Subgrade Soils in Ohio. Transp Res Rec. 1978;671:75–84.
9. Zhou C, et al. Resilient Modulus of Unsaturated Subgrade Soil: Experimental and Theoretical Investigations. Can Geotech J. 2013;50:223–232.
10. Nguyen BT, et al. Resilient modulus of fine grained soil and a simple testing and calculation method for determining an average resilient modulus value for pavement design. Transp Geotech. 2016;7:59-70.
11. Osouli A, et al. Fines Content, Plasticity Index and Dust Ratio Influencing the Modulus and Permanent Deformation Behavior of Aggregates. Transp Geotech. 2021;30:100630.
12. Paulo JZ, et al. Study of the Permanent Deformation of Three Soils Employed in Highway Subgrades in the Municipality of Santa Maria-RS, Brazil. Int J Pavement Res Technol. 2021;14:729–739.
13. Hodges J, et al. A guide to the structural design of bitumen surfaced roads in tropical and sub-tropical countries. 4th Edition. Overseas Centre publisher, United Kingdom. 1993;31:1-75.
14. Rouge, et al. permanent deformation characterization of subgrade soils from rlt test. J Mater Civ Eng. 1999:274–282.
15. Scharifi, et al. Influence of Plastic Deformation Gradients at Room Temperature on Precipitation Kinetics and Mechanical Properties of High Strength Aluminum Alloys. J Eng Res Appl. 2019;9:24–29.
16. Talukdar, et al. A Study of Correlation between California Bearing Ratio (CBR) Value with Other Properties of Soil. Int J Emerg Technol Adv Eng. 2014;4:559–562.
17. Tamrakar, et al. Moisture Effects on Moduli of Pavement Bases. Int J Pavement Eng. 2019;0:1–13.
18. Werkmeister S, et al. Pavement Design Model for Unbound Granular Materials. J Transp Eng. 2004:665–674.
19. Yildirim B, et al. Estimation of California Bearing Ratio by Using Soft Computing Systems. Expert Syst Appl. 2011;38:6381–6891.
20. Zumrawi, et al. Prediction of CBR from Index Properties of Cohesive Soils. Adv Civ Eng. 2012;22:561–565.