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Flexible Pavement Assessment of Selected Highways in Orolu Local Government South - Western Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author AAB designed the study, wrote the protocol and wrote the first draft of the manuscript and managed literature searches. Authors AUA and JAI collected samples and carried out the analysis in laboratory and also conducted literature searches. All authors read and approved the final manuscript.

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ABSTRACT

This research aim at investigating the flexible pavement performance of some selected Highways in Orolu Local Government area of Osun State, South-western Nigeria. In order to achieve this, the study involved interview sessions with relevant parties, administering of questionnaires, site observations, Pavement Condition Rating (PCR) was adopted to place a numerical value on the state of some selected roads and geotechnical investigative studies of the selected Highways. Laboratory determination of design parameters, namely Atterberg Limits, particle size distribution, California Bearing Ratio (CBR) and compaction were carried out in accordance with BS1377 (1997) method of soil testing for Civil Engineers. Thereafter, the soil samples that have been collected from failed portions of some of these roads to determine the structural integrity of the underlying soil strata were classified using AASHTO and USCS classifications. Compaction test with Maximum Dry Density MDD between 1730.02 kg/m^3 - 1960 kg/m^3 and Optimum Moisture Content

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OMC between 13.05%-20.0% were also carried out. The values of California Bearing Ratio (CBR) of soaked soil samples were within the range of 4.60% and 20.69, while un-soaked soil samples fall within the range of 10.13% to 65.07%, these results shows that samples T1, T3, T5, T7, T8, T9 and T10 are all good as subgrade materials, while samples T2, T4 and T6 are poor subgrade materials and they could have contributed to the failure of their roads: AFP4 (Kelebe road), AFP7 (Elder Akande road) and AFP9 (Ile- Olode road).The PCR values ranged from 61.28 and 100. The results of laboratory tests and field observation produced herein indicates that the failure of pavements in Orolu Local Government Area, Ifon-Osun, Osun State, South-western Nigeria can be attributed to the following: Poor or no design, infiltration of surface runoff into underlying course, growth of shrubs and lack of effective routine maintenance by the concerned agencies.

Keywords: Flexible pavement; geotechnical investigative studies; pavement condition rating; structural integrity.

1. INTRODUCTION

Transportation Infrastructure (roads, rail, airports and seaports) represents important infrastructure to all countries' economies. A country's economic status depends so much on the effectiveness of the transportation sector. A major problem that faces highway and transportation in Nigeria is that roads may be in poor condition but are still usable, making it easy to defer repair until conditions of such roads become unacceptable. The rate, frequency and magnitude of pavement deformation in virtually all major highways in Nigeria have reached an alarming proportion [1]. The gradual deformation of a pavement occurs due to many factors, including variations in climate, drainage, soil conditions, and truck traffic among others. The most common of these road deformation modes are fracture, distortion and disintegration.

Therefore, Pavement maintenance is essential as far as highway is concerned, it is important for periodic check to be carried out at time intervals to ensure safety and comfort of the pavement users. There are several standard of pavement maintenance guideline depending on the regulatory body. It has been described that road transportation as by far the most widely used means of transportation system in Nigeria [2-4]. Therefore, there is need for the roads to be in good shape. However, the performance of Nigerian roads sector has not been satisfactory despite its enormous potentials for growth and development. Traditionally, the poor transport facilities and infrastructure have severely delayed economic development and this weakened transport infrastructure has contributed negative attempts to alleviate poverty in the country. The Nigerian inland waterways and railways are ineffective, as road transport accounts for 90% of the internal movement of goods and people, which makes the grave state of the roads all the more important that they receive much needed rehabilitation interventions.

As part of research effort in the Civil Engineering Department of Osun State University, a study was carried on the assessment of flexible pavements in Orolu Local Government. The objective (s) of this study is to identify type and severity of pavement distresses and deformations through pavement condition survey, identify possible causes of pavement failure in the area and to provide procedures and guidance for performing project level evaluation of pavement structures in the area been considered. To a large extent, this paper also serves as microcosm of what is obtainable in other areas which experience similar trend in the maintenance of flexible pavement.

1.1 Assessment of Flexible Pavement

Flexible pavements usually consist of a bituminous surface underlaid with a layer of granular material and a layer of a suitable mixture of coarse and fine materials (see Fig. 1.1). Traffic loads are transferred by the wearing surface to the underlying supporting materials through the interlocking of aggregates, the frictional effect of granular materials, and cohesion of fine materials. The general causes of primary deterioration include traffic, environment/aging, and material problems [3-5]. A secondary cause of deterioration is due to moisture infiltration. These factors initiate the gradual failure of the pavements and if not controlled eventually results in the overall failure of such pavements.

The failure of the flexible pavement is defined as the localized depression and heaving up in its vicinity. The sequence of depression and heaving develops a wavy surface of the pavement. The settlement of any of the component layer of the flexible pavement develops waves and corrugations or longitudinal ruts and shoving on the pavement surface. The excessive unevenness of the pavement surface may itself be considered as a failure [4-8]. Therefore, there is a need to carry out periodic assessment of flexible pavements. Assessment of flexible pavement surface condition is necessary to measure the ability of the pavement to continue to provide the required service to the public.

1.2 Brief Description of Study Area

Orolu is a Local Government Area in Osun State, Nigeria. Its headquarters are in the town of Ifon or (Ifon Osun) at 7°52′00″N 4°29′00″. It has an area of 64 km² and a population of 119,497 at the 2006 census (see Fig. 1.2).

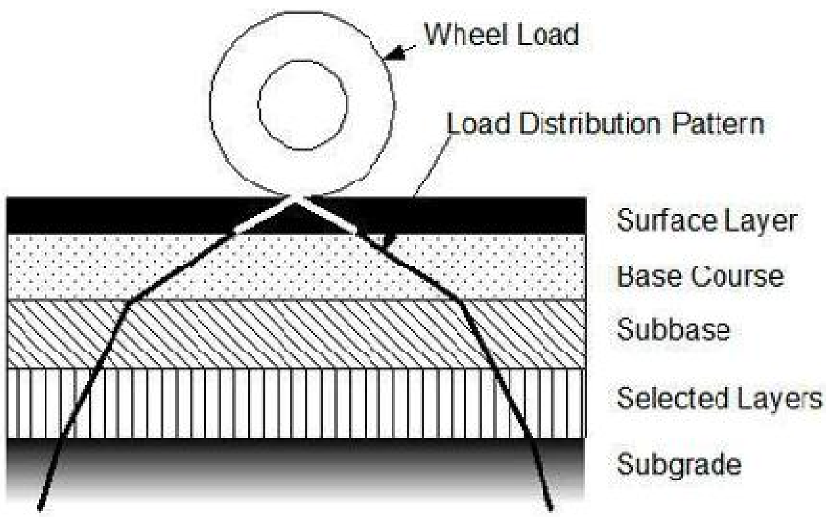

Fig 1.1. Load distribution of flexible pavement (4)

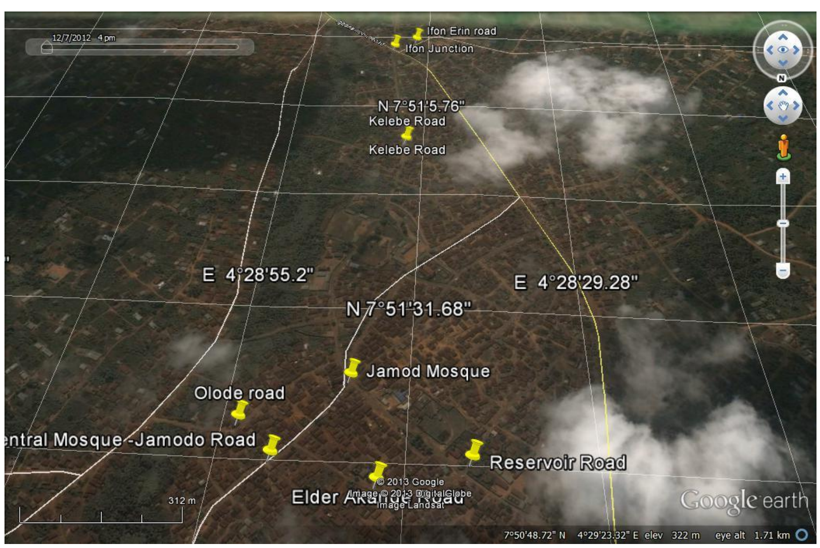

Fig. 1.2. Location map (Source: field Study)

2. METHODS OF INVESTIGATION

2.1 Site Visit and Data Collection

A site visit of the selected pavements was conducted to familiarize with the location, and to identify the best time for the data collection. During this visit, data collection was conducted during the low traffic flows, which is during the weekend (Saturday and Sunday) and public holidays. A visual site assessment was conducted with permission of the Authority concerned for the maintenance of these selected roads. This assessment has provided some indication on the pavement defects and the possible causes of the defects along these roads. Relevant photographs were taken to show the actual site condition and the type of defects. See Annex.

2.2 Pavement Condition Survey

The rating method used is based upon visual inspection of pavement distress. Although the relationship between pavement distress and performance is not well defined, there is general agreement that the ability of a pavement to sustain traffic loads in a safe and smooth manner is adversely affected by the occurrence of observable distress. The rating method provides a procedure for uniformly identifying and describing, in terms of severity and extent, pavement distress. The mathematical expression for pavement condition rating (PCR) provides an index reflecting the composite effects of varying distress types, severity, and extent upon the overall condition of the pavement. The model for computing PCR is based upon the summation of deduct points for each type of observable distress. Deduct values are a function of distress type, severity and extent. Deduction for each distress type is calculated by multiplying distress weight times the weights for severity and extent of the distress. Distress weight is the maximum number of deductible points for each different distress type. The mathematical expression for PCR is as follows:

$$\text{PCR} = 100 - \sum_{k=1}^{n} Deduct \qquad (1)$$

Where:

n = number of observable distresses and
Deduct = (Weight for distress) (Wt. for severity) (Wt. for Extent)

A Pavement Condition Rating (PCR) Scale was developed to describe the pavement condition using the PCR numbers calculated from Equation (1). This scale has a range from 0 to 100; a PCR of 100 represents a perfect pavement with no observable distress and a PCR of 0 represents a pavement with all distress present at their “High” levels of severity and “Extensive” levels of extent. Fig. 3.1 illustrates the PCR Scale and the descriptive condition of a pavement associated with the various ranges of the PCR values [5].

2.3 Drainage Condition Assessment

Assessment of the surface and sub-surface drainage was conducted, as these elements contribute significantly to the overall performance of the pavement structure. Surface drainage is judged by the ability of the pavement surface to drain water as well as not allowing water to pond either on the bituminous surfacing or on the shoulder verge. Observations have been made to identify whether the existing drainage system is sufficient and properly functioning to safeguard the pavement structure.

2.4 Sample Collection and Geotechnical Testing

Soil samples were collected from the pavements that have failed severely for geotechnical testing. These soil samples were obtained from trial pits that were dug at some specific locations along the pavement surface so as to ascertain the suitability of the materials used as base course, sub-base course and subgrade and whether it is one of the possible factors responsible for the pavement failure in Orolu local Government Area.

The laboratory tests carried out on the soil samples that were obtained from these specific locations are particle size distribution (mechanical sieve analysis), atterberg limits (consistency limits), specific gravity, linear shrinkage, compaction, California Bearing Ratio (CBR). These laboratory tests were performed in accordance with the procedures specified (BS, 1990). The tests were conducted at geotechnical laboratory of Department of Civil Engineering Osun State University (UNIOSUN), Osogbo.

2.5 Administering of Questionnaire

Questionnaires were distributed to highway officials at the state and local government levels.

Relevant information on the current state of pavements and maintenance system adopted by the agencies were considered.

2.6 Data Analysis

The preparation stage of the analysis involves a devising a good form in which to produce the data so that it could be readily analyze and provide a fair summary of study. Data will be presented in the form of the graphs and charts for easy reference. Each tabulated data are to be described and analyzed.

3. RESULTS AND DISCUSSION

3.1 Pavement Condition Survey

The method of survey employed is the Pavement Condition Rating (PCR). A total of nine roads were surveyed with route numbers indicated in the Table 3.1 below. According to the PCR rating scale it was observed that only three roads AFP1, AFP2 and AFP7 were in very good condition, while AFP4, AFP5 and AFP6 can be regarded as good, AFP8 and AFP9 falls in the category of fair and only AFP3 sits in the class of fair to poor. During this survey, it was also observed that AFP3, AFP6 and AFP9 do not conform with the standard width of 7.30 m (3.65 m x 2) for two lane highway sections and road furniture such as shoulder, walkway and median were invariably absent in all roads as specified [6].

3.2 Drainage Condition Assessment

From visual inspection it was observed that most of the drains were in poor condition. The drains are shallow with depth ranging from 0.1- 0.8 m. All drains except that of AFP2 were constructed with block wall. It was also observed that surface runoff from rainfall takes a long time to drain off the pavement surface because of the inconsistency in the camber shape of the pavement.

3.3 Sample Collection and Geotechnical Testing

Ten trial pits were dug from five selected pavement with each pavements having two pits at considerable intervals. The depth ranges from 0.6 – 0.8 m on failed sections of the selected pavements. The pavements considered were AFP3, AFP6, AFP7, AFP8 and AFP9.

3.4 Specific Gravity

The values of the specific gravity ranges between 2.2 and 2.84 which is typical for sands and clay materials [7-10].

3.5 Particle Size Distribution

The percentage of sample passing through No. 200 BS sieves for samples T1, T2, T3, T4, T5, T6, T7, T8, T9, and T10 are 58.0%, 38.8%, 44.8%, 60.8%, 24.8%, 61.2%, 26.8%, 18.8%, 22.8% and 16.0% respectively as shown in Table 3.2. Therefore samples T5, T7, T8, T9 and T10 can be classified as gap graded as shown in Fig. 3.2, while samples T2 and T3 can be considered as well graded and samples T1, T4 and T6 as fairly graded. This result indicates that samples T5, T7, T8, T9 and T10 can be deduced as good subgrade, subbase and base materials as the percentage passing the BS 200 sieve is less than 35% while the remaining samples gives an insight to the probable cause of failure on the pavement from which they were collected. None of these samples qualifies to be a stone base material because the percentage passing BS 200 sieve is greater than 15 for all samples [6-9]

Table 3.1. Showing PCR values of roads assessed

Route no	Description	Length of road (km)	Width of road (m)	Functional classification	PCR Value
AFP1	Jamodo - Central Mosque	1	7.80	Residential collector	96.88
AFP2	Ifon-Erin Road	1	8.10	Community collector	100
AFP3	Abattoir Road	0.250	6.70	Local	61.28
AFP4	Kelebe Road	1.1	7.70	Residential collector	80.88
AFP5	St John Road	0.850	7.40	Residential collector	87.40
AFP6	Reservoir Road	0.475	6.50	Local	77.08
AFP7	Elder Akande Road	0.450	7.10	Local	95.36
AFP8	Alhaji Aralamo Road	0.850	7.80	Residential collector	71.34
AFP9	Ile-Olode Road	0.450	6.65	Local	73.37

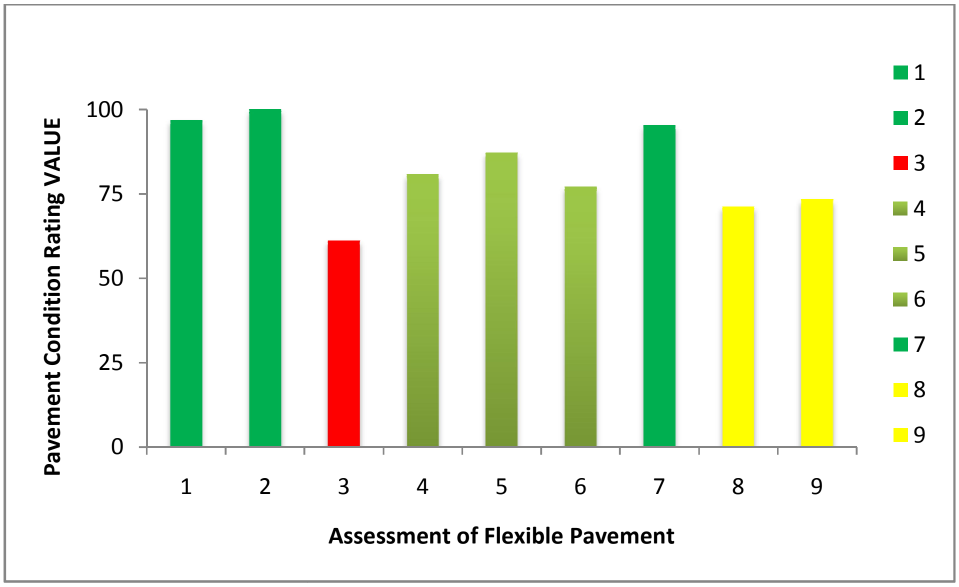

Fig. 3.1. Bar chart representing the PCR of the roads

Table 3.2. Showing physical properties of soil samples

Properties	T1	T2	T3	T4	T5	T6	T7	T8	T9
% Passing 0.075 µm	58.0	38.8	44.8	60.8	24.8	61.2	26.8	18.8	22.8
Liquid limit (%)	51.6	23.8	26.84	68.29	40.16	51.44	29.59	22.90	34.37
Plastic limit (%)	34.7	17.75	14.29	24.15	-	23.86	5.57	10.80	19.81
Plastic index (%)	16.9	6.05	12.55	44.14	-	27.58	24.02	12.1	14.56
Maximum dry density (Kg/m^3)	1810.1	1730.02	1790	1680.40	1870.00	1780.50	1920.05	1960.00	1980
Optimum moisture content (%)	16.6	19.40	17.00	20.00	13.80	18.40	16.00	16.00	13.05
CBR Soaked (%)	10.81	4.60	14.47	5.87	19.75	7.35	16.35	15.67	20.39
CBR Un-soaked (%)	28.09	10.85	26.82	10.13	65.05	18.69	50.48	56.62	57.07
AASHTO	A-7-5	A-4	A-6	A-7-5	A-1-b	A-7-6	A-2-6	A-1-b	A-1-b
USCS	MH	SC - SM	SC	CH	-	CH	SC	SC	SC
Specific gravity	2.7	2.2	2.58	2.63	2.77	2.8	2.2	2.64	2.41

3.6 AASHTO and USCS Classification

According to AASHTO classification, samples T5, T8, T9 and T10 belong to the A-1-b subgroup, samples T1 and T4 belong to A-7-5 subgroup, while samples T2, T3, T6 and T7 belong to groups A-4, A-6,A-7-6 and A-2-6 respectively as shown in Table 3.2 above and will require a layer of subbase material if used as subgrade. In the Unified Soil Classification System, T1 has a group symbol MH and group name Sandy elastic silt, T2 has a group symbol of SC – SM and a group name Silty, clayey sand with gravel, T3, T7, T8 and T9 have a common group symbol SC and group name Clayey sand, T4 and T6 also have a common group symbol CH and group name Sandy, fat clay, while T5 and T10 could not be classified.

3.7 Atterberg Limits

The liquid limits value falls between 7.08% and 68.29%, while the plastic limits falls between 5.57% and 34.74% and the plasticity index ranges between 6.05% and 44.14%. Generally, soils with liquid limits of less than 30% are considered to be of low plasticity, those with liquid limits between 30% and 50% are considered to be of medium plasticity and those with liquid limit higher than 50% exhibits high plasticity. This indicates that samples T2, T3, T7, T8 and T10 are of low plasticity while samples T5 and T9 are of medium plasticity and samples T1, T4 and T6 are of high plasticity. It was recommended that a liquid limit of 50% maximum and plasticity index of 15% maximum for subbase and base materials [6,8,10-12]. Based on this, samples T1, T4 and T6 are considered not suitable for subbase and base materials and could have contributed to the failure of pavements in such area.

3.8 Compaction

West African standard was used. The maximum dry density (MDD) ranges between 1730.02 kg/m^3 and 1960 kg/m^3, which is typical for materials within the range of silty clay to sandy clay, while the optimum moisture content (OMC) ranges between 13.05% and 20.0% as indicated in table. Figs 3.4 – 3.13 shown values of MDD against OMC Sample T4 has the highest optimum moisture content and lowest maximum dry density.

3.9 California Bearing Ratio

The CBR values for the un-soaked soil samples ranges from 10.13% to 65.07% while the values for soaked samples falls within the range of 4.60% and 20.69% as shown in Figs. 3.14 – 3.27. The notable decrease in CBR value between the un-soaked and soaked samples implies that the resistance to penetration decreases drastically after the soaking. It was recommended that for soaked samples the values of CBR for subgrade, subbase and road base should not be less than 10%, 30% and 80% respectively [7,12-15]. This implies that samples T2, T4 and T6 are not suitable as subgrade material and could have contributed to the failure of the pavement at the section, also one can infer that none of the samples tested qualifies to be either subbase or base material and if otherwise used might pose a threat to the pavement in Orolu Local Government.

3.10 Administering of Questionnaire

Questionnaires were distributed to highway officials at the state and local government levels but only few respondents filled and submitted theirs while some felt they might be quoted in public others thought it was a sort of political exercise.

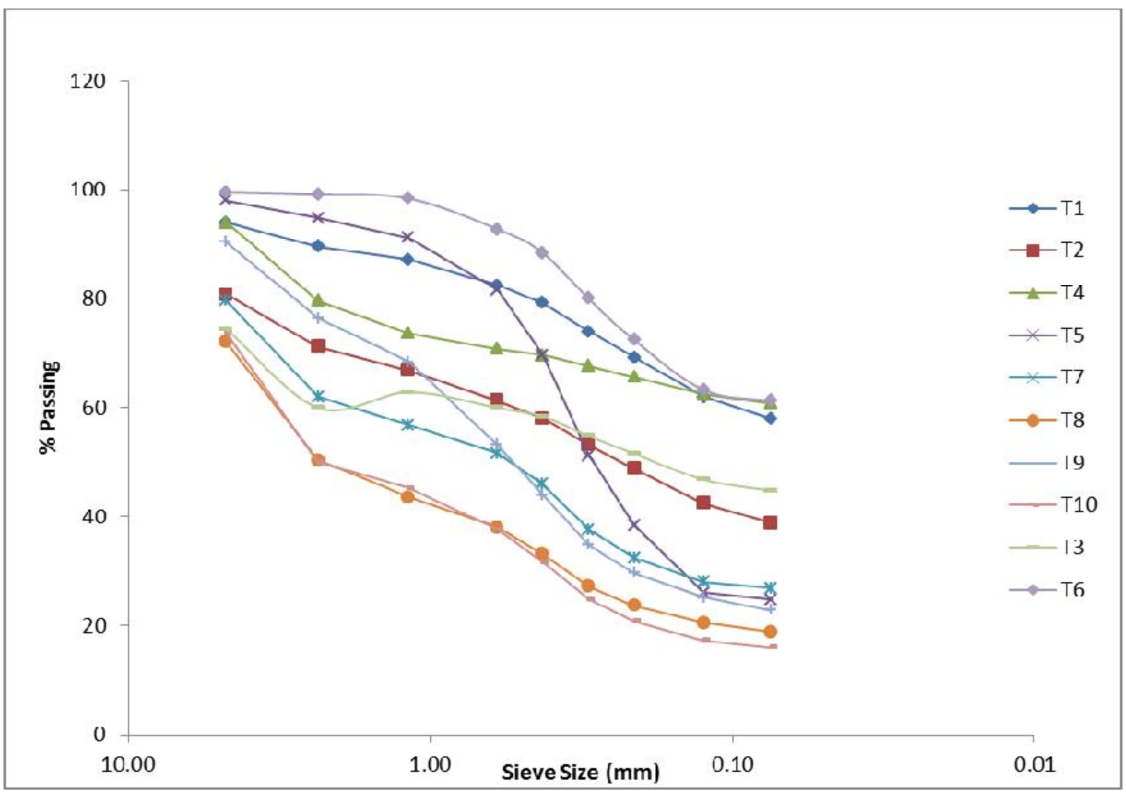

Fig. 3.2. Particle size distribution of the samples

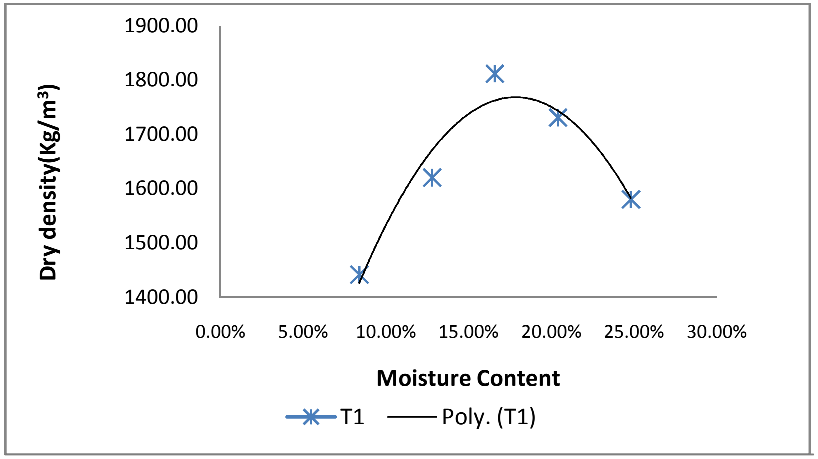

Fig. 3.4. Compaction curve of sample T1

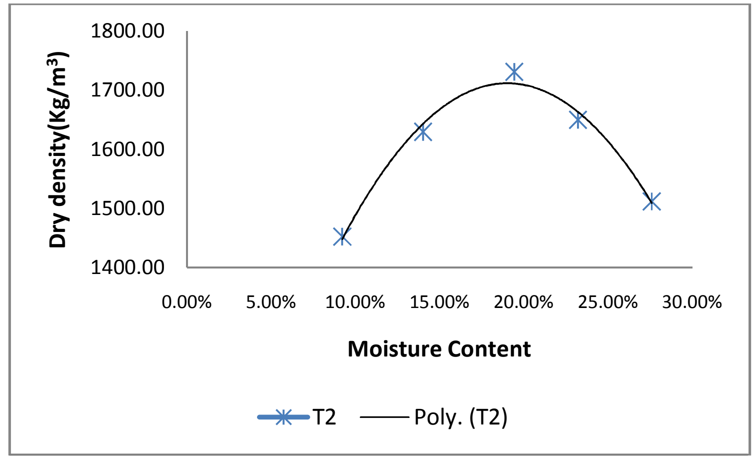

Fig. 3.5. Compaction curve of sample T2

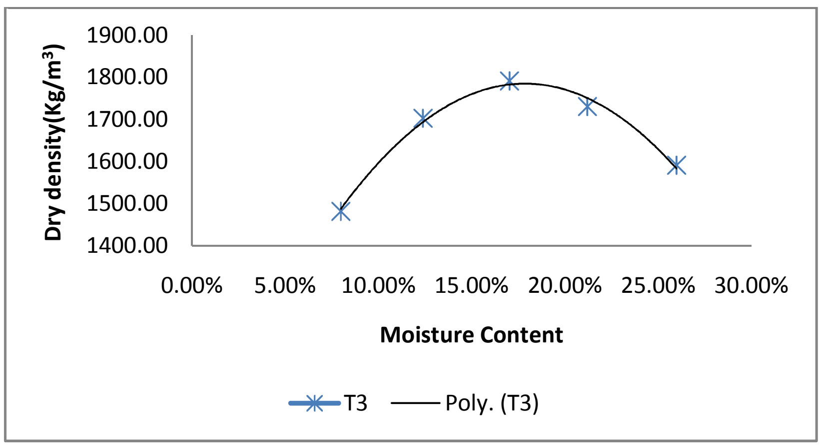

Fig. 3.6. Compaction curve of sample T3

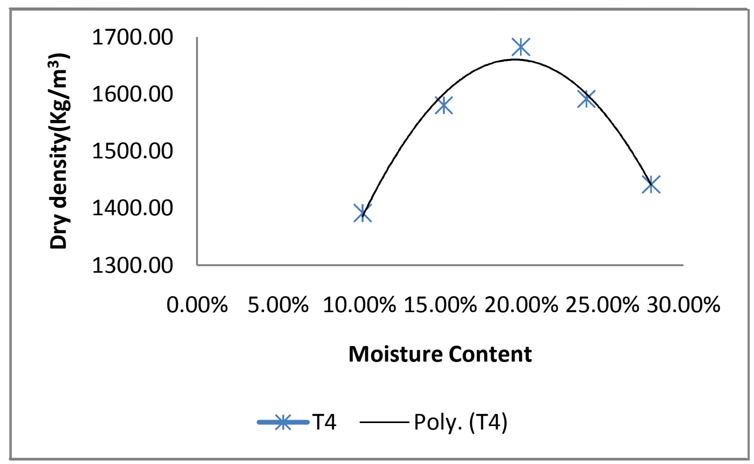

Fig. 3.7. Compaction curve of sample T4

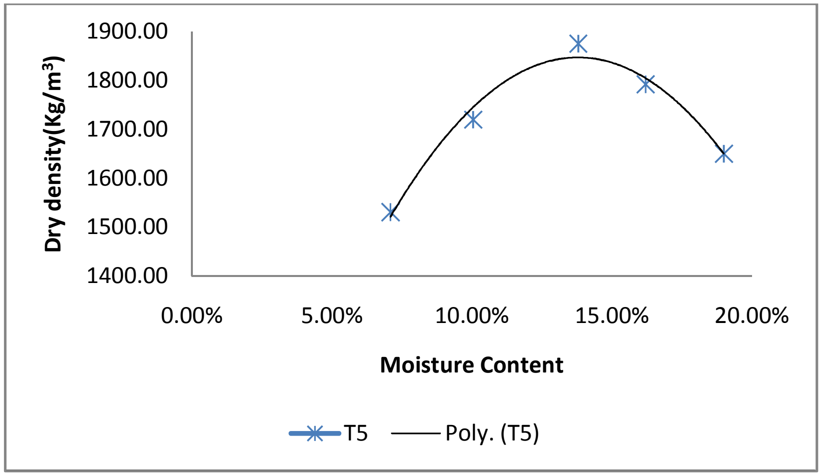

Fig. 3.8. Compaction curve of sample T5

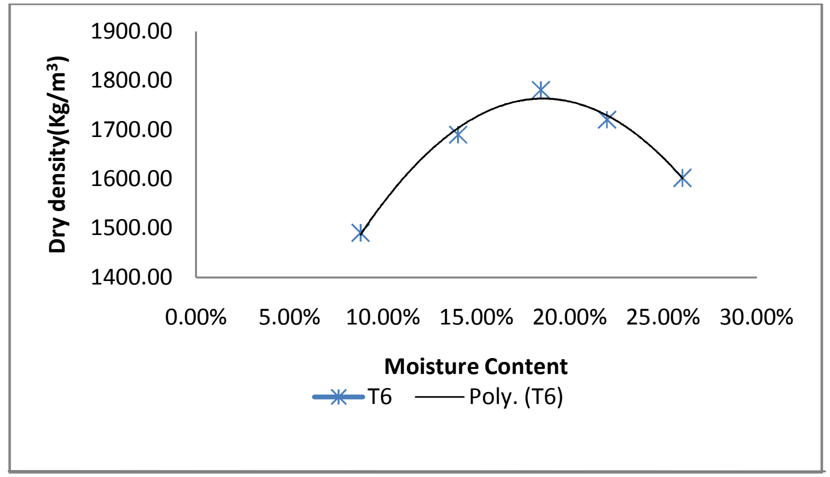

Fig. 3.9. Compaction curve of sample T6

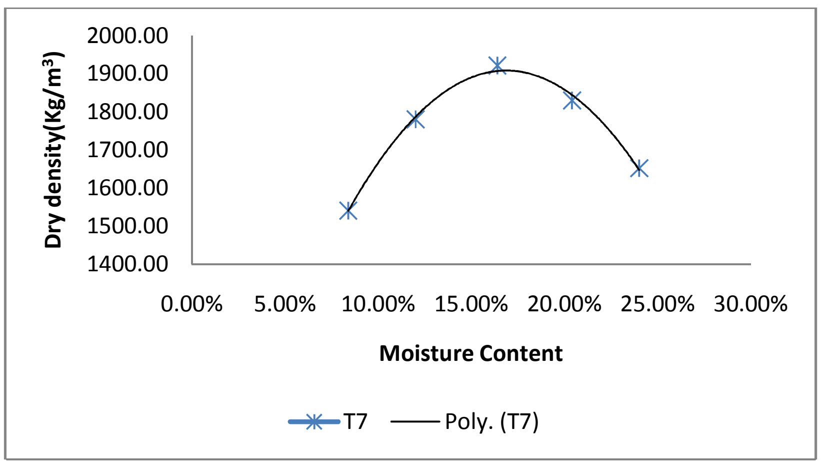

Fig. 3.10. Compaction curve of sample T7

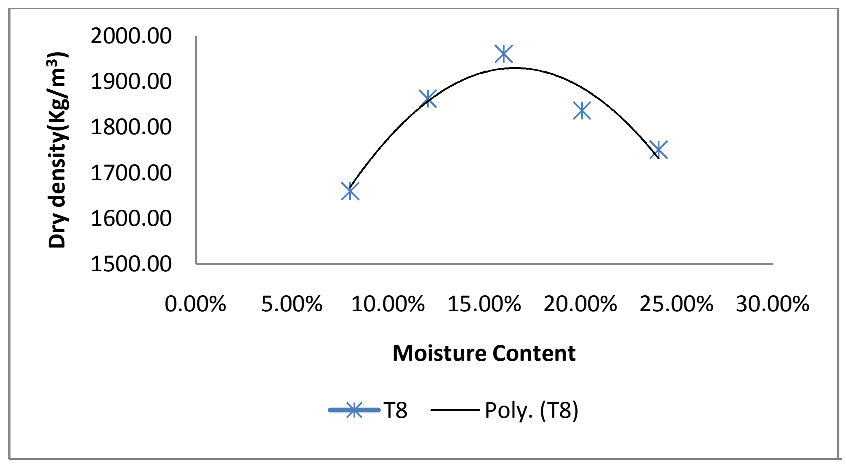

Fig. 3.11. Compaction curve of sample T8

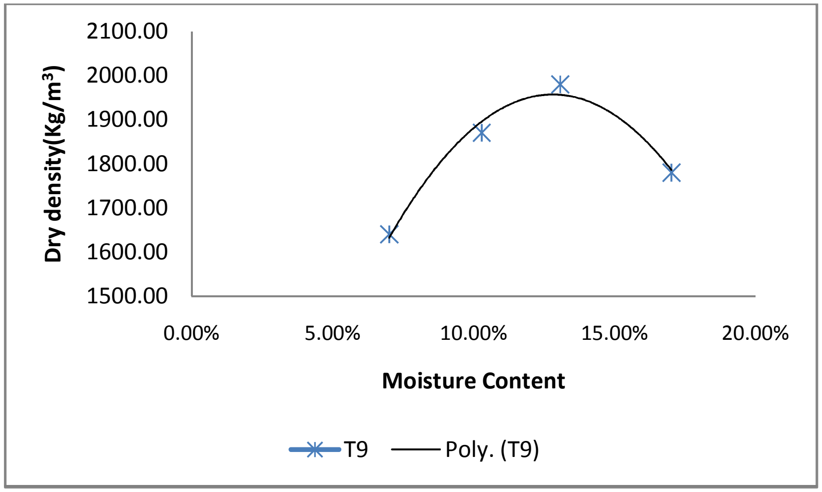

Fig. 3.12. Compaction curve of sample T9

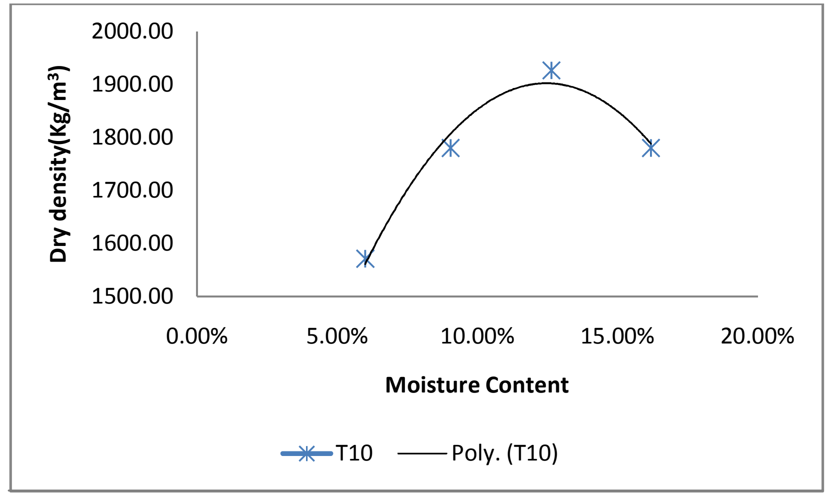

Fig. 3.13. Compaction curve of sample T10

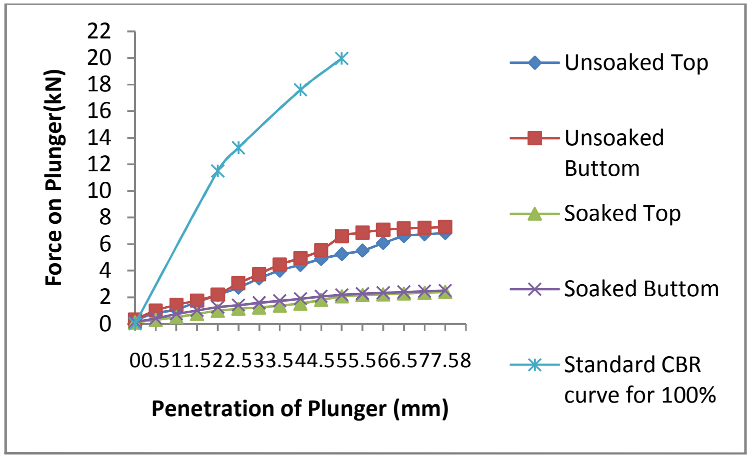

Fig. 3.14. CBR curve of sample T1

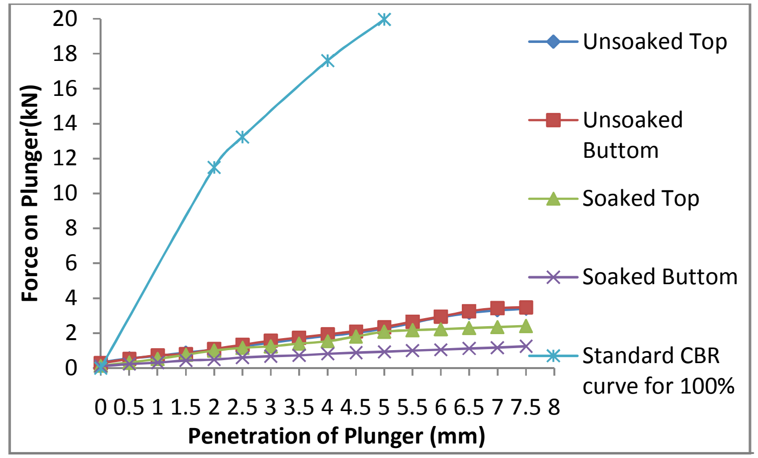

Fig. 3.15. CBR curve of sample T2

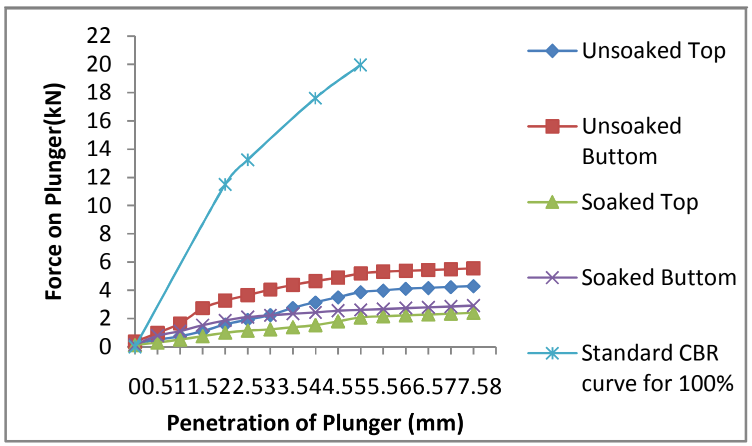

Fig. 3.16. CBR curve of sample T3

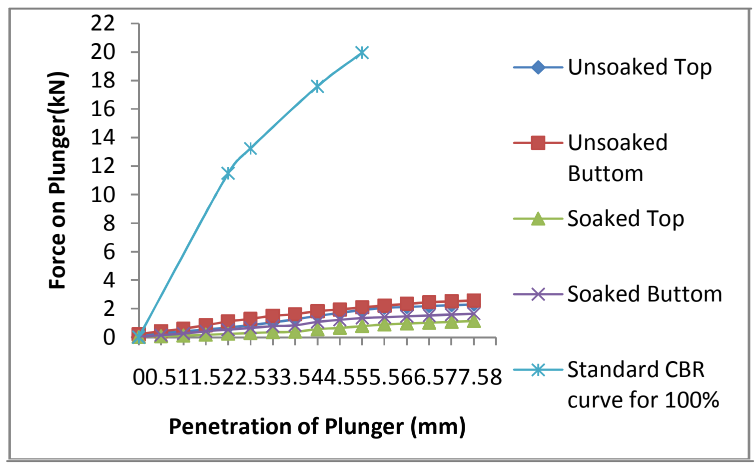

Fig. 3.17. CBR curve of sample T4

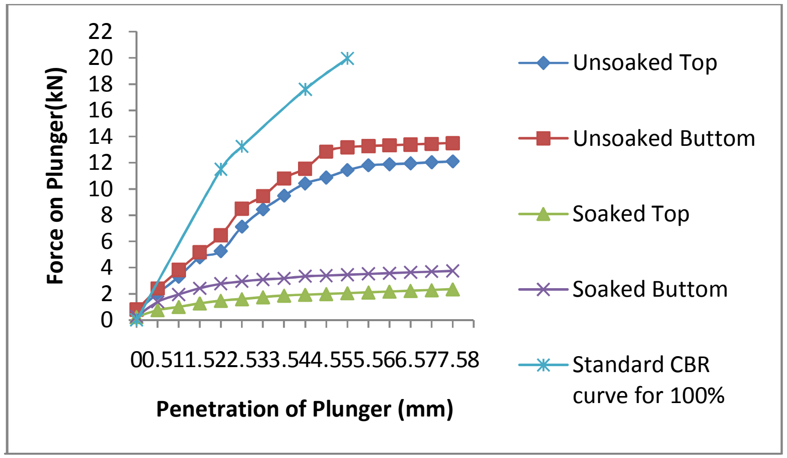

Fig. 3.18. CBR curve of sample T5

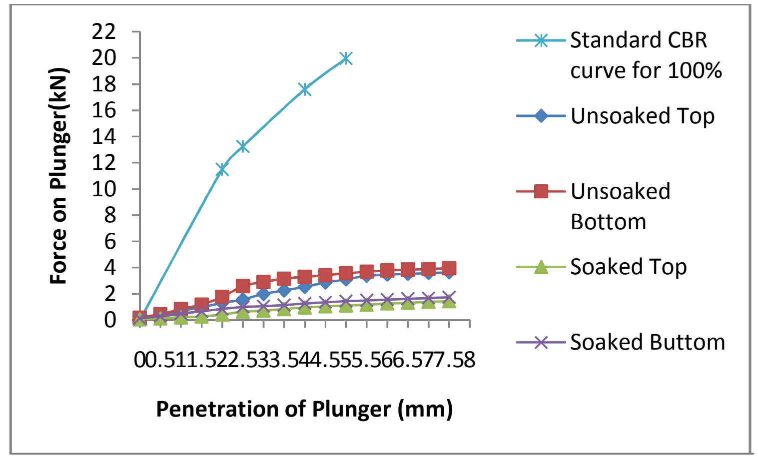

Fig. 3.19. CBR curve of sample T6

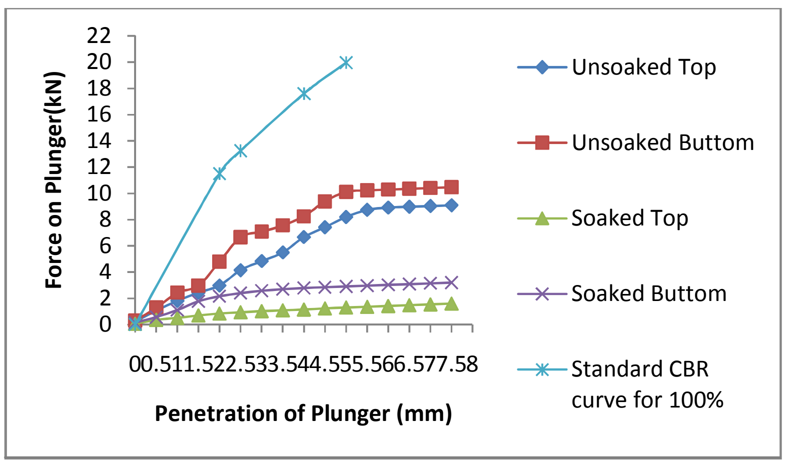

Fig. 3.20. CBR curve of sample T7

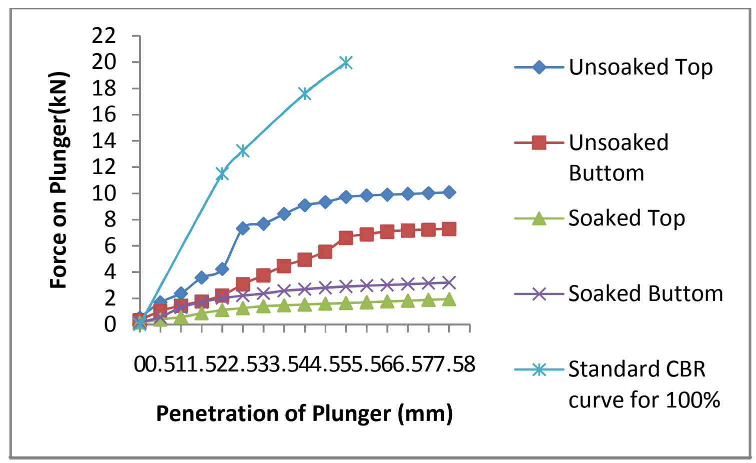

Fig. 3.21. CBR curve of sample T8

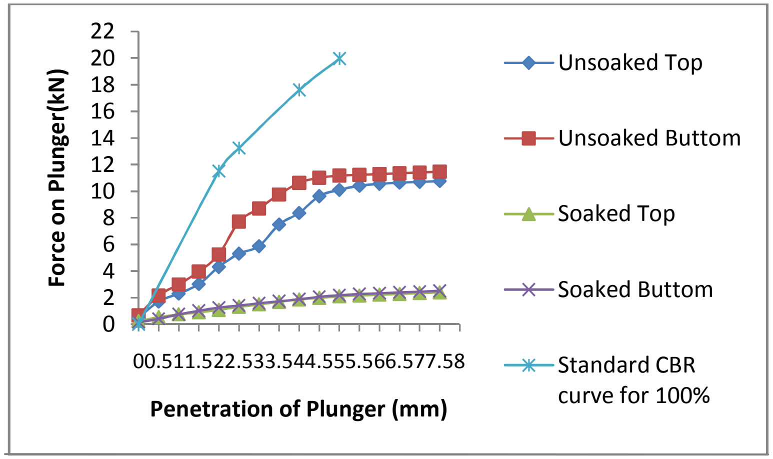

Fig. 3.22. CBR curve of sample T9

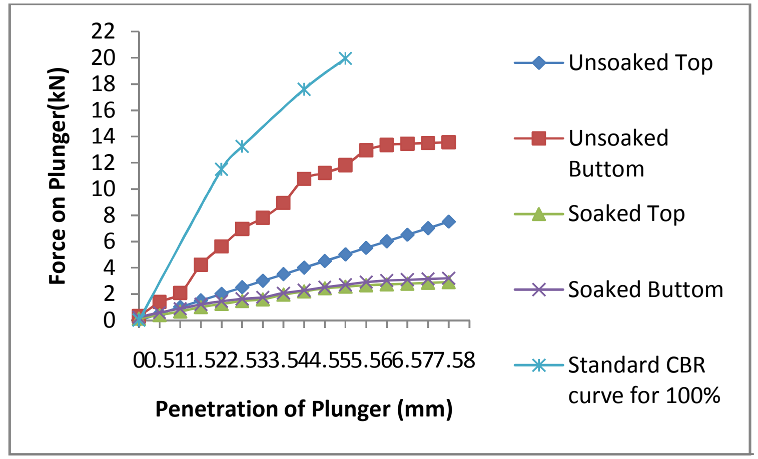

Fig. 3.23. CBR curve of sample T10

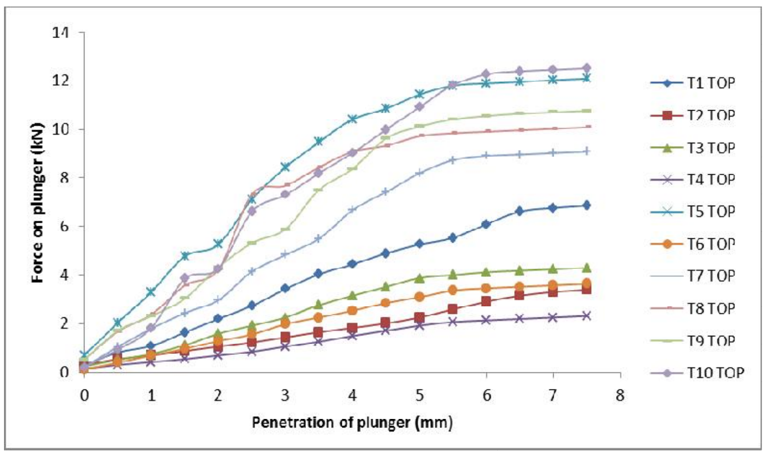

Fig. 3.24. California bearing ratio of unsoaked soil samples (Top)

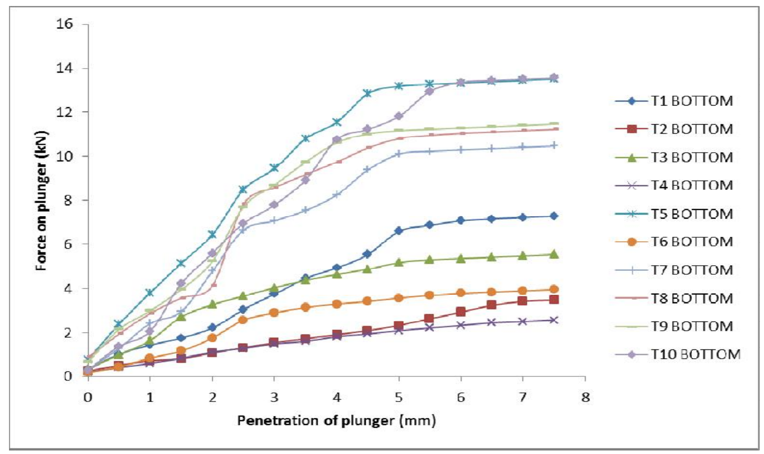

Fig. 3.25. California bearing ratio of unsoaked soil samples (Bottom)

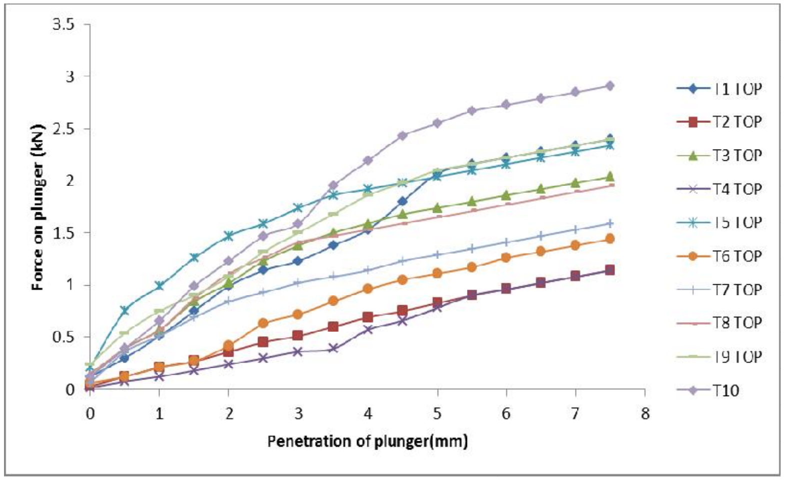

Fig. 3.26. California bearing ratio of soaked soil samples (Top)

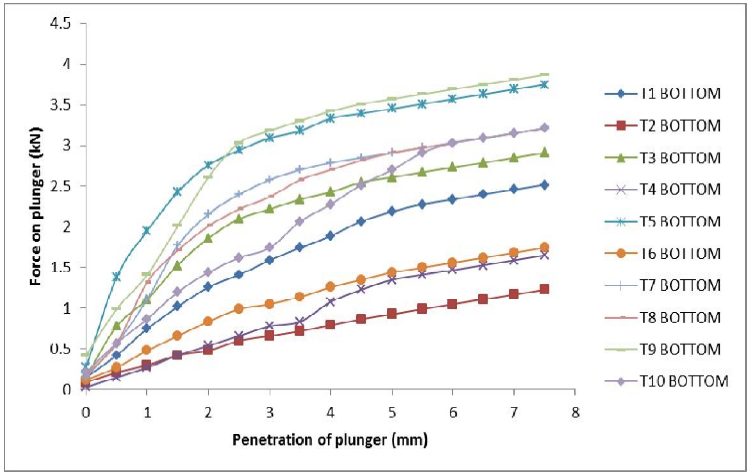

Fig. 3.27. California bearing ratio of soaked soil samples (Bottom)

4. CONCLUSION

Result obtained from the field exercise has revealed that there are different surface defects existing in Orolu Local Government Area, Ifon-Osun, Osun State, South-western, Nigeria but some of these defects are predominant. Some of the predominant defects are edge cracks, alligator cracks, potholes, ravelling and longitudinal cracks. These defects may a have occurred as a result of inadequate drainage facilities, infiltration of surface runoff to the underlying course and poor soil material at some sections of the roads. The most severe roads (poor - fair) in terms of surface defects are AFP3 (Abattoir road), AFP8 (Alhaji Aralamo road) and AFP9 (Ile-Olode road) with PCR values of 61.28, 71.34 and 73.37 respectively while AFP4 (Kelebe road), AFP5 (St. John road) and AFP6 (Reservoir road) have PCR values of 80.88, 87.40 and 77.08 respectively and can be considered as good, whereas the PCR values of AFP1(Jamodo – Central Mosque road), AFP2 (Ifon – Erin road)and AFP7 (Elder Akande road) are 96.88, 100 and 95.36, which is rated as very good according to the pavement condition rating scale.

Geotechnical property analysis of soil samples from selected roads shows that the result of particle size distribution indicates that samples T5 (24.8%), T7 (26.8%), T8 (18.8%), T9 (22.8%) and T10 (16.0%) can be classified as gap graded, while samples T2 (38.8%) and T3 (44.8%) can be considered as well graded and samples T1 (58.0%), T4 (60.8%) and T6 (61.2%) as fairly graded. This result indicates that samples T5 (24.8%), T7 (26.8%), T8 (18.8%), T9 (22.8%) and T10 (16.0%) can be deduced as good subgrade, subbase and base materials as the percentage passing the BS 200 sieve is less than 35%, while samples T1 (58.0%), T2 (38.8%), T3 (44.8%), T4 (60.8%) and T6 (61.2%) do not conform to the standards. Result obtained from Atterberg limits test suggests that samples T2 (23.80%), T3 (26.84%), T7 (29.59%), T8 (22.90%) and T10 (7.08%) are of low plasticity while samples T5 (40.16%) and T9 (34.37%) are of medium plasticity and samples T1 (51.67%), T4 (68.29%) and T6 (51.44%) are of high plasticity. Therefore, T1, T4 and T6 could have contributed to the failure of pavements in such areas. AASHTO and USCS classification of the soil samples are as follows: T1 (A-7-5, MH), T2 (A-4, SC-SM), T3 (A-6, SC), T4 (A-7-5, CH), T5 (A-1-b), T6 (A-7-6, CH), T7 (A-2-6, SC), T8 (A-1-b, SC), T9 (A-1-b, SC), T10 (A-1-b), based on the result herein one can conclude that samples T2, T3, T6 and T7 will require a layer of subbase material if used as subgrade and samples T5, T8, T9 and T10 are good subgrade materials .West African standard was used for the compaction test .The maximum dry density ranges between 1730.02 kg/m^3 and 1960 kg/m^3, which is typical for materials within the range of silty clay to sandy clay, while the optimum moisture content ranges between 13.05% and 20.0%.It was observed that Sample T4 with OMC (20.0%) and MDD (1680.40kg/m^3) has the highest optimum moisture content and lowest maximum dry density. California Bearing Ratio (CBR) tests of soaked soil samples are T1 (10.81%), T2 (4.60%), T3 (14.47%), T4 (5.87%), T5 (19.75%), T6 (7.35%), T7 (16.35%), T8 (15.67%), T9 (20.39%) and T10 (13.41%). For un-soaked soil samples the values are T1 (28.09%), T2 (10.85%), T3 (26.82%), T4 (10.13%), T5 (65.05%), T6 (18.69%), T7 (50.48%), T8 (56.62%), T9 (57.07%) and T10 (55.89%).these results shows that samples T1, T3, T5, T7, T8, T9 and T10 are all good as subgrade materials, while samples T2, T4 and T6 are poor subgrade materials and they could have contributed to the failure of their roads: AFP4 (Kelebe road), AFP7 (Elder Akande road) and AFP9 (Ile- Olode road).

The response obtained from questionnaires distributed to the highway officials at state and local government level reveals that most of the roads in Orolu local Government Area, Ifon – Osun, Osun State are either earth roads or roads built of asphaltic concrete. About 90% of the officials agree that pavement management system is not practised, while a very few percentage is of the opinion that it is been practised but needs improvement. It was also gathered that sections of pavement which require maintenance or rehabilitation is always known by the following; engineering judgement, worst pavement condition, operational priorities, age of pavement and when danger is perceived. Furthermore, when asked about the maintenance treatment and practice the agencies have adopted over the years, all respondents agree that routine maintenance has been adopted and the most practised treatment is small area patching using hot or cold mix.

After careful assessment of the pavements in Orolu Local Government Area, Ifon-Osun, Osun State, South-western Nigeria, It will be appropriate to conclude that the failure of pavement in Orolu Local Government could be attributed to the following: Poor or no design, inadequate drainage facilities, infiltration of surface runoff into underlying course, growth of shrubs, base failure and lack of effective routine maintenance by the concerned agencies.

5. RECOMMENDATION

i. Roads which have deteriorated beyond rehabilitation should be completely redesigned and reconstructed to standard.
ii. Considering the engineering properties of soils collected from Orolu Local Government Area, Ifon-Osun, Osun State, South-western, Nigeria. They are suitable for subgrade in highway construction.
iii. Subsequent drains in Orolu Local Government should be constructed with reinforced concrete.
iv. Agencies concerned with the maintenance of flexible pavements in Orolu Local Government Area, should adopt an effective routine maintenance schedule for safe and comfortable operation of such pavements.
v. More academic research should be carried out on mapping and engineering geology of Orolu Local Government Area.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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ANNEX

Plate 1 Showing the presence of edge crack with high severity (Kelebe Road)

Plate 2 Showing the presence of edge crack defect with high frequency therebyleading to the collapse of the drain wall. (Kelebe Road).

Plate 3 Showing the growth of shrubs on the pavement (Olode Road)

Plate 4 Showing pothole with medium severity (Olode road)

Plate 5 Showing the presence of edge crack defect and the absence of line drain (Elder Akande road).

Plate 6 Showing a good section of a pavement with adequate drainage facility(Jamodo - Central Mosque road).

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