

Assessment of Factors that Necessitating the Preference in the Use of Reinforced Concrete Pavement to Asphalt Pavement on Road Construction in Ebonyi State, Nigeria

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Abstract

Design and construction standards for streets and roadways should provide for pavements with both long service life and low maintenance. As a guide in achieving this goal, thus, this research work title "Assessment of factors necessitating the preference in the use of reinforced concrete pavement to asphalt pavement on road construction in Ebonyi State, Nigeria". The largest advantage for using rigid pavement is its durability and ability to hold its shape against traffic and difficult environmental conditions. This study therefore aims to bridge the current knowledge gap by assessing the factors that necessitates the preference in the use of reinforced concrete pavement to asphalt pavement of road construction in Ebonyi State among the already established factors identified based on literature review. The study utilized a census method of the 57 reinforced concrete pavements road networks of 17 Local government of Ebonyi state and use of questionnaire to collect data from 100 respondents among clients, consultants' quantity surveyors, contractors, civil engineers and residents project engineers of Ebonyi state ministry of works and housing. To test validity, the instruments were forwarded to the supervisors at works department of Ebonyi state ministry of works and housing for validation. The appropriate modification based on the experts' advice was made on the pre-tested instruments in reorder capture the relevant information related to the study objectives. To subject its results to a statistical test, a null hypothesis 'H₀: There is no factors that necessitating the preference in the use of reinforced concrete pavement to asphalt pavement on road construction in Ebonyi State, Nigeria' was postulated. The statistical analysis adopted was correlation. Reliability test was carried out through a pilot test and computation of Cronbach's Alpha at 0.7. Data analysis was through descriptive and inferential techniques. Analysis of data was obtained effectively using the Statistical Package for Social Sciences (SPSS programme version 23). Analysis method as *ranking of the factors that necessitating the preference in the use of reinforced concrete pavement to asphalt pavement in road construction in Ebonyi state* tool model were used. The research findings show that the reinforced concrete pavement appear to increase effectiveness but reduce instability, available coarse aggregate and available reinforced concrete rigid construction technology in Ebonyi state. Thus, the study recommended that; there should be total enforcement of soil, water capillary and concrete tests should be conducted before subbase formation is carried out. Moreover, apposite punitive move must be made by professional authorities once road construction project is awarded to make that specification is followed.

Keywords: Reinforced Concrete, Rigid pavement, Road Construction, Asphalt pavement, Environment.

Introduction

General Reinforce Concrete pavement design has over the years become a more important part for the promoting of concrete roads. A high investing cost has to be motivated, and the benefits of a pavement with less maintenance over a longer design life have to be proved already before construction. Efforts to avoid premature performance failing of reinforced concrete roads are, at a larger degree, considered than for other pavement alternatives since rehabilitation techniques are expensive [23]. A modern design methodology has to take into account all sorts of environmental conditions as well as future estimations on, for example traffic growth or environmental changes. The optimization of materials in the pavement system, demands for long-term fatigue resistance at the lowest cost and ecologically sound choices must be considered. The understanding of the behaviour of a concrete road is vital for the design and the performance prediction.

The current Ebonyi state reinforced concrete design method was developed in the 2015's in a trial to modernize the concrete pavement design, and create a chance for competition between road paving alternatives in the state, Roller [26]. The design methodology is used for highway pavements, industrial pavements, and public pavements, accessible in [26], [27]. It is a simple method in the way both traffic and temperature stresses are dealt with and provides a conservative design with just a limited number of calculation steps. It also simplifies both the material and loading inputs, making it restrained for possible optimization. Every simplification also comes with a safety margin that can be quantified. The development of a new design procedure consists of the quantifications of different unknown aspects that are important for the performance of a reinforced concrete pavement. The project aim at modernising the design of reinforced concrete pavements by assembling knowledge in Ebonyi state and Nigeria to create basis for a new reinforced concrete pavement design that can be integrated in the Ebonyi state Road Administration's.

A highway pavement is a structure consisting of superimposed layers of processed materials above the natural soil subgrade, whose primary function is to distribute the applied vehicle loads to the subgrade [3]. The pavement structure should be able to provide a surface of acceptable riding quality, adequate skid resistance, favourable light reflecting characteristics, and low noise pollution. The ultimate aim is to ensure that the transmitted stresses due to wheel load are sufficiently reduced, so that they will not exceed the bearing capacity of the subgrade. A highway pavement, because of its exploitation conditions, damaging factors and the technologies used in road building are the most difficult engineering constructions, both in analyses and design, even though they belong to the most simple ones for realization. Flexible pavements are most commonly used. For flexible pavements, it is very important to properly characterize the behaviour of subgrade soils and unbound aggregate layers as the foundations of the layered pavement structure [4]. Flexible pavements will transmit wheel load stresses to the lower layers through grain-to-grain transfer through the points of contact in the granular structure. The wheel load acting

on the pavement will be distributed to a wider area, and the stress decreases with the depth. Taking advantage of this stress distribution characteristic of flexible pavements normally has many layers. Hence, the design of flexible pavement uses the concept of a layered system [3]. Flexible pavements generally suffer from rutting which results from heavy traffic and severe environmental condition [5]. Flexible pavements are those having negligible flexural strength and are flexible in structural actions under loads. [14] The major flexible pavement failures are fatigue cracking, rutting, and thermal cracking. The fatigue cracking of flexible pavement is due to the horizontal tensile strain at the bottom of the asphaltic material. The failure criterion relates the allowable number of load repetitions to tensile strain and this relation can be determined in a laboratory fatigue test on asphaltic concrete specimens. Rigid pavements have sufficient flexural strength to transmit the wheel load stresses to a wider area below. Compared to flexible pavement, rigid pavements are placed either directly on the prepared subgrade or on a single layer of granular or stabilized material. Since there is only one layer of material between the concrete and the subgrade, this layer can be called base or sub-base course [3]. In rigid pavement, the load is distributed by the slab action, and the pavement behaves like an elastic plate resting on a viscous medium. Rigid pavements structure consists of a cement concrete slab, below which a granular base or sub base course may be provided [14]. Reinforced concrete pavements, often called rigid pavements, are made up of reinforcement bars, Portland cement concrete and may or may not have a base course between the pavement and subgrade. As a general rule, the concrete, exclusive of the base, is referred to as the pavement. The concrete pavement, because of its rigidity and high modulus of elasticity, tends to distribute the applied load over a relatively wide area of soil; thus, the major portion of the structural capacity is supplied by the slab itself [9].

Road is also defined as a specially designed hard surface for cars, buses, bicycles, etc to travel on. The Wikipedia [31], defined the term street, road and highway as those travelled ways on which people, animals and wheeled vehicles have moved throughout recorded history. Road transport remaining one of the strategic sectors of Nigeria's economy [17]. Actively implementing asphalt and ridged concrete roads pavements both government and business actors i.e. contractors and consultants are on course, but still encounter some obstacles in such a limited budget; lack of regulation; no government incentives for construction industry actors; expensive initial investment in technology; lack of technical specifications and implementation guidelines; lack of expertise in government, contractors and consultants; lack of understanding and willingness; no request; lack of tools that use in evaluating adaptability reinforced concrete pavements of road construction and at the beginning of the project, when the scope and definition are in the early stages of development, no or little information is available, yet there is often a need for evaluating probable cost effectiveness of the projects.

Aim

The aim of the study is to appraise the factors that necessitates the preference of use of reinforced concrete pavement to asphaltic pavement of road construction in Ebonyi State, Nigeria.

Objective of the Study

To establish the factors that necessitates the preference of use of reinforced concrete pavement than asphalt pavement on road construction in Ebonyi state, Nigeria.

Research Question

What are the factors that necessitates the use of reinforced concrete pavement mostly than asphalt pavement road construction in Ebonyi state?

Research Hypothesis

The following hypothesis is postulated for this study;

Hypothesis₁. H_0 ; There is no factors to considering selecting reinforced concrete pavement to asphalt pavement in roads construction in Ebonyi state.

Review of Literatures

Concrete roads were probably first constructed in the USA in the beginning of the twentieth century, and spread to Europe in the twenties, Williams [12]. In Sweden three main concrete pavement epochs can be distinguished; in the twenties, the fifties, and the seventies with the construction of plain, unjointed concrete pavements. These roads were constructed in the south of Sweden, and apart from the highway E6 in Vellinge from 1978, only parts of evidence of these roads remains. In the nineties, on the other hand, a new effort to develop concrete pavements as an alternative to asphalt roads took place. A new design method was developed by Emeka, [13], and the construction of four new highways was undertaken during a ten year period; a short part of a highway connecting E4 and the international airport at Arlanda in 1990, E6 Heberg – Långås at Falkenberg in 1993, E6 Fastarp – Heberg at Falkenberg in 1996, and E20 Eskilstuna – Arphus in 1999. The latest contribution is E4 Uppsala – Mehedeby, completed in 2006. Today, the total length of concrete roads in Sweden is 87 km. The concrete roads constitute less than 1 ‰, and are extremely underrepresented in comparison to the USA and several countries in Europe. For example, Germany has 28 % of its road network consisting of concrete pavements, that is almost as much as the total length of the primary road network in Sweden, European Commission (1999).

Type of road: There are generally 2 types of pavements

- Flexible pavement (Asphalt pavement).
- Rigid Pavement (Concrete road).

Design of the road: The design of the road depends on the strata underneath the road and the traffic load (usually calculated in Million Standard axles (MSA)). The type of strata is determined by CBR value of the soil underneath. This will give you the thickness of various layers like Subgrade, Sub-base, Base Course, Asphalt Base, Binder / cement and Surface courses [6].

In a typical rigid pavement, the layers above asphalt course will be replaced by a concrete pavement.

Type of layers used: Road base course can be achieved by using WBM, which is a mixture of Murray and 40 mm aggregate, WMM (Wet Mix Macadam), which is prepared by adding aggregates of various sizes like dust, 6mm, 12mm, 20mm and 40mm aggregate. WMM is typically designed mix and requires a proper mixing plant to achieve the designed mix ratios. Similarly, you can use DBM (dense bituminous macadam) or alternatively use premix carpet. So, these layers are to be determined based on the bearing capacity of the native soil/earth, before arriving at the cost [29].

Road Construction Variables

From the literature review and priced bill of quantity, a number of variables provide explanations for the variations of pavement cost performance. These include the following "primary" factors:

- Pavement type
- Highway class or route type
- Usage (cumulative traffic loading, or age)
- Environmental region
- Types and levels of annual maintenance

Other "secondary" factors are as follows:

- Subgrade quality
- Subsurface drainage
- Pavement thickness
- Design and construction features
- Topography and nature of surface geology
- Climatic features (freeze-thaw cycles, precipitation, freeze index, etc).

The latter group of factors is described as secondary because in the absence of data on such factors, they may be represented by surrogate variables included "primary" factors. For instance, highway 180 class or route type may be considered a surrogate dummy variable for subgrade quality and design and construction features, because design and construction standards and specification typically vary by route type. To some extent, highway class may also be used as a surrogate for pavement thickness and subsurface drainage as Interstate pavements are generally associated with presence of subsurface drains [4] and greater thicknesses. Also, a dummy factor indicating environmental region could be used to

represent topography, nature of the surficial geology and climate, especially in the case of Indiana where such features vary considerably by region [4].

The major dependent variables identified above fall under two categories: "dynamic" (time-dependent) factors whose values change with as the pavement increases in age, such as accumulated values of loading, weather effects, and maintenance; and "static" (time-independent) factors that generally remain fairly constant with the passage of time, such as subgrade strength, pavement type, and functional class. Under each category, are two sub-categories: stress factors, which contribute to pavement deterioration and strength factors, which militate against pavement deterioration. "Accumulated" time-dependent factors may refer to cumulative value of the factors, or the total "moment" of such factors [4].

Types of Concrete Pavements

Table 1: Design Output for Asphalt Pavement with Granular Base [15]

Subgrade CBR (%)	300mm Subbase Thickness		600mm subbase Thickness	
	Chart No.	Base Thickness (mm)	Chart No.	Base Thickness (mm)
1	6	No practical solution	11	No practical solution
2	7	No practical solution	12	Not required
5	8	No practical solution	13	Not required
10	9	500	14	Not required
30	10	Not required	15	Not required

Source: Literature review

The results obtained for the design method and pavements using different CBR values are discussed to reveal the changes in material specification, construction technology and corresponding maintenance requirements due to component layers sensitivity of performance of heavy load pavement. Charts employed in design of the component layers for the two pavements under consideration. The design results show that asphalt pavement on granular base with subgrade CBR values of 1%, 3 % and 5% and subbase thickness of 300mm and also with CBR value of 1% and subbase thickness of 600mm did not produce any thickness of base course. This is because asphalt surfacing on such soils and thicknesses are not practical solutions. Asphalt pavement placed on soils of 30% CBR and 300mm thick subbase and of 3% 5% 10% and 30% and 600mm thick subbase will not require the provision of a base course (see Table 1).

Table 2: Design Output for Rigid Concrete Pavement

Subgrade CBR (%)	300mm Subbase Thickness		600mm subbase Thickness	
	Chart No.	Base Thickness (mm)	Chart No.	Base Thickness (mm)
1	36	325	41	290
2	37	300	42	280

5	38	275	43	270
10	39	250	44	240
30	40	100	45	0

Source: Literature review

The results also show that it will not be practically wise to construct a concrete pavement on all five subgrade CBR values and 300mm thick subbase as well as soils with CBR values 1% 3% and 5% and 600 mm thick. In the case of rigid concrete pavement, with subbase thicknesses of 300mm and 600mm and for all CBR values (Tables 2).

Table 3: Design Output for Reinforced Concrete Pavement

Asphalt pavement with Granular Base		
CBR = (%)	Base thickness(m) for 300 mm subbase	Base thickness(m) for 600 mm subbase
1		
3	-	-
5	-	-
10	0.500	-
30	-	-
Reinforced Concrete Pavement		
CBR (%)	Base thickness(m) for 300 mm subbase	Base thickness(m) for 600 mm subbase
1	0.245	0.205
3	0.205	0.200
5	0.200	0.190
10	0.175	0.110
30	0	0

Source: Literature review

Table 3 shows that reinforced concrete pavement is an improvement over the rigid concrete pavement as the resulting base thicknesses.

Table 4: Design Results by Analysis Technique

Pavement Type	Base thickness(m) for 300 mm subbase	Base thickness(m) for 600 mm subbase
CBR = 1%		
Asphalt (Granular Base)	-	-

Reinforced Concrete	0.245	0.205
CBR = 3%		
Asphalt (Granular Base)	-	-
Reinforced Concrete	0.205	0.200
CBR = 5%		
Asphalt (Granular Base)	-	-
Reinforced concrete	0.200	0.190
CBR = 10%		
Asphalt (Granular Base)	0.500	-
Reinforced concrete	0.175	0.110
CBR = 30%		
Asphalt (Granular Base)	-	-
Reinforced concrete	0	0

Source: Literature review

Tables 4 presented show clearly that all pavements, the base course thicknesses decrease with increase in subgrade CBR values, thickness. The traditional approach adopted for the design in this paper involves selecting a container handling equipment (in this case a straddle carrier) according to operational requirements, then design a pavement system to withstand the damage afflicted by the selected equipment. The choice will be a compromise between the technicality and economy of the design method. The most important thing is to be aware of the available choices of the relevant factors and adopt them appropriately.

Perpetual Pavement (PP) Design Concept

The PP concept was derived from a mechanistic principle that thickly designed HMA pavements with the appropriate material combinations, if properly constructed, will structurally outlive traditional design lives while simultaneously sustaining high traffic volumes/loads. The PP design philosophy is such that the pavement structure must[12]:

- Have enough structural strength to resist structural distresses such as bottom-up fatigue cracking and permanent deformation (rutting).
- Be durable enough to resist damage due to traffic forces (abrasion) and environmental effects (e.g., moisture damage).

The PP mechanistic design principle consists of providing enough total pavement thickness and flexibility in the lowest HMA layer to avoid bottom-up fatigue cracking and enough stiffness in the upper pavement layers to prevent rutting. The principal approach to PP design focuses on pavement response related to both distresses (fatigue cracking and rutting), and the following limiting strain criteria are used as mechanistic benchmarks:

- Tensile strain at the bottom of composite HMA layer: < 70 micro-strains (for limiting bottom-up fatigue cracking).

- Compressive strain at the top of subgrade: < 200 micro-strains (for limiting full-depth rutting).

Also, special attention is required in designing a durable foundation to provide long-term support to the pavement structure/traffic loading and to reduce seasonal support variation due to environmental effects (e.g., freeze-thaw and moisture changes) [1].

Factors affecting pavement design

There are many factors that affect pavement design which can be classified into four categories as traffic and loading, structural models, material characterization, environment.

Traffic and loading; Traffic is the most important factor in the pavement design. The key factors include contact pressure, wheel load, axle configuration, moving loads, load, and load repetitions [18].

Contact pressure

The tyre pressure is an important factor, as it determines the contact area and the contact pressure between the wheel and the pavement surface. Even though the shape of the contact area is elliptical, for sake of simplicity in analysis, a circular area is often considered.

Wheel load: The next important factor is the wheel load which determines the depth of the pavement required to ensure that the subgrade soil is not failed. Wheel configuration affect the stress distribution and deflection within a pavement. Many commercial vehicles have dual rear wheels which ensure that the contact pressure is within the limits. The normal practice is to convert dual wheel into an equivalent single wheel load so that the analysis is made simpler.

Axle configuration: The load carrying capacity of the commercial vehicle is further enhanced by the introduction of multiple axles.

Moving loads: The damage to the pavement is much higher if the vehicle is moving at creep speed. Many studies show that when the speed is increased from 2 km/hr to 24 km/hr, the stresses and deflection reduced by 40 per cent.

Repetition of Loads: The influence of traffic on pavement not only depend on the magnitude of the wheel load, but also on the frequency of the load applications. Each load application causes some deformation and the total deformation is the summation of all these. Although the pavement deformation due to single axle load is very small, the cumulative effect of number of load repetition is significant. Therefore, modern design is based on total number of standard axle load (usually 80 kN single axle)[27].

Structural models: The structural models are various analysis approaches to determine the pavement responses (stresses, strains, and deflections) at various locations in a pavement due to the application of wheel load. The most common structural models are layered elastic model and visco-elastic models.

Layered elastic model: A layered elastic model can compute stresses, strains, and deflections at any point in a pavement structure resulting from the application of a surface load. Layered elastic models assume that each pavement structural layer is homogeneous, isotropic, and linearly elastic. In other words, the material properties are same at every point in a given layer and the layer will rebound to its original form once the load is removed. The layered elastic approach works with relatively simple mathematical models that relates stress, strain, and deformation with wheel loading and material properties like modulus of elasticity and poissons ratio [2].

Material characterization

The following material properties are important for both flexible and rigid pavements.

- When pavements are considered as linear elastic, the elastic moduli and poisson ratio of subgrade and each component layer must be specified.
- If the elastic modulus of a material varies with the time of loading, then the resilient modulus, which is elastic modulus under repeated loads, must be selected in accordance with a load duration corresponding to the vehicle speed.
- When a material is considered non-linear elastic, the constitutive equation relating the resilient modulus to the state of the stress must be provided.

However, many of these material properties are used in visco-elastic models which are very complex and in the development stage. This book covers the layered elastic model which require the modulus of elasticity and poisson ratio only [27].

Environmental factors

Environmental factors affect the performance of the pavement materials and cause various damages. Environmental factors that affect pavement are of two types, temperature and precipitation and they are discussed below [4][11]:

Temperature: The effect of temperature on asphalt pavements is different from that of concrete pavements. Temperature affects the resilient modulus of asphalt layers, while it induces curling of concrete slab. In rigid pavements, due to difference in temperatures of top and bottom of slab, temperature stresses or frictional stresses are developed. While in flexible pavement, dynamic modulus of asphaltic concrete varies with temperature. Frost heave causes differential settlements and pavement roughness. Most detrimental effect of frost penetration occurs during the spring break up period when the ice melts and subgrade is a saturated condition [2].

Precipitation: The precipitation from rain and snow affects the quantity of surface water infiltrating into the subgrade and the depth of ground water table. Poor drainage may bring lack of shear strength, pumping, loss of support, etc. <https://www.nbmcw.com/register-nbmcw.html> Several factors affecting pavement design were discussed, the most important being wheel load. Since pavements are designed to take moving loads, slow moving loads and static loads can be detrimental to the pavement. Temperature also

influences pavement design especially the frost action which is very important in cold countries.

Problematic Factors that least affect the pavement are as follows;

- Speed of vehicles
- Wheel load
- Axle configuration
- Load repetition

Standard axle load is

- 140kN
- 60kN
- 80kN
- 10kN

Solution to factors that least affect the pavement is

- Speed of vehicles
- Wheel load
- Axle configuration
- Load repetition

Standard axle load is

- 40kN
- 60kN
- 80kN
- 10kN

Factors Affecting Stability of Road Pavements: The thickness of pavements depends on a number of variables, but from experience it has been found that the following factors affect the performance of pavements to a great extent [11][4].

- Traffic Factors
- Soil Factors
- Environmental Factors
- Stress Distribution Factors



Source: Literature review

Traffic Factor: Traffic is the most important factor in the pavement design. The key factors include contact pressure, wheel load, axle configuration, moving loads, load, and load repetitions.

Contact pressure: The tire pressure is an important factor, as it determines the contact area and the contact pressure between the wheel and the pavement surface. Even though the shape of the contact area is elliptical, for sake of simplicity in analysis, a circular area is often considered.

Wheel load: The next important factor is the wheel load which determines the depth of the pavement required to ensure that the sub grade soil is not failed. Wheel configurations affect the stress distribution and deflection within a pavement. Many commercial vehicles have dual rear wheels which ensure that the contact pressure is within the limits. The normal practice is to convert dual wheel into an equivalent single wheel load so that the analysis is made simpler.

Axle configuration: The load carrying capacity of the commercial vehicle is further enhanced by the introduction of multiple axles.

Moving loads: The damage to the pavement is much higher if the vehicle is moving at creep speed. Many studies show that when the speed is increased from 2 km/hr to 24 km/hr, the stresses and deflection reduced by 40 per cent.

Soil Factors: Soil under the pavement foundation is seldom homogeneous. Large variations may occur in its properties. To predict the behavior of the soil under different conditions, it is essential to carry out certain tests. The soil strength varies with type of the soil, bulk density, moisture content, permeability, internal structure of the soil etc. It also depends upon the method of application of load on the soil. We know that the soil strength increases with increased density and decreasing moisture content. As the elastic properties of soil are very low, in the design of flexible pavement, the supporting power of sub grade is very important factor. To evaluate the supporting power of the sub grade, comprehensive and tensile strength are not of much important. To determine the supporting power of sub grade generally following properties of all the soil are determined [4][2].

- Shear Strength
- Bearing Power
- Penetration Resistance of the soil

Durability and Conditions of use of Road pavements

Road pavements undergo surface and structural damage under the influence of traffic load and climatic conditions. Damages correspond to the type of pavement and materials used for it is construction, thus flexible pavement may undergo the following damages: deformation in the subgrade is transferred to the upper layers, design is based on load distributing characteristics of the component layers, flexible pavement carries low flexural strength, load is transferred by grain to grain contact surfacing cannot be laid directly on the subgrade but a sub-base is needed, no thermal stresses are induced as the pavement has the ability to contract and expand freely, expansion joints are not needed, the strength of the road is highly dependent on the strength of the subgrade, rolling of the surfacing is needed, road can be used for traffic within 24 hours, the force of friction is less, and deformation in the subgrade is not transferred to the upper layers, damaged by oils and certain chemicals On the other hand, rigid pavement undergoes the following damages: deformation in the subgrade is not transferred to subsequent layers, design is based on flexural strength or slab action, rigid pavement carries high flexural strength, no such phenomenon of grain to grain load transfer exists, have low repairing cost but completion cost is high, life span is more as compare to flexible (Low Maintenance Cost)[16], surfacing can be directly laid on the subgrade, thermal stresses are more vulnerable to be induced as the ability to contract and expand is much less in concrete, expansion joints are needed, the strength of the road is less dependent on the strength of the subgrade, rolling of the surfacing in not needed, road cannot be used until 14 days of curing have passed, the force of friction is high, and no damage by oils and greases. The designing of new road pavements and the strengthening the ones already existing in Poland has got a special meaning, especially recently when our road networks were included in the trans-European system. In this situation it became necessary to adjust the basic road network to load standards in the European Union in trans-border traffic where the load allowed for a vehicle

axle is 11,5 tons (until now the axial load allowed in Poland was 10,0 tons). This change of the axial load causes the change of its influence on pavement structure mainly due to the fatigue of structure construction. A greater load causes higher stress and strain deformation at the bottom of the structure, for both the asphalt one and the concrete one. An increase in vehicle axial load is even more harmful for the concrete structure [1]. An increase of the load becomes a reason for pavement damage [2, 3, 5, 6]. The costs of additional damages are considerable and are increasing along with lowering the road quality: - a vehicle with a single axial load of 11,5 tons on a road where the allowable load is 10,0 tons / axle, will cause a damage amounting to 1,33 zł/km, - the same vehicle, with a single axial load of 11,5 tons, on a provincial road where the allowed load is 8,0 kN/axle will cause damage amounting to 12 zł/km, - however, a vehicle with a single axial load of 11,5 ton district or community roads will cause a damage of 40 zł/km. Next to being influenced by traffic, the road pavement is also influenced by environmental factors that include water, glazed frost, acid rains and temperature. Temperature amplitude in the exploitation of pavement is extremely important, especially for asphalt structures made of mineral – asphalt mixtures which are thermoplastic materials and change properties depending on the temperature. In higher temperatures they may have permanent deformations and in low temperature they can crack. That is why the appropriate choice of material is so important. In Poland, in continental climate conditions, the environmental requirements are very difficult to achieve due to the high air temperature amplitudes from + 30 C in the summer to – 20 C in the winter. Thus, pavement temperatures may be from + 60 C to – 30 C. Such a broad range of temperatures requires special care while choosing materials, especially asphalt binders. Requirements for road pavements consider both technical – usage and environmental aspects. Technical-usage aspects include: - mechanical features: resistance to deformation, resistance to cracking, load carrying capacity. - comfort and user safety: evenness, roughness. Environmental requirements concern the whole life cycle of the pavement: - from the stage of construction; pavements should be made in a way and of materials which do not threaten the environment, - phases of exploitation of the structure should contribute to lowering the arduousness of truck transportation for the road users and for the surrounding environment, - after exploitation: materials used in road building should be recycled and, when used again they cannot change into scrap arduous to the environment. The necessity of meeting all these diversified, sometimes even opposing requirements (resistance to deformation and resistance to low temperature cracking) resulted in the generalization of the notion of the functional division of pavement layers and a belief in the necessity of using different binders and mixtures for individual pavement layers.

Literature Knowledge Gap

From the observations made by different researchers about the subject area, [13]. [23] noted that building of asphalt and reinforced pavements in roads construction in Ebonyi state Nigeria is very expensive, but reinforced concrete pavement is more costlier and last

longer compared to asphalt pavement alternative. [20] also noted that road projects in Nigeria habitually suffer cost overruns, delayed completion etc, does not just influence project cost and quality, cost effectiveness [20][23], but also research conducted by [10] and [25] stated that road pavement type and other factors like environment, construction methods, purpose, on cost etc, does not just influence the road pavement type selection of any given project. Undoubtedly there have been studies carried out on factors that influences road pavement selection cost of reinforced concrete and asphalt pavements road construction in other states in Nigeria, but there is little or no study on this topic **"An Appraisal of the factors that necessitates the preference of use of reinforced concrete pavement to asphaltic pavement of road construction in Ebonyi State, Nigeria"**. There is need to carry out this study using Ebonyi state, which is currently using concrete pavement mostly in her road construction and being one of the states that receive the least allocation in the south east zone from the federal government, as studies in this area has not been sufficient. The researcher seeks to fill this gap in this study to help Quantity surveyors, Civil engineers, public institutions and budget planners on how environmental and other can influence pavement road construction projects type in order to be using the right pavement in future.

Durability and Rehabilitation of Road Pavements

The durability of pavements should be understood as a set of features decisive for the time of road exploitation and the costs of its maintenance [2-15]. They include; resistance to traffic load: fatigue durability, resistance to deformation (lateral and longitudinal evenness), resistance to environmental factors: resistance to cracking (low temperature - thermal fatigue), resistance to water and anti-freezing agents. Control over fatigue durability is exercised by the construction of road pavement, the thickness and the quality of layers, i.e. the mechanical properties of materials. The strategy for maintaining the correct structure conditions for a given type of pavement construction must consider maintenance treatments carried out with the right frequency so that they prevent excessive pavement damage which may be responsible for lowering its structural durability. Rigid pavements are built with Portland Cement Concrete (PCC). These pavements have a relatively higher capacity to withstand vehicular and environmental loads. A rigid pavement may be one of two types of PCC pavements: a Jointed Concrete Pavement (JCP) or a Continuously Reinforced Concrete Pavement (CRCP).

A JCP relies on regularly spaced joints to control cracking in the concrete. A CRCP has no transverse joints except at the beginning and end of the pavement and at interrupting structures like bridges. CRCPs use longitudinal steel reinforcement rather than transverse joints to control cracking. Transverse construction joints do occur at the end of each day's construction. However, in CRCP, the longitudinal reinforcing is continuous at these construction joints. A rigid pavement will undergo deformation due to the loading imposed on it from the axles of vehicular traffic. The weight on each axle and the frequency of passes

affect the life span of the pavement. The loading from environmental factors, such as temperature change or excessive moisture increase in the base and sub base, can also put a pavement at risk. Deformation in a rigid pavement also occurs because of shrinkage in concrete during hardening and drying. The volumetric change in concrete is restrained by friction between concrete and the base material resulting in increased stress in the pavement's surface course. The stress increase can lead rigid concrete to crack. If uncontrolled, cracking greatly limits the life of rigid pavements.

A Framework for Pavement Type Selection

(1) Decision-making approaches:

Ranking techniques evaluate several related factors of a project simultaneously and yield a quantitative ranking value based on the evaluation of these factors. While ranking methods don't necessarily provide an optimal solution, a ranking approach is nevertheless simple to use and provides the relative order of importance of different alternatives [24][21].

(2) forecasting traffic, (3) assigning future maintenance and rehabilitation treatments, and (4) performing.

Fundamental Factors for Pavement Type Selection

1) Performance

Pavement performance is a key concern from both the agency and road user perspectives. Carey and Irick (Carey 60) established that pavement serviceability must be defined relative to the basic purpose of pavements, i.e., to provide a smooth, comfortable, and safe ride. Based on this definition, the present serviceability index (PSI) measure was developed and used at the American Association of State Highway Officials (AASHO) Road Test. Based on objective measurements of pavement surface roughness and distresses, PSI predicts pavement serviceability ratings (PSR) and public perception of ride quality. PSI ranges from 0 to 5, with 5 representing the highest level of serviceability. The area under the performance curve represents the accumulated service or performance. Within the Texas Department of Transportation (TxDOT), both flexible and rigid pavement design procedures derive primarily from the PSI-based performance concept. Figure 2.1 illustrates a typical pavement design strategy and associated performance levels and costs for a life cycle of 30 years. The framework outlines three phases of a typical decision-making process [1]:

- Input data: Type selection methodology is based on evaluating user-specified alternative strategies. Economic evaluation requires data pertaining to:

(1) project size and location, and

(2) the strategies' materials quantities and performance.

- Mathematical models Transportation therefore, has an important role to play not only in serving the productive sectors such as agriculture and industries but also in bringing about economic growth. Although there exists other means of transportation in Nigeria, road

transport has become the dominant means of transportation in Nigeria due to its large coverage and ability to provide a door-to-door service with an estimated percentage of 95% of the national passenger and freight services and provide the only access to most rural communities where majority of the economically active population lives [16]. Road construction in Nigeria received a major boost in the 1970's during the 'oil boom' era and had since then become a major component of annual capital budgets at both the states and national levels [16]. The national road network grew from its total length of 6,500 KM in 1960 to 10,000 KM in 1970 to 29, 000 KM in 1980 and it is presently estimated at over 37,000 km Federal road network and 1,671 bridges with a total length of 177km [13].

Reinforced Concrete (Rigid)Pavement

Rigid Pavements

Rigid pavements are named so because of the high flexural rigidity of the concrete slab and hence the pavement structure deflects very little under loading due to the high modulus of elasticity of their surface course. The concrete slab is capable of distributing the traffic load into a large area with small depth which minimizes the need for a number of layers to help reduce the stress. The most common type of rigid pavement consists of dowel bars and tie bars. Dowel bars are short steel bars that provide a mechanical connection between slabs without restricting horizontal joint movement. Tie bars on the other hand, are either deformed steel bars or connectors used to hold the faces of abutting slabs in contact. Although they may provide some minimal amount of load transfer, they are not designed to act as load transfer devices and are simply used to 'tie' the two concrete slabs together capacity of the subgrade soil. Consequently, the thicknesses of the layers above the subgrade vary depending upon strength of soil affecting the cost of a pavement to be constructed[7][8].

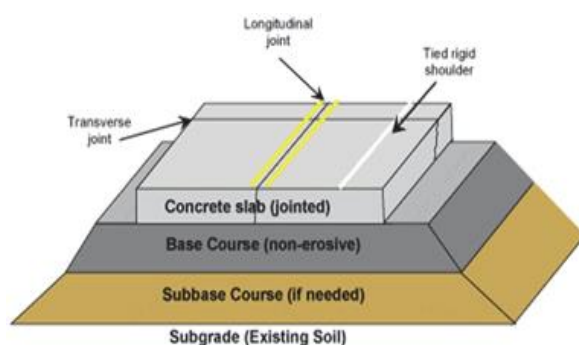


Fig. 1: Rigid(Reinforced concrete Pavement)

Source: www.theconstructor.org

Table 5: Rigid(Reinforced concrete pavement)

1	It consists of one layer Portland cement concrete slab or relatively high flexural strength.
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2	It is able to bridge over localized failures and area of inadequate support.
3	Its structural strength is provided by the pavement slab itself by its beam action.
4	Flexural strength of concrete is a major factor for design.
5	It distributes load over a wide area of subgrade because of its rigidity and high modulus of elasticity.
6	Temperature changes induce heavy stresses in rigid pavements.
7	Any excessive deformations occurring due to heavier wheel loads are not recoverable, i.e. settlements are permanent.

Source: www.theconstructor.org

Rigid Pavement Design Rigid pavements are analyzed using the plate theory. These pavements have a structure composed of hydraulic cement concrete surface course with an underlying base and sometimes a sub-base course. The surface layer is the stiffest of all the layers. This layer is a concrete slab that provides the majority of the strength to the pavement. In order to reduce thermal stresses or eliminate joints and maintain tight crack widths, these types of pavements commonly use reinforcing steel. The following are types of rigid pavements: continuously reinforced concrete pavement (CRCP), concrete pavement contraction design (CPCD) or jointed concrete pavement, jointed reinforced concrete pavement (JRCP), post-tensioned concrete pavements, and composite pavement [1].

In practice, while several pavement types are often technically feasible for a given roadway project, one is often selected over the others based on decisions that involve no systematic evaluation. Pavement type evaluations should be based on a consideration of all pavement strategies, including initial as well as future activities undertaken throughout the life cycle of strategies. A range of pavement materials, such as asphalt concrete, Portland cement concrete (PCC), chemically stabilized materials (lime- and cement-treated layers), and granular materials, can be used to build pavements. Several feasible structural sections for flexible and rigid pavement types can be developed for different combinations of layer materials, material properties, and performance periods for a particular set of project design data (e.g., traffic, soil condition, and climatic data). At times, these factors become critical as a result of prevailing project conditions. The American Association of State Highway and Transportation Officials' Guide [1][4] outlines several principal and secondary factors that affect pavement type selection. The guide recommends that pavement type selection be facilitated by economic comparison of alternative structural designs for pavement types designed through theoretical or empirically derived methods.

Pavement Type Selection Factors

A highway system designation shall not determine the choice of pavement type. The following factors should be considered when choosing a pavement type:

Economics – Pavement type determination can be influenced by the results of an Engineering Economic analysis (e.g., a Life-Cycle Cost Analysis) on the cost of construction and future maintenance [[28][29].

Alternate Bidding – Pavement type may be determined through Alternate Bidding.

Performance of Similar Pavement in the Area – Knowing how a particular design type performed in the past is a valuable guide in predicting future performance. However, there must be a good correlation between conditions and service requirements of the reference pavements and the designs under study. Caution is urged against relying on performance records of reference pavements subjected to much lighter loadings for a large portion of their service life. Caution is also urged when considering the performance of pavements containing materials and/or design features that are no longer commonly used or expected to be used. Reference pavements should be re-analyzed periodically.

Adjacent Existing Pavements – The choice of pavement type may be influenced by the pavement types of adjacent sections that have similar conditions to the project and that have provided adequate long-term service.

Difference between Flexible Pavements and Rigid Pavements:

	Flexible Pavement	Rigid Pavement
1.	It consists of a series of layers with the highest quality materials at or near the surface of pavement.	It consists of one layer Portland cement concrete slab or relatively high flexural strength.
2.	It reflects the deformations of subgrade and subsequent layers on the surface.	It is able to bridge over localized failures and area of inadequate support.
3.	Its stability depends upon the aggregate interlock, particle friction and cohesion.	Its structural strength is provided by the pavement slab itself by its beam action.
4.	Pavement design is greatly influenced by the subgrade strength.	Flexural strength of concrete is a major factor for design.
5.	It functions by a way of load distribution through the component layers	It distributes load over a wide area of subgrade because of its rigidity and high modulus of elasticity.
6.	Temperature variations due to change in atmospheric conditions do not produce stresses in flexible pavements.	Temperature changes induce heavy stresses in rigid pavements.
7.	Flexible pavements have self healing properties due to heavier wheel loads are recoverable due to some extent.	Any excessive deformations occurring due to heavier wheel loads are not recoverable, i.e. settlements are permanent

They are two types of costs that are affected by Roads with respect money, the first is constructing cost and the second is maintaining cost.

Methodology

This study adopted survey descriptive research design where both quantitative and qualitative data was collected. This design enabled the researcher to fully establish the factors that necessitate the use of reinforced concrete pavement in road construction in Ebonyi state. The target population for this study was civil engineers, road contractors, construction professionals and quantity surveyors in Ebonyi state. The study utilized a

census method of the 57 reinforced concrete pavements road networks of 17 Local government of Ebonyi state and use of questionnaire to collect data from 100 respondents among clients, consultants' quantity surveyors, contractors, civil engineers and residents project engineers of Ebonyi state ministry of works and housing. To test validity, the instruments were forwarded to the supervisors at works department of Ebonyi state ministry of works and housing for validation. The appropriate use of However, the above research is only at the theoretical stage at this stage, and the practicality is not too strong. The extension and expansion of the Internet of Things based on the Internet are a large network formed by combining various information sensing devices on the network. The appropriate modification based on the experts' advice was made on the pre-tested instruments in reorder capture the relevant information related to the study objectives. Reliability test was carried out through a pilot test and computation of Cronbach's Alpha at 0.7. Data analysis was through descriptive and inferential techniques. Analysis of data was obtained effectively using the Statistical Package for Social Sciences (SPSS) programme version 23.

Results and Discussion

Analyses of the Objective

To establish the factor that necessitates the use of reinforced concrete pavement mostly to asphalt pavement road construction in Ebonyi state.

Table 1: Twelve highest Ranking factors that necessitate the use of concrete pavement mostly that asphalt pavement road construction in Ebonyi state.

S/N		W	VI-----LI					ΣFX		RANK
			5	4	3	2	1			
1	Environmental conditions	F	25	5	3	2	1	35		1 ST
		WF	125	20	9	4	1	159	4.54	
2	Drainage	F	23	5	7	-	-	35		2 nd
		WF	115	20	21	0	0	156	4.45	
3	Mixture composition	F	22	4	5	4	-	35		3 rd
		WF	110	20	15	8	0	153	4.37	
4	Construction method	F	21	5	3	4	2	35		4 th
		WF	105	20	9	8	2	144	4.11	
5	Moisture	F	20	4	3	3	5	35		5 th
		WF	100	16	9	6	5	136	3.88	
6	Weather Condition	F	19	3	5	4	4	35		6 th
		WF	95	12	15	8	4	134	3.82	
7	Surface subsurface	F	19	2	3	2	9	35		7 th
		WF	95	8	9	4	9	125	3.57	

8	Binder Properties	F	18	3	2	2	10	35		8 th
		WF	90	12	6	4	10	122	3.48	
9	Segregation	F	17	3	2	2	11	35		9 th
		WF	85	12	6	4	11	118	3.37	
10	Compaction	F	15	4	4	2	10	35		10 th
		WF	75	16	12	4	10	117	3.34	
11	Gradations	F	14	4	4	2	11	35		11 th
		WF	70	16	12	4	11	113	3.22	
12	Volumetric Properties	F	13	4	4	2	12	35		12 th
		WF	65	16	12	4	12	109	3.11	
	Grand Mean								3.77	

SOURCE: Researchers field survey, October, 2022

The table of ranking values above which indicates the highest-ranking factors that necessitates the use of reinforced concrete pavement and asphalt pavement mostly in road construction in Ebonyi state. The result indicates that environment has the highest mean value of 4.54 which takes the first ranking, strictly followed by drainage with a mean value of 4.45, followed by mixture composition with a mean value of 4.37, followed by construction with a mean value of 4.11, followed by moisture with a mean value of 3.88, weather condition, surface substance, binder properties, segregation, compaction, gradation and volumetric properties with a mean value of 3.82, 3.57, 3.48, 3.37, 3.34, 3.22 and 3.11 respectively and a grand mean of 3.77 indicating that the above identified factors are ranked accordingly.

Graph showing the ranking of the factors that necessitate the use of reinforced concrete pavement mostly in road construction in Ebonyi state.

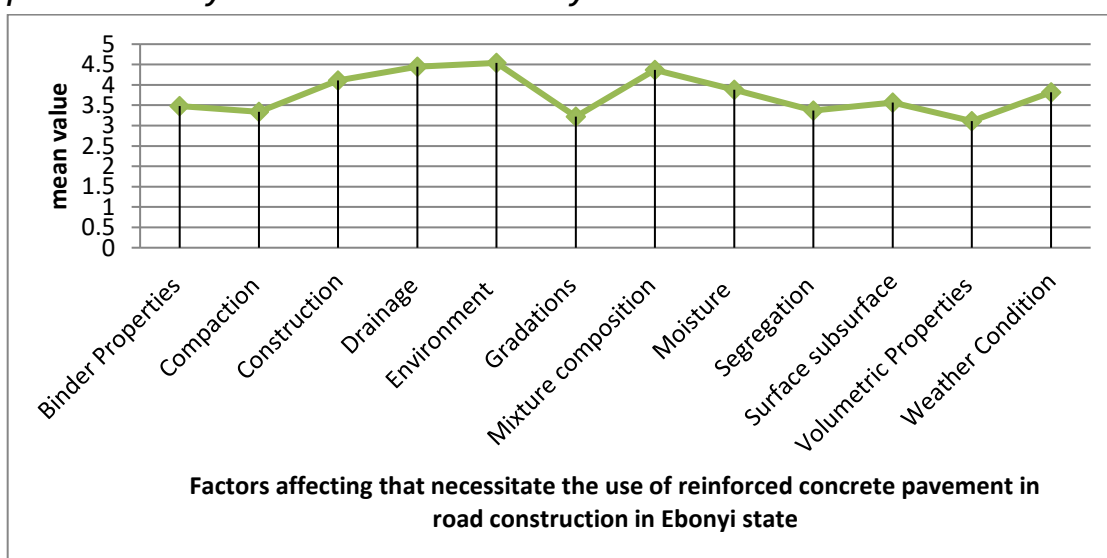


Fig.1 chart showing the ranking of the identified factors that necessitates the use of reinforced concrete pavement mostly asphalt pavement in road construction in Ebonyi state.

From the chart, environment has the longest bar, followed by drainage, mixture composition, construction, moisture, weather condition, surface substance, binder properties, segregation, compaction, gradation and volumetric properties respectively. This is a confirmation of the ranking value in table 1.

Findings

The study identifies several factors that necessitate the use of reinforced concrete and asphalt pavement in road construction in Ebonyi state such as the environmental factor, drainage system, mixture composition, moisture, weather condition, surface subsurface, binder properties, segregation, compaction, gradation and volumetric properties. These identified factors are ranked according to their level of impact.

Table 2 Environmental conditions are one of the factors that necessitate the use of reinforced concrete pavement mostly in road construction in Ebonyi state.

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid strongly agree	65	65.0	65.0	65.0
Agree	30	30.0	30.0	95.0
Disagree	3	3.0	3.0	98.0
strongly disagree	2	2.0	2.0	100.0
Total	100	100.00	100.0	

Source: Field survey, October, 2022.

Table 2 show the responses of respondents to the environmental conditions as one of the factors the use of reinforced concrete pavement in road construction in Ebonyi state.

65 of the respondents representing 65.0percent strongly agree that environmental conditions are one of the factors the use of reinforced concrete pavement in road construction in Ebonyi state.

30 of the respondents representing 30.0percent agree that to the environmental conditions as one of the factors the use of reinforced concrete pavement in road construction in Ebonyi state.

3 respondents representing 3.0percent were undecided. 3 of the respondents representing 3.0percent disagree that environmental conditions are one of the factors the use of reinforced concrete pavement in road construction in Ebonyi state.

2 of the respondents representing 2.0percent strongly disagree that environmental conditions as one of the factors the use of reinforced concrete pavement in road construction in Ebonyi state.

Test Hypothesis

H_0 ; There is no factors to consider in selecting reinforced concrete pavement to asphalt pavement in roads construction in Ebonyi state.

Level of significance: 0.05

Decision rule: reject the null hypothesis H_0 if the p value is less than the level of significance. Accept the null hypothesis if otherwise.

Table 3 Test Statistics

	There is no factors to consider in selecting reinforced concrete pavement to asphalt pavement in roads construction in Ebonyi state.
Chi-Square	105.520 ^a
Df	3
Asymp. Sig.	.000

a. 0 cells (.0%) have expected frequencies less than 5. The minimum expected cell frequency is 25.0.

Conclusions based on decision rule:

Since the p-value= 0.000 is less than the level of significance (0.05), we reject the null hypothesis and conclude that there is no factor to consider selecting reinforced concrete pavement to asphalt pavement in roads construction in Ebonyi state.

Coefficients analysis Coefficients analysis on the strength of the predictor variables on the dependent variable was undertaken. The results are presented in Table 2.

Table 4: Coefficients analysis

Model	Unstandardized Coefficients	Standardized Coefficients	t	Sig.
	β	Std. Error	Beta	
Environmental conditions	1.354	0.673	0.427	2.827 0.005

2 Environmental conditions factors were found to have a positive linearly significant influence on the use of reinforced concrete pavement in Ebonyi state ($\beta=1.354$,

$p=0.005<0.005$). Here, one unit change in environmental conditions factors results in 1.542 unit increase in the reinforce concrete pavement selection.

Discussion of Results

Reliability Analysis Scale reliability for variables was determined by computing the overall Cronbach's alpha reliability coefficient for the items of environmental conditions as one of the factors the use for selection reinforced concrete pavement in road construction in Ebonyi state. The reliability was demonstrated since the Cronbach's alpha statistic for environmental conditions as one of the factors the use of reinforced concrete pavement in road construction in Ebonyi state was 0.786, which were greater than the threshold value of 0.7 recommended by Sekaran (2009) as a cut off of reliability as indicated in Table 2.

Contribution to Knowledge

This study has added knowledge on evaluation of factors that influences the use of reinforced concrete pavement to asphalt pavement road construction in Ebonyi state to policy makers, civil engineering projects contractors and quantity surveyors.

Conclusion and Recommendations

Conclusions

Reinforced concrete is more durable pavement material. Using reinforced concrete as a pavement material will result in savings over the lifespan of the road. The maintenance appraisal for the road project gave the following results:

- Less maintenance materials and time.
- Moderate technology in its construction is required. Using the Discounted payback method,
- The result of the study further indicates that reinforced concrete have positive and significant impact on the stability and sub-base compatibility in road construction in Ebonyi state.

In view of the findings, reinforced concrete as rigid pavement can be used as an alternative pavement material since it is better in preventing swelling nature of the soil texture to asphalt pavement which is flexible in nature.

Recommendations

The following recommendations are made as deriving from the outcome of the analysis of the findings. Factors ranking analysis was conducted to compare the adaptability test of two pavements road construction over a given location. Other factors besides cost effectiveness factors that influence the use of reinforced concrete pavement road constructions were investigated. This research focused on the factors that influence selection of reinforced concrete pavement in road construction. Other research areas are

suggested, such as; time management, quality management the road sub-base, and scope management.

Based on this, a complete assessment of the factors *necessitates the use of reinforced concrete pavement mostly in road construction in Ebonyi state* was exhibited in this study. Straight from the poll review held with some construction professionals in Ebonyi state construction industry, major factors *necessitate the use of reinforced concrete pavement to asphalt in road construction in Ebonyi state* were recognized by factor analysis. Eleven main factors were highlighted from the factors created through a blend of past research and the opinions from professionals in the construction industry. From this research, the eleven factors necessitating to the use of reinforced concrete pavement in road construction in Ebonyi state are: environmental factor, drainage system, mixture composition, moisture, weather condition, surface subsurface, binder properties, segregation, compaction, gradation and volumetric properties. In spite of the fact that the investigation was carried out within the construction professional in Ebonyi state, it was indicated that the outcomes bring forth true reflection, positive hypothetical and pragmatic experience about the factors contributing to use of reinforced concrete pavement in Ebonyi state.

The result displayed in this research will provide adequate proof and helpful information in order to clear up a few misinterpretations about factors *necessitating the use of reinforced concrete pavement mostly in road construction in Ebonyi state*. Thus, the study recommended that:

- there should be total enforcement of soil, water capillary and concrete tests should be conducted before subbase formation is carried out.
- Moreover, apposite punitive move must be made by professional authorities once road construction project is awarded to make that specification is followed.
- The road subbase must be well constructed to receive the reinforced concrete pavement. This study can also be carried out among other professions in the construction industry for comparison and further study. Moreover, additionally studies may deploy more strategies in collecting reliable data from respondents. In this paper, questionnaires were used in gathering vital information from the professionals, additional use of other techniques like soil test, water capillary and cube tests will make the result more adaptable and precise. Despite the fact that this research provided helpful information in regards to factors that necessitates the use of reinforced concrete pavement to asphalt in road construction in Ebonyi state, the study is restricted by the population of the study which is limited to Ebonyi state. Further study can also be carried out in other states in Nigeria whose road project execution are similar to that of Ebonyi state.

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