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Sustainable Road Development in Nigeria: A Case for Asphalt Pavement Recycling

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Abstract: Nigeria roads are bad, during the oil boom years of the seventies, a period of unprecedented road construction was witnessed. Many of such roads, though already approaching the end of their lives were not designed to withstand today's traffic loadings and some that were for one reason or the other are failing prematurely. These roads have to be strengthened or fully reconstructed-a costly and time consuming exercise involving long delays to traffic. As traffic volumes steadily increase, the problems can only get worse, more so the dwindling economic fortunes of our country does not give room for the proper funding of the maintenance and development of our road network any longer. The possibility of recycling roads made with asphalt is a plus, most especially as it is well favoured by 'green campaigners, however, will it convince the naturally conservative highway engineers and as well be 'sellable' to the government and people of Nigeria? This study presents a relatively new concept in road reconstruction/rehabilitation, quicker and cheaper than traditional methods and according to research, capable of performing just as well. Adopting this method, might be saving the country 200 billion Naira + over the next ten years going by the road recovery programme and as well be the country's local contribution to Agenda 21 of the UN resolutions on Environment and Development as it maintains and promotes a healthy, safe and sustainable environment, while still achieving the goal of development and maintenance of engineering infrastructure.

Key words: Road development, asphat pavemevt, witnessed

INTRODUCTION

The growth and progress of any nation can be measured to a large extent by its socio-economic development and these largely depend on its road network. Thus the development and the management of roads have always been a topical issue for discussion not only in the developed countries, but also in the developing countries of the world especially in Africa. This is quite understandable, considering the fact that for decades, roads have played effective and preferred mode of transportation for movement of goods and persons. For example, in the fifties and sixties, railroad played a very significant role in the transport sector, but in early seventies, there was a big shift from the mode because of the oil boom in Nigeria[1]. The road sector, no doubt benefited most from this. Several thousands of kilometers of roads were constructed across the country, as the problem then was not how to get money, but how to spend it. The road network which at the time of independence in 1960 was about 65,704 km increased to about 96,000 km in 1972 and to the present figure of 200,000 km[1]. This rapid successive growth of road network buttresses the UN report that, 'road transport accounts for 80% of passengers and goods movement in Africa'. Then suddenly, the country's economy nose-dived and worse still, as the road network increased, the budgetary provision for their maintenance was dwindling. This was expected as the Federal Government had to cater for the other sector of the economy with its scarce revenue. As a result, the well constructed road network started experiencing severe deterioration and disintegration due to aging, overuse, premature distress, use of marginal materials or poor construction practices and the aforementioned *a fortiori* i.e., lack of proper maintenance. Candidly, the current situation of the country's road network calls for urgent and drastic action to be taken in the area of rehabilitation and maintenance, in fact a state of emergency should be declared on our roads.

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As highway costs continue to increase, pavement deterioration under today's traffic will continue to progress far faster than needed repair and rehabilitation can be funded most especially in a country such as Nigeria. In the search for cost-effective alternatives, a technique, which involves reworking of in-place surface and base materials and as well meets the provisions of sustainable development, is presented. Thus this study focuses on: Sustainable Road Development in Nigeria: A Case for Asphalt Pavement Recycling. The potential and prospects of such a method in a developing economy such as ours is looked into.

This excellent tool and technique of action for road rehabilitation, is environment friendly, economically effective and encourages waste minimization. The method as well, enhances/encourages the conservation of scarce highway materials and in essence is long overdue in a developing economy such as Nigeria. In essence, this will bring about a good road network, which really fosters the socio-economy of a nation. For example when we have good roads, higher GND and GDP are achieved, since less money is spent on the rehabilitation of such roads. In the same vein, the per capita income is improved upon since expenditure will now be relatively lower to income of the nation. By the virtue of good a road network as well, the vehicle per capita is greatly reduced, as the demands for new vehicles will be low, so far the old ones are still manageable. Good roads as well, will ensure effective distribution of economic activities. Apart from these, good roads will bring about a decrease in cost of living and thus enhance the standard of living of the populace, since people will have goods and services delivered to them at reduced cost. Good roads bring about enhanced export-import ratio, improved agriculture, enhanced health care delivery and industrial production, access to social amenities, improved communication system, reduced unemployment rate, enhanced tourism industry and the uplift of the nation's educational standard and cultural values just to mention a few, which really have been eluding us.

The challenge of sustainable road development: For sustainable road development to be possible, our human activities will have to be redesigned to reuse our raw materials and construction materials many times over. This will include salvaging construction materials such as concrete and asphalts from roads, the reuse of metals and other natural and synthetic materials. Waste recycling and reuse will have to become our way of life. Interestingly, the developed nations are catching on but the reverse is the case in developing nations such as Nigeria. One of the most interesting examples of resource recovery is the use of recycled products as construction materials. It is estimated that over 2.5Trillion Naira are spent annually on roads in developing countries, much of this on road rehabilitation[2]. The Federal Government of Nigeria presently spends about 4.44 billion Naira annually on direct labour allocation for minor road maintenance excluding rehabilitation/major maintenance and development of new roads. This is justifiable and should, in fact be reviewed upwards on the ground that Nigeria road network which was about 200,00 km in year 2000 with a value of about 1.85Trillion Naira is, indeed, one the nation's single largest asset[1]. A substantial percentage (33%) of the network is in asphalt. The most expensive element of the road pavement is the asphalt (bitumen +aggregate) which forms the surfacing and often forms the principal load bearing layers of the road.

The cost of asphalt is typically more than 3 times the cost of unbound aggregate, but when roads are rehabilitated, the asphalt is almost always removed and discarded as a waste product. To worsen the situation, in Nigeria, the disposal is done indiscriminately since environmental laws are not being fully enforced. Very large volumes of good quality aggregate and asphalt are therefore lost and new materials must be quarried/ procured to replace the discarded materials. The use of thick asphalt layers is increasing to keep pace with expanding networks and ever greater traffic loadings. Unfortunately as this several overlays are being done, the free passage of high vehicles under bridges is being threatened as the head rooms under bridges keep reducing each moment an overlay is done. Whereas asphalt pavement recycling is relatively new in Nigeria, it has been successfully practiced since the mid 20th century in the US and Europe[3]. Adopting this method of road rehabilitation in Nigeria will not only engender sustainable development, large cost savings, but will serve as Nigeria's local contribution to Agenda 21.

The traditional approach to pavement rehabilitation has been to either reconstruct it with all new material or patch and overlay it with a new wearing surface, which is expensive, time consuming, wasteful and causes considerable inconvenience to the road user. This is clearly obvious in the extension cum maintenance works done along Lagos-Ibadan expressway in recent times. Apart from these, it leads to the depletion of the natural resource base essential for future development, increased hydrocarbon pollution, the need to locate tipping sites for waste road stone and transport required to remove waste material and bring in new material can add greatly to traffic congestion, reduction of the life cycle of fair

existing pavements and safety problems. Apart from these, most of the processes involved in these conventional/traditional methods contravene the provisions of Agenda 21 of the UN resolutions during its Earth Summit meeting held on Sustainable Development in Rio de Janeiro, Brazil, in 1992.

These weak points of the traditional/conventional methods of pavement rehabilitation and the increasing construction costs inform the search for new methods of rehabilitating highway pavements. One of such methods is pavement recycling. The recycling concept is not particularly new to the highway field. Various methods, some quite successful, have been practiced in a limited manner since about 1915.

The Asphalt Institute[4] defines pavement recycling as the reworking of in-place surface and base material. In the broader sense of it, reducing the reclaimed materials to a suitable size for processing, blending the reclaimed material with virgin ones and relaying the materials as a base, binder or surface course. However, the ready availability of cheap aggregates and binders did not make these method very attractive to the highway engineer and it required the 'energy crisis' which followed the 1973, Arab Israeli conflict to re-awake interest in this rehabilitation method.

Recycling road provides a lot of benefits. The first and most obvious benefit is the saving in the amount of fresh material required. This saving is wide-reaching. Less material equals less quarrying (energy reduction as well as reduced environmental impact), equals less fuel used, equals less transport (reduced damage to road network and noise pollution), equals ... and so on. In the same vein, experience has shown that the in situ recycling process is up to 50% faster than conventional reconstruction. This brings benefits through reduced site supervision costs. Also, a reduced construction period minimizes traffic delays caused by roadwork, which contributes to the economic benefit of the process. Reusing the existing road and footway materials leads to a reduction in the waste to land fill. This produces environmental and economic benefits.

Pavement recycling is usually categorized by the procedure used, the type of materials, or the structural benefit to be gained. Of these, the procedure approach has tended to become most widely accepted and on this basis, recycling can be divided to whether it is:

- Surface recycling
- In place surface and base recycling (cold-mix recycling)
- Central plant surface and base recycling (hot-mix recycling)

However, it should be noted that pavement recycling is applicable to both flexible and rigid pavements.

Surface recycling: This is the on-site removal, reuse or the incorporation of some of the existing pavement surface into a reconstituted pavement[5]. O'Flaherty[6] stated that the method normally consists of reworking the surface of a bituminous pavement to a depth of 25 mm or less. Surface recycling is not a cure all; in fact, it is in some cases applied as a stopgap measure, as way of buying more time until such roads can be completely overhauled. In essence, it is applicable where surface distress is concentrated in the top inch of the pavement[7].

Generally, in surface recycling, five basic operations are performed: the old surface is first softened with radiant heat, the top layer of the old material is loosened with air-bag mounted scarifiers, a small amount of liquid asphalt is applied to the scarified or planned material, the loosened material is then redistributed into any depressions and it is then laid and compacted to form a thin asphalt concrete overlay as new wearing course. Surface recycling has this great advantage that the traffic can resume flow on repaired pavement in 25 min.

Well, this method i.e., surface recycling has the limitation that it is only suitable for pavements with at least 38 mmm of an asphalt mixture and that, it is only good for the correction of defects in the pavement surface only[5]. It must however be noted that surface recycling only refurbishes only the top inch of the pavement. Thus when pavement problems extend down several inches into the pavement, surface recycling in such case merely masks the problem.

Cold-mix recycling (in-place recycling): As the name dictates, this method of pavement rehabilitation is usually carried out cold and without heating the reused material. This method is normally used in order to conserve materials and energy and to improve pavement surface conditions; in addition, however it can be used to improve the load carrying capacity of the pavement[6]. The key steps involved in this type of pavement recycling are: ripper first breaks up pavement, with grid roller following to break pieces to maximum 6 in size; after the material has been windrowed, traveling pulverizer breaks up material to 1 in maximum size; material stockpiled nearby as workers repair underlying soil-firm up soft spots etc; reclaimed material next dumped in traveling mix paver where it is mixed with asphalt emulsion/recycling agent and probably the virgin aggregate; resulting cold-mix laid down by the same machine; and finally workers spray asphalt on base, spread stone chips on top; waterproofs road; provides a wearing course[8]. Apart from the fact that significant time

saving is achieved on any project of cold-mix recycling, it has the advantage that very little energy in comparison with conventional methods or with hot-mix recycling is used. Energy is saved because materials don't have to be hauled from the job site to a hot-mix recycling plant and back. But by far the biggest energy saver is that fact that, the mix doesn't have to be heated to a high temperature, a process that has traditionally used a tremendous amount of energy[8]. Cold-mix recycling has this weak point in that there is less control over the mix design. One has to work with what is in the original roadway. Another thing is that one doesn't get perfect mixing or perfectly homogenous mix. The old asphalt and the new asphalt don't have a chance to melt and flow together. The upshot: a cold-mix recycled pavement isn't as strong as a hot-mix-recycled pavement. However, there is tremendous potential for cold mix recycling as all these weak points are now being taken care of by improved laboratory testing and design procedures and depending on the results, further trial mixes may be necessary to determine exactly the optimum percentage additions required to produce a strength applicable, on which a full specification is then prepared[9].

Hot-mix recycling (Central plant surface and base recycling): Hot-mix recycling is a proven approach for the rehabilitation of worn-out asphaltic pavements. It is also referred to as central plant recycling. The method involves:

- Removing the existing pavement to full or partial depth
- Reducing the reclaimed materials to a suitable size for processing
- Blending the reclaimed material with virgin aggregates and liquid asphalt with or without agent
- And relaying the materials as a base, binder or surface course.

Two approaches are used to size the material prior to recycling it in the central plant. The pavement is either reduced in size in-place and then hauled to the central plant, or it is reaped and removed from the site and crushed at a later time at the central plant[6]. The reclaimed material is subjected to sieve analysis to determine the aggregate gradation and to reveal any deficiencies in aggregate gradation. It will normally be necessary to add virgin aggregate to the reclaimed asphalt pavement to produce a mix with the desired gradation[10]. New low-viscosity asphalt must normally be added to the mixture of reclaimed pavement and new aggregate to increase the total asphalt content to the desired quantity and to provide asphalt with a desired vicosity. In addition, organic materials called recycling agents are usually added to restore the old asphalt to desired specifications[10].

The case for recycling is clear and obvious in terms of conserving energy and mineral resource base[11]. It would also appear to be justified on structural grounds, for example, research has shown that hot rolled asphalt containing reclaimed material has stiffness and deformation characteristics, which are for all practical purposes, indistinguishable from those for conventional rolled asphalt. Furthermore, the following parameters have been shown to have no practical effect upon the performance of a hot rolled asphalt mix containing recycled material viz.

- Reclaimed material content
- Source of reclaimed material
- The removal process
- The type of softening[6].

MATERIALS AND METHODS

Appraisal of pavement recycling method of road rehabilitation: The developing interest in pavement has been worldwide, with many countries now becoming increasingly involved in various forms of pavement recycling; some of them are presented in the following sections

The UK experience: In-situ deep recycling, which is also, referred to as linear quarrying is an area of road recycling in which Perth and Kinross Council has made considerable success in the UK. The biggest scheme that has been progressed to date is on A977 through Crook of Devon. The road is part of a strategic link, particularly for heavy good vehicles moving from the west central belt of Scotland over the Kincardine Bridge to the industrial areas of Fife. Constraints were placed on the site, that is, the road had to remain open to traffic at all times and the job had to be completed within a five-week window. It is interesting to note that one contractor put in an alternative tender for a conventional reconstruction but quoted a construction period of 14 weeks at 35% addition cost. With the recycling option, the council is convinced that road recycling is here to stay when compared to traditional reconstruction methods took 35% of the time at 65% of the cost, using 22% of the material. With more contractors making the capital investment and entering the market, prices look to hit home with authorities and communities: that is, with the reducing budget for road maintenance, can anyone afford not to recycle[12].

The tilbury dock experience: The works comprised the repair of an existing paving constructed mainly of lean mix concrete base with a section of clinker base, surfaced with hot rolled asphalt. The new base was to be constructed from recycled material to a thickness of 300mm surfaced with 100mm of Hot Rolled asphalt (HRA). The area of about 3700m^2, which was to be treated was used mainly for the handling and storage of containers at the dockside. Independent cube testing confirmed that the recycled material had achieved the target compressive strength specified. In practical terms, the execution of the contract was carried out very much as predicted, despite periods of inclement weather. The area of 3700m^2 was recycled in six working days. This represented a time saving of at least 40% as compared to conventional treatment. In terms of overall cost, it is estimated that a saving of 7-10% was realized. Really, the conventional repair would have involved the excavation and transport to tip of approximately 2500 tons of waste, followed by the introduction of a similar quantity of new lean mix. This is equivalent to up to 300 vehicles trips. This dramatic increase in local traffic would probably have caused some damage to adjacent paving and would certainly have disrupted normal traffic flows in and out of the Port[9].

The america experience: During the past few years, interest across the US in the recycling of old pavements and road bases has snowballed. Behind it all: soaring costs of asphalt, aggregates, cement, energy, labour, at a time when road maintenance budgets are being squeezed. The US has about 3 million Km of road many of them in asphalt. It was recently reported that one-third of the nation's roads are in poor or mediocre condition costing American drivers an estimated $5.8 billion and contributing to as many as 13,800 highway fatalities annually[13]. The quick and cheap recipe the US had been using to tackle this problem and the like has been the pavement recycling option. Take for example, since 1969, in Wichita, Kansa, alone 1.9 million m^2 or more of roads have been recycled. In 1977, a 16-mile segment of US-59 in South-Western Minnesota was selected fro a recycling project. This project provided the concrete design most desirable for field application and this resulted in a project with surface that has good riding quality. The US-59 recycling project is considered to be a success. An Arizona, a net saving of $4.02 per ton of asphalt concrete has been accomplished in a recycling project[5]. Probably far more than any other state, Wisconsin has made a serious commitment to recycling old pavements. In 1980 alone, it worked on over 30 pavement-recycling jobs[8]. North Dakota, after recycling Portland cement concrete pavements in 1984 discovered that, the process is cost effective, encourages material conservation, provides opportunity to correct design and structural deficiencies economically and that the number of construction cycles over life of the pavement can be reduced. After assessing the performance of pilot recycling projects, Michigan immediately planned five more major interstate recycling projects in 1985 as part of rebuilding their transportation. This was based on construction cost, state-of the art improvements in equipment and the excellent end product[14]. Like numerous other states, Texas has many miles of term-to-market roads in need of repair. The fact is that many roads in Texas are over 20 or 30 years old. By switching to pavement recycling, the Texas Department of Transport was able to rehabilitate its pavements thus yielding a cost saving over the conventional method of 50%. In the same vein, California Department of Transport has in recent time been involved in pavement recycling as commitment to Sustainable development. These are just few of the several cases of success recorded in pavement recycling in the US. It is time Nigeria takes on this excellent method.

Potentials and prospects of pavement recycling method of road rehabilitation in nigeria: Though a little bit of recycling has been done in the Northern part of the country (this was only used to patch roads)[3]. In Nigeria, the widely used mode of transportation is by road and indeed, the economic expansion of Nigeria is highly dependent on its road network. Hence, the importance of highway transportation. The National Road Network length as at present is about 200,000 km and the statistical data is as shown in Table 1 and 2. The Road Network is about 1850 billion Naira and indeed, one the nation's single largest asset. Share of Road Transport of all surface transport is about 95%. Share of GDP is 15%. At present, about 50% of Federal Roads, 30% of State Roads and 5% of Local Government Roads can be said to be in good shape. Where as 30, 40 and 75% of these respective roads are in poor condition. The resultant effect of this poor condition include among others:

- Abnormal slow rate of growth of the National Road Network
- Annual loss of network value due to lack of maintenance is 100 billion Naira
- Additional vehicle operating costs to operators due to poor roads is 66 billion Naira per annum
- Total estimated loss to the economy is 5.5 of GDP[1].

Table 1: Road network of nigeria broken down to federal, state and local governments[1]

Type of road	Federal road	State road	Local govt. roads	Total
Paved roads	26.500	10.400	-	36.900
Unpaved roads	5.600	20.100	-	25.700
Urban roads	-	-	21.900	21.900
Main rural Roads	-	-	72.800	72.800
Village access roads	-	-	35.900	35.900
Total	32.100	30.500	130.600	193.200
Percent	17%	16%	67%	100%

Table 2: Current condition and use of the road network in % denoted by Idowu[1].

Type of road	Good	Fair	Poor	Share of network	Use of the network (Vehicle km^{-1})
Federal	50	20	30	17	50
State	30	30	40	16	25
Local	5	20	75	67	25

Having been faced with the above scenario, the need to proffer solution to the problems which in this case is titled Pavement Recycling cannot be overemphasized. It has been estimated that annual requirement of road Recovery Programme Planned for the nation will cost;

Road maintenance = 30 billion Naira
Road rehabilitation
(conventional approach) = 40 billion Naira
Total = 70 billion Naira

This programme, if executed for a period of 10 years will mean an expenditure of about 700 billion Naira and in essence will amount to 400 billion Naira spent on the conventional method of road rehabilitation, not considering annual increase in rate of inflation.

Adopting the pavement recycling option will mean 200 billion Naira (definitely more) has been saved, since from experience, pavement recycling will cost about 50% of the cost of conventional rehabilitation method and considering the fact that more economical methods of pavement recycling are emerging everyday. Thus adopting this method of pavement rehabilitation will go a long way in getting the nation's road network fully recovered from its present poor condition without depleting the nation's limited scarce resources financially and otherwise, which foster the socio-economy of the country.

CONCLUSION

Recycling roads provides a number of benefits. The most obvious is environmental, in that it provides an avenue of meeting present need of road rehabilitation while conserving and protecting environmental quality and the national resource base essential for future development. Also, by adopting the pavement recycling option of road rehabilitation, Nigerian Government will be saving about 200 billion Naira (or more) over the next 10 years going by the Road Recovery Programme. The money could be spent on projects that would impact positively on the average common man in the country. In the same vein, pavement recycling encourages waste minimization since it involves reusing the existing road materials, which in essence leads to a reduction in the waste to landfill.

Apart from these, it will create an avenue of meeting the country's obligations to the provisions of sustainable Development, Nigeria being one of the 174 countries that are signatories to the Agenda 21 resolution of the UN during the Earth Summit held in Rio de Janeiro in 1992.

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The hot-mix and cold-mix recycling are viable alternatives for rehabilitation of roads and highways. These are methods which have been tested and proven. These methods are thus applicable in Nigeria. To this effect, the government of Nigeria should as a matter of urgency set up a body that will see to the eventual transfer and taking off of the pavement recycling technology in Nigeria, which really is a laudable programme. Federal Road Maintenance Agency (FERMA) could as well in the same vein champion this course by sponsoring research works aimed at verifying the reliability, suitability and applicability of this method in Nigeria.

However, it must be noted that the controlling factor in deciding whether a Portland Cement Concrete Pavement should be repaired or recycled is generally the amount of joint repair that is necessary. When the cost of repairs of such pavements approaches one-third the cost of recycled pavements then recycling is considered. Availability of funding and scheduling then become the controlling factors. Also, care should be taken so as not to damage the asphalt in the salvaged mix by overheating.

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