PAPER NO. 565

THE INCIDENCE OF RUTTING ON BITUMINOUS ROADS

BY

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SYNOPSIS

As a result of satisfactory performance as road paving material in US $ 27 Million AASHO Road Test conducted at a location near Ottawa, Illinois about 80 miles South West of Chicago, bituminous concrete began to be accepted as the standard paving material in most of the American States. There were so many methods of bituminous mix design prevalent at that time but it was the U.S. Corps of Engineers Marshall Method which was universally accepted. The Marshall Method of Mix Design, was primarily meant for temperate climates where the road surface temperature was not to exceed 60°C with standard axle loading. Without keeping in view these limitations, the German, British, Italian and American Consultants paved all the Roads and Highways in Saudi Arabia, and other parts of Middle East and Asia using Marshall Method of Mix Design. Not long after the construction of these roads wherever the road surface temperature substantially exceeded 60°C and the axle load was also in excess of the standard axle longitudinal depression or rutting was noticed.

U.S. National Research Council realizing the necessity of constructing more durable roads set up a US $ 150 million Strategic Highway Research Programme in 1987. The research under this programme was initiated in 1988 and was finalized in March 1993. The results of the Strategic Highway Research Programme are neither fully known nor can be made use of before the end of the second millennium since long-term pavement performance test results being carried out on 1000 pavements in 50 State/countries would not be available earlier than next 20 years. So far as Pakistan is concerned the research carried out by the Americans would not be of much help to us for still many more years because the newly devised field and laboratory testing equipment required for this purpose would not be commercially manufactured so soon.

In this milieu an endeavour has been made, in this technical paper, to highlight the mechanics of rutting not hithertofore attempted in as much details and depth and to suggest measures to minimize it indigenously and cost-effectively till "Superpave" mix is evolved as a result of the new research. Follow-up research on various issues has also been suggested to be carried out in Pakistan by various laboratories involved in highway testing.

THE INCIDENCE OF RUTTING ON BITUMINOUS ROADS

In order to comprehend the mechanics of rutting it is necessary to understand various parameters which affect the behaviour of asphalt concretes from

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manufacture in the ashalt-plant to performance on the road. All those parameters which increase or decrease rutting have been discussed hereunder one by one with the same objective in view. At present there is no mix design which takes into account the variations occuring in the mix over the full range of temperatures to which a mix gets subjected in hot weather nor does it measure directly its rutting resistance at different temperatures.

MIX CONSTITUENTS AND COMPOSITION

In a bituminous mix bitumen is the binding or cementing material and its tendency to rut primarily depends upon the quality and quantity of bitumen used in the mix. By manipulating mix composition and constituents the tendency to rut can greatly be modified and controlled. If for the sake of durability the quantitly of bitumen is increased there will be greater tendency in the mix to rut because though primarily it acts as a aggregate cementing material at normal pavement temperatures, its cementing strength gets weakened with decrease in viscosity at higher than normal temperatures. Similarly if highly viscous bitumen is used its rutting potential will get reduced though it will have greater tendency to crack and strip in cold weather. Therefore, more viscous the bitumen the lesser the rutting tendency. The viscosity of bitumen, however gets changed with the addition of fines such as stone dust, fine cement, cinder ash, fly ash, powdered carbon black and even ordinary dust on the road, or in the air. The addition of these fines enhances the viscosity and increases the chances of the mix to resist rutting even at high temperatures. Apart from meeting the requirements of gradation of fine aggregates, fines as bitumen additives have a great potential for combating the malaise of rutting. Through research it should be possible to select a suitable fine which would provide maximum resistance to rutting at high temperatures in sultry summers without cracking in winter. There should be fines which would make the bitumens or asphalts so viscous that they would not allow the mix to deform vertically as a depression nor horizontally as edge-flow and they would not allow the volatiles in the mix to get escaped in the summer heat. This aspect of research was required to be given top priority by the SHRP and can easily be done by the veterans of Road Research & Material Testing laboratory Lahore and other laboratories in the country. We can experiment by using for instance, cheaply available rice-husk ash as bitumen modifying additive forgetting what the U.S. Research Council is doing at their level. Similarly other fines can also be tried.

Rutting can be controlled to some extent by increasing the resistance of the mix to deform or making it a strong material under the compressive wheel load and managing this strength not to drop in high summer temperatures. One way of increasing strength or stability is pragmatic manipulation of coarse and fine

aggregates. This can be done by totally eliminating rounded aggregates and maximizing aggregate interlocking. Such a mix is apt to be harsh to pave and to lay but it will evince greater resistance to rutting because of higher resistance to displacement. If suitable fines are also added as explained above the malaise of rutting can be resisted to a still greater extent. Increase of bitumen decreases resistance to deformation and increases the chances of rutting. Another way of minimizing rutting is to use barest minimum of asphalt with maximum aggregate interlocking and resultantly higher compressive strength under traffic wheels. Rutting can also be curtailed by using highly viscous asphalts with relatively higher softening point and lower flow value. It will be highly advantages to use 60/70 or 40/50 grade bitumen instead of the normal 85/100 grade from the point of view of rutting alone. 40/50 or 60/70 penetration bitumens being more viscous will not rut as easily as the softer 85/100 penetration. But it should be kept in mind that harder grade bitumens are also more likely to crack in severe winters especially during winter rains and there is a possibility of stripping or separation of adhension or bond between the aggregate and the bitumen not necessarily during the first year after the construction but definitely earlier than the 85/100 grade bitumen.

For the sake of minimizing rutting the value of loss of stubility should be reduced from 25% to 20% or even lower. Besides, bitumen contents should not be increased simply to bring the loss in stability within the specified limits. Stability flow ratio also needs to be modified and research follow-up needs to be initiated to get the optimum values which would offer maximum resistance to rutting. Maximizing interlocking of aggregates and deploying some suitable fines wihch would increase resistance to rutting at summer temperatures without embrittling and disintegrating in winters could be another research follow-up issue.

TRAFFIC POLISHING AND SMOOTHENING

On completion when a road is opened to traffic its surface gets smoothened and polished with passage of traffic; specially lighter traffic like cars, vans, wagons and buses. This smoothening and polishing effect, influences the behaviour of the laid asphalt concrete. It not only further increases its impermeability and seals it off against the possible ingress of water during rains and other modes of precipitation but it also decreases evaporation of volatiles from the mix. This sealing-off process is greatly enhanced by the heat generated by the flow of traffic as well as the ambient temperature. In summer the mix becomes still more receptive and easily catches suspended dust particles in the air. With the absorption of fines from the air as well as the dusty surroundings the top of the road surface becomes more resistant to rutting than its interior. For the same

reason smoothening and polishing effect greatly improves the performance of the surface treatments in spite of the fact that the thickness of the triple surface treatment never exceeds one inch or 25 mm. It is however, certain that absorption of fines over the length and breadth of the mix laid is never uniform and ipso facto its performance is irregular and its behaviour is non-unifrom. The parameter of smoothening and polishing also decreases thermal cracking. It is therefore always helpful to allow fast moving light traffic on the road intially before allowing heavier traffic to ply. One of the primary reason for the good performance of the roads constructed before partition of the Indo-Pak subcontinent is that in those days there was more polishing and smoothening traffic and road damaging heavy-axled traffic was almost non-existant.

OXIDATION AND WEATHERING

Both the parameters of oxidation and weathering influence the pavement rutting potential as well as development of alligator or block cracking and make the mix laid more and more stiffer with the passage of time. A bituminous mix becomes harder and harder when exposed to air. This hardening process primarily takes place in the bitumen or asphalt and makes the mix less liable to rut with the passage of time as compared to a fresh mix. A newly laid mix therefore, is more likely to rut under the same temperature and loading conditions as compared to an older mix laid two or three years before. Hardening or oxidation of bitumen as well as bituminous mixes takes place as a result of evaporation of volatiles or plasticizers in the bitumen; higher the bitumen contents and mix temperature greater the oxidation. Similarly longer the oxidation or exposure time greater the hardening. As a result of evaporation of volatiles or plasticizers in the mix a bitumen of 85/100 penetration becomes that of 60/70 penetration after a few years and of still more harder grade if it is subjected to further oxidation for a couple of more years. It is in fact a natural distillation process in which only the residue is left and the evaporated volatiles cannot be condensed and made use of.

As per research conducted by Dickinson in 1982 reported by Dr. Livneh of the Israel Institute of Technology, Haifa, rate of oxidation is doubled for every 10°C rise in temperature and as per Shahin (1977) penetration drops with the passage of time quite rapidly during the first in-service ten years. If this hardening process is not arrested and is allowed to continue the pavement becomes ultimately so hard and brittle that it no longer remains flexible and cracks easily with the movement of traffic under a deflective load.

Oxidation in the interior of the mix largely depends upon the extent of air voids in the mix. Hardening and oxidation would be less if the air voids are minimum.

At zero air voids oxidation in the interior of the mix also becomes zero but the mix begins to bleed and can also rut as well because this can only happen with higher bitumen contents. It is therefore normal not to drop air voids in mix more than 3%.

Some Highway Engineers thinking that rutting takes place because of lack of proper compaction recommend, Refusal Method of mix design (Percentage Refusal Density Method) and subject the mix in the laboratory to unlimited blows till it refuses to get compacted further ensuring simultaneously that the air contents do not fall below 3 %. The very premise that the mix ruts because of lack of compaction like that of the settlement of improperly compacted sub-grade, sub-base, or aggregate base is not true. With increase in pavement temperature beyond 60°C the mix laid on the road does not remain as stiff as to resist deformation under heavily loaded traffic wheels and succumbs to its rutting pressure and deforms. Rutting does not take place because there is room for further compaction and settlement as assumed in the Percentage Refusal Density Method but it takes place because of the revival of the lubricative effect of bitumen at higher temperatures. In adequately colder ambience and climate, it becomes all the more viscous and holds the aggregate particles with all the more tenacity. In hotter climatic regions both the bitumen viscosity and tenacity become too weak to keep the mix urutted and undeformed.

Weathering on the other hand covers the total spectrum of changes which take place with the passage of time resulting from the variations in the vagaries of weather including exposure to sun, rain, all sort of other precipitations and seasonal weather changes. Weathering invariably includes oxidation and hardening but oxidation does not cover all the facets and aspects of weathering. Like oxidation weathering tends to reduce rutting though it creates more problems than it solves. With the passage of time the mix becomes brittle and the bond between the aggregate and the bitumen weakens and the water from the rain, hail or snow gets easy access to stone aggregate which may break the adhesion of bitumen with the aggregate and pavement may disintegrate instead of rutting. After the rains the weakening of the bond becomes immediately visible in the shape of all sorts of fine as well as more pronounced cracks along the planes of weakening. If the bitumen used in the mix is on the lower side as is being done in Pakistan now-a-days to get higher stability, the weakening of the bond between bitumen and stone aggregates takes place much earlier than when the bitumen contents are within normal limits. Similarly if harder grade bitumen is used in the mix in the first place weathering weakens the adhesion much earlier. Use of more viscous or harder grade bitumen is only helpful during the initial years of construction when the weathering effect is not so pronounced. But when weathering effect increases or gets enhanced with the

passage of time the bitumen used in the mix becomes still more harder and not only embrittles very easily but also loses its grip on the stone aggregate and begins to ravel and disintegrate.

ROAD PAVEMENT TEMPERATURE

Formation of longitudinal depressions on the highways has much to do with the road pavement temperature. It is, evident that road pavement temperature in cold climates would not rise as high as it could in hot countries. Similarly this temperature would also depend upon such other factors as frequency or infrequency of rains, presence or absence of wind flow, existence of obstructions to exposure to sun and difference of day and night temperatures. In both Hveem and Marshall methods of mix design there is an implicit limitation that the road pavement temperature would not rise above 60°C or 140°F. This is why the resistance to deformation or stability is measured by application of the load at 60°C. Since both Hveem and Marshall methods measure mix strength at 60°C, they can only be relied upon if the pavement temperature does not exceed 60°C.

It was observed during the construction of Hingorja - Ranipur Section of National Highway N-5 that the road pavement temperature goes as high as 75°C during day time. Road pavement temperature could be still higher in such notoriously hotter areas as Sibbi and Jacobabad. Hveem or Marshall mix designs which are based on the upper higher pavement temperature limit of 60°C are apt to rut or deform in such areas. This is one of the major reasons why Marshall method of mix design is not applicable to hotter climates and its blatant and wanton adoption and use in Pakistan by everybody is both improper and against the national interest. We should not blindly follow the West. The roads we are building today should be durable enough to be used by our posterity and if they begin to rut or deform a few years after construction it would be tremendously expensive for our future generations to rebuild them again. Moreover, it would also be a great economic setback and may paralyze our already bleak economic system. There is, therefore, immediate need for discarding the Marshall method of mix design in favour of more rational methods most appropriate to hot climates. There is no dearth of talent in this country and it should not be difficult for us to devise new mix designs most appropriate to our climate, traffic composition and transportation needs. Modified versions of Marshall, Hveem, Hubbard-Field and unconfined compression can be devised.

AXLE LOADING

Axle loading is closely related to rutting. There will be no rutting if the axle load is lighter. Car traffic whatever its density and intensity can never produce any

rutting nor even bus traffic. It is the heavy axled traffic alone which produces rutting when the road pavement temperature is also very high. There are, therefore, very remote chances of rutting taking place in very cold climates and weathers if the mix is properly designed and bitumen contents are not very high. When U.S. Crops of Engineers fixed the stability testing temperature of 60°C, it was fairly high temperature keeping in view the American weather conditions including Arizona but it was not high enough to include all the hot regions of the world. Marshall or Hveem methods of mix design therefore which were primarily meant for road pavement temperatures not exceeding 60°C were not to be used in very hot climates. It was therefore a great technical mistake to design and lay road pavements on the basis of Marshall or Hveem methods of mix design in Saudi Arabia, Muscat, Kuwait and Pakistan. Classical examples of rutting failure could be seen on Riad-Dammam Road in Saudi Arabia, Sangjani - Taxila Road near Islamabad Circular Road near Muslim Masjid & Do-Moria Pul Lahore. From the rutting point of view our conditions are such that we can neither control our weather nor there is any possibility to restrict the road pavement temperature to 60°C. By planting fast-growing-sun-interrupting trees along our highways this can be done to some extent but it cannot be done on motorways and four-lane dual carriage-ways because of the larger road formation widths. Similarly as law-enforcement conditions prevails in Pakistan it would neither be possible to reduce truck-loading nor to impose restrictions on loading as it would increase the transportation cost and would adversely affect the private transportation industry in Pakistan.

RUTTING IN THE GLOBAL CONTEXT

Realizing the mal-effects of the malaise of rutting various endeavours have been made at international level either to eliminate rutting totally or to minimize it. Strategic Highway Research Programme under the National Research Council of America, French Method of Mix Design for hot countries under the LCPC (Laboratoire Central des Ponts et Chaussees) and the Franco - Israel technique of Mix Design by Moshe Livneh are some of the global attempts to resolve the problem of rutting. How far these attempts would succeed in overcoming the problem of rutting only time will tell. It would be, however, interesting to know the work being done by the above lofty institutions and experts with special reference to climatically hot regions and countries.

STRATEGIC HIGHWAY RESEARCH PROGRAMME

SHRP is roughly spending one third of the total allocation of US$ 150 million on asphalt-related research including rutting. This also includes long-term

pavement performance observation of about one thousand pavements in fifty different States/Countries. The observation will extend over twenty years and will include exposure of pavements to different climates and traffic loads over a wide range of designs. Test sites include Asia, Africa, Pacific countries, Europe as well as South America in addition to the United States. Physical observation of rutting on roads and pavements built specifically for this purpose is very expensive but the gravity of the issues urges National Research Council to undertake it at whatever the cost. In addition to the long term pavement observation SHRP has devised and designed the following new asphalt concrete mix design and testing equipment for measuring its viscoelastic properties as part of its research programme:-

Bending Beam Rheometer

For testing low temperature stiffness behaviour of asphalt concrete.

Dynamic Shear Rheometer

For measuring and testing asphalt concrete stiffness at high temperatures. This equipment is new for asphalt concrete but has been used for other materials for a number of years. Both Dynamic Shear Rheometer and Bending Beam Rheometer indicate the ability of the asphalt mix to resist rutting, fatigue and thermal cracking.

Direct Tension Tester

For low temperature asphalt failure and gauging its fracture properties.

Gyratory Shear Compacton

For simulating field compaction.

Shear Testing Device

For simulating compressive and shear stresses induced by traffic wheels.

Indirect Tensile Test

For predicting whether a pavement will crack at low temperatures.

Pressure Aging Vessel

For measuring oxidation and weathering effect during the first few years of services.

It has also been claimed that with the research work carried out under SHRP it would be possible to understand the exact role played by bitumen in the mix and this in turn would help in making use of the asphalt concretes more usefully. The role of such bitumen constituents as amphoterics in the development of rutting, potholes and thermal cracks would be better understood through chemical models developed under Strategic Highway Research Programme by Pennsylvania Transportation Institute under Pennsylvanic State University U.S.A.

THE FRENCH METHOD

The French Method of mix design is primarily meant for hot climatic countries aimed to check rutting, fatigue and thermal cracks not covered by the Marshall or Hveem Method and requires the following testing equipment.

1. **Gyratory Shear Compaction.**
2. **Wheel Tracking Rutting.**
3. **Direct Tensile.**
4. **Unconfined Compression (with and without immersion).**

The French Method of mix design further establishes three mix design strategies, the rutting strategy, the fatigue strategy and the durability strategy. Mix can only be designed if the above testing equipment is available. This does not appear to be possible in immediate future since it is not being manufactured at commercial level.

THE FRANCO - ISRAEL METHOD

The method proposed by Dr. Livneh Director Technion of the Israel Institute of Technology Haifa is an improvement of the Marshall Method for the interim period till sophisticated and state-of-the-art equipment as deployed by the French becomes available. Dr. Livneh suggests changed Marshall mix design criteria for hot countries and specifically recommends that as per Israel experience water absorption of aggregates should be less than 2.0 per cent and harder grade bitumen than 85/100 penetration should be used in hot climatic regions like Southern Israel. As far as Pakistan is concerned all of our approved sources of aggregates have water absorption much lower than 2% and harder grade bitumen is also being already used. As per Pakistan experience all aggregates having water-absorption higher than 2% fail in other quality tests.

REVIEW OF THE GLOBAL EFFORTS

At this juncture when various aspects of the phenomenon of rutting have been adequately highlighted and global endeavors to resolve the problem have been explained, it would not be inappropriate to see if the work done by the Americans, the French and the Israelis would be applicable to us and if yes to what extent. In the first place there should not be any doubt or ambiguity that whatever research work is being done at international level, is primarily meant for the nations who are carrying the research. The American, French or Israeli climatic, traffic and loading conditions are not the same as in Pakistan and their solutions to the problem of rutting cannot be applied without understanding the

basic limitations under which the solutions were primarily derived. It is evident that it is the Pakistanis alone who have themselves to find solutions to their problems and it would be too much to expect solution from people foreign to our land who do not know the solution themselves. This is also understandable because they neither know the extent of our axle loading, loading habits of our transporters nor the peculiar hotness of our weather. Foreign Highway Consultants are therefore least bothered about our problems and tend to give solutions which could be appropriate for them but would be inapplicable in our conditions.

There are engineers in this country who are looking forward to the outcome of the Strategic Highway Research Programme so that it may be applied in Pakistan. That application would be as much unfortune as the application of Marshall Method of mix design is for a climatically hot country like Pakistan. If certain stretches of our highways designed as per Marshall Method have not rutted or deformed in the initial one or two years, it is because of some of the rutting resistant parameters which have already been fully explained, their reiteration here would be uncalled for. Some hasty modification of the original design mix parameters such as requiring the stability to be not less than 1000 Kg and bitumen contents to be around 4 to 5% irrespective of its long term negative effect on the performance of the bituminous concrete is not a solution which can be relied upon and continued.

What was missed by the Americans in the post-test evaluation and appraisal of AASHO Road Test in sixties is again being missed in the SHRP and other global efforts to resolve the issue of rutting. In the evaluation, the influence of temperature on the performance of the various sections of the loop subjected to testing could not be thought of and escaped the notice of the engineers observing the performance. It was because of this technical lapse that the layer co-efficient of bituminous concrete was assumed to be constant both in summer and winter as if summers would never soften and reduce its stiffness. The total scenario and milieu of Chicago was too prone to cold weather to think about any hot weather. It was a mistake or rather technical lapse which is again being repeated by the controllers of strategic highway research programme as well as the French and the Israelis. In carrying out the research work at global level there is a tacit and implied assumption that the road pavement temperature even in hot weather would not exceed 60° C and based on this assumption gyratory shear compaction, wheel tracking rutting and other tests have been carried out at 60°C. As far as is known the mechanics of variations in the behaviour of bitumen and bituminous mixes with variation in temperature upto 75°C has not been observed nor any testing equipment was devised and deployed for this purpose. Any research which does not cover the total temperature spectrum of

road pavements especially for hot climatic region is apt not to succeed and to be fruitful to us as well as all those countries which are very hot. It can, therefore, safely be concluded that work done by the Americans, the French and the Israelis would not be useful for us to the extent it could have been, had these temperature limitation been observed. The people living in temperate and cold climates are likely to forget that there are countries in the world where temperature during the day remains close to 50°C and that too for weeks and months together without any cooling wind-flow at nights and shaded trees along the roads and highways during the day.

One thing, however, is certain from the work carried out by the French and the Israelis that the present Marshall Method of mix design cannot be applied and used in a hot country. This was pointed out in Engg. Congress Technical paper No. 41 much earlier than the Israelis though little attention was paid to what was said in the Paper. Prior to the publication copies of the paper were sent to all the Engineers who were responsible for deciding the fate of highway construction in Pakistan.

It therefore, can be concluded without derogating work carried out at international level and without negating the sophistication of the new testing equipment that so far as rutting or deformation or channelization is concerned, the new research fails to consider the primary parameter of temperature and its resultant effect of reduction in stability and increase in flow value.

INDIGENOUS SOLUTIONS TO THE PROBLEM OF RUTTING

Rutting can be eliminated by evolving a bituminous mix having high resistance to deformation at road temperatures higher than 60°C under repeated applications of heavy axled traffic. To some extent resistance to deformation is indicated by the mix stability. It is, however, not a dependable indicator of resistance to deformation as it is highly variable at different temperatures. Its measurement in the laboratory at a fixed temperature of 60°C is more suited to a cold and temperate climatic region and is not at all helpful for a hot climate like that of Pakistan. It is so because bitumen behaves differently at different temperatures. This behaviour is so variant that bitumen of different drums of the same penetration are apt to behave differently at different temperatures though at testing temperature of 25°C all would indicate more or less same penetration. The bitumens therefore, behave so unpredictably at higher than 60°C that deformation in the form of rutting takes place even under loads where that deformation is not expected to take place. Stability measured at a fixed temperature of 60°C is, therefore, not a dependable indicator of rutting resistance though it does indicate the ability of a mix to resist deformation at

temperatures upto 60°C. It is now an established fact that road surface temperature in hot climatic regions exceeds 60°C and goes beyond 75°C.

It is around these temperatures that resistance to deformation, falls unpredictably and anisotropically. Anisotropy has made bitumen as one of the most complex and unpredictable construction materials. One of the solutions to rutting lies in the production of an isotropic and a homogeneous bitumen which should have predictable and uniform behaviour with change in temperature and it should be the same in each and every bitumen drum. This high quality bitumen is yet to be produced and it is not known whether any research under SHRP has been directed towards this end. It appears that SHRP emphasis is on the devising of new testing equipment which could measure and gauge the various bitumen characteristics during various stages of construction and use. This would definitely help in knowing the extent of bitumen anisotropy but the equipment alone cannot make the bitumen or asphalt to behave properly and predictably unless we improve its quality through super-refined production. It was much easier for the Americans and the French to intensify their research in this direction had they diagnosed the malaise of rutting correctly.

In the absence of quality bitumen having predictable characteristics within the pavement temperature range including both the cold and hot climatic regions, it would be difficult to completely eliminate the incidence of rutting though it can be greatly reduced by minimizing the lubricative role of bitumen in the asphalt concrete by keeping its contents at the lowest possible without jeopardizing durability and without maximizing air contents and by ensuring that no rounded aggregate, coarse or fine is allowed to be used in the mix. Using the same testing equipment as is available in our standard Highway Laboratories it should not be difficult to search out suitable polymers and bitumen additives which would provide and evince comparatively higher stabilities at temperatures upto 75°C instead of the standard 60°C. Follow up research can be carried with long range of polymers, synthetic rubbers, shredded old tyres with sulphur, powdered graphite, carbon black, cinder ash, volcanic ash, rice-husk ash and other cost-effective fines. Finely shredded asbestos, coaconut fibre and jute can also be tried as bituminous mix reinforcement against thermal hardening or fatigue cracking and also as an additional rutting resisting material incorporated in the body matrix of the mix during the process of manufacturing.

In the present milieu and in the present stage of development of bitumenous mixes bituminous concrete cannot be used in climatically very hot regions of Pakistan with impunity and without fear of rutting till we carry out our own basic research, develop our own modifiers and additives and build our roads accordingly or we make intelligent use of the research carried out at

international level. The present obdurate and unthoughtful attitude of those who are entrusted with the responsibility of deciding the fate of construction in continuing to allow ruttable mixes to be placed on highways and motorways is ultimately going to cost the Nation tremendously.

At this juncture when neither research carried out at international level is of much use to us for lack of availability of the new testing equipment as well as the end product of the research nor we have done our homework of research in our own laboratories the question naturally arises " What is the most cost-effective and simple solution to the problem of rutting?" For a country like Pakistan bituminous concrete used as wearing and base course material is one of the most expensive item of highway construction both for overlays as well as new constructions requiring most sophisticated and elaborate fleet of machinery from multi-million dollar Asphalt Plant, to equally expensive fleet of Paver Finishers, Dump Trucks, Pneumatic Tyred Rollers and Tandum Rollers in addition to Wheel Loaders, Bitumen Distributors and Power Brooms. Another equally vital question which arises at this stage is " Is it necessary to purchase such costly machinery from the industrially advanced nations of the world to make ruttable roads?" A very simple answer to this vital question is that it is not at all necessary if we use our own head and scratch our brains and exert ourselves to find a solution. But if we continue to be followers of white-skinned Advisors and consultants we cannot do without the above fleet.

Indigenous and most cost-effective solution to the problem of rutting is to lay 2" to 3" or even bigger size hand broken stone aggregate over a well compacted sub-base in loose thickness of 6" to 8" and compact it with Vibratory Rollers of adequate weight and vibration till it gets almost compacted and evinces no sign of movement. The aggregate must have all sides broken and should produce maximum interlocking. Los Angeles abrasion value of the aggregate should be below 30 and sulphate soundness below 10. The interstices between the 2" to 3" stone aggregate are to be filled with properly designed bitminous slurry using fine aggregate passing sieve No. 8. The slurry can have sulphur, synthetic rubber or other additives to improve its interstices-filling qualities. After filling the interstices with slurry, the layer can be further rolled till it gives 100 % modified compaction. Similarly another layer of hand broken stone having maximum interlocking can be laid as per requirements of the design structural number. The interstices between the aggregates can also be filled with any other void filling material as cheaply available or found suitable with experience. In other words for the time being till we find more suitable interstices filling material we can lay bitumen bound macadam instead of the water bound. If properly laid and filled with bituminous slurry such a bituminous concrete would neither rut nor evince flow at the edges nor would require such an

expensive fleet of machinery as is required for normal laying of asphalt concretes. Moreover, there would be no chances of reduction of layer co-efficient in summers. In our case the role of the slurry will be not only that of filler but also of aggregate binder in such a manner that its softening or reduction of stiffening would not affect the load bearing strength or stability of the bitumen bound macadam. The whole purpose of BBM is to let the stone aggregate take the total brunt of stress and strain of heavy traffic and let the bitumen play the secondary role of void-filler and aggregate binder. This role of binder would only come into play if per chance the aggregate interlocking fails and the stress gets transferred to bitumen. Voids can also be filled with finely ground slurry of lime and slag or other pozzolanic materials capable of forming cementitious compounds when wet as is being done by "Pavital" the Italian Contractors working on G.T. Road Lahore near Kala Shah Kaku.

For providing extra smoothness the top of the bitumen bound macadam can be overlaid with bituminous concrete using 6mm aggregate. If, however, skid-resistant surface is required it can be given one or two coats of surface treatment.

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