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Methodology of Construction of Hot Mix Asphalt Paving and Our Experiences on the Execution of Lahore-Pattoki Section of Third Highway Project

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METHODOLOGY OF CONSTRUCTION

OF

HOT-MIX ASPHALT PAVING

AND

OUR EXPERIENCES ON THE EXECUTION OF LAHORE–PATTOKI SECTION OF THIRD HIGHWAY PROJECT

BY

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SYNOPSIS

The paper deals in two parts :

(i) The detailed outline of the methods and procedures generally adopted for the construction of hot-mix asphaltic concrete courses.

The asphaltic concrete consists of a very carefully proportioned mixture of coarse aggregate, fine aggregate and mineral filler coated with bitumen. When properly designed, it will provide a surfacing of exceptional durability capable of carrying the heaviest traffic. It is widely used for the surfacing of heavy duty roads, motorways, and air-field runways under all types of climatic conditions.

The main requirements of a good quality asphaltic concrete are as follows :–

Sufficient stability, that is it must be able to carry the traffic loads which are envisaged without deformation either in the form of rutting or pushing.

The mix must be durable, that is it must not fret or wear away under the action of traffic and weather.

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The mix must be non-skid and must remain so during its life.

There must be sufficient voids in the total compacted mix to allow for a slight amount of additional compaction under traffic loading without flushing, bleeding and loss of stability, yet low enough to keep out harmful air and moisture.

The mix must have sufficient workability to permit efficient placement of the mix without segregation.

(ii) Experiences gained on the execution of Lahore–Pattoki Section of Third Highway Project as regards :

- Clearance of site from existing utility lines, trees, water courses etc.
- Execution of highway as per the contract specifications.
- Difficulties encountered with suggested remedial measures.
- Suitability of completed highway as per the present traffic load.

i) METHODOLOGY OF CONSTRUCTION OF HOT-MIX ASPHALT PAVING

1. METHODOLOGY

1.1 The methodology of various operations, such as preparations, mixing, spreading and compacting, essentially required for producing good quality hot-mix asphaltic concrete courses are described.

2. DESCRIPTION OF WORKS

2.1 The construction of hot-mix asphaltic concrete courses consists of the preparations, mixing, spreading, and compacting of one or more of the courses described in the subsequent paragraphs.

The asphaltic concrete courses are laid on the top of an approved, primed or tacked subgrade, base–course, asphaltic levelling course or binder course in accordance with the standard specifications and in conformity with the lines, grades, thicknesses and typical cross-sections shown on the drawings or established by the Engineer.

2.2 Regulating Course : The regulating course shall be constructed in varied widths and

thicknesses for the purpose of eliminating irregularities and depressions in existing bituminous pavements. The exact limits of construction and widths and thicknesses of regulating courses will be determined by the Engineer and will be based on job conditions existing at the time the work is performed.

2.3 Binder Course : "Binder Course" work shall consist of the construction of one course of hot mix, hot laid, bituminous mixture, spread and compacted on a new or existing base-course, regulating course, concrete pavement or bridge deck in accordance with the specifications and drawings.

2.4 Surface Course : "Surface Course" work shall be the construction of the final top surface of the pavement to take the wear from the traffic and shall consist of one course of hot mix, hot laid asphaltic concrete, spread and compacted on an existing bituminous or concrete pavement or on a bridge deck, new regulating course or binder course in conformity with the lines, grades and typical sections shown on the drawings.

3. MATERIALS

3.1 Approval of Materials : All materials shall be subjected to laboratory tests under the supervision of the Engineer or his authorized representative. No material, regardless of its source, shall be incorporated in the work until representative samples taken by the contractor and tested in an approved laboratory or tested by the contractor in the presence of the Engineer or his representative, have been approved and written certificate is issued by the Engineer to his representative for the use thereof. On change of source of any material, tests shall be performed again for the new samples, but any way, frequent testing of materials shall be carried out to ensure its fitness for use in the work.

3.2 Materials shall be tested in accordance with the relevant AASHTO or ASTM standards as shown hereunder or as directed by the Engineer.

3.3 Asphaltic Materials (Asphaltic Cement) :

TEST	AASHTO	ASTM
Sampling Bituminous Materials	T 40	–
Penetration of Bituminous Materials	T 49	D 5
Kinematic Viscosity of Asphalt	T 201	D 2170
Flash Point	T 48	D 92
Thin Film Oven Test	T 179	D 1754
Ductility of Bituminous Materials	T 51	D 113

Solubility of Bit. Materials in Organic Solvents	T 44	D 4
Coating and Stripping of Bitumen – Aggregate Mixtures	T 182	–
Specific Gravity of Bituminous Materials	T 228	D 113

3.4 Aggregate for Use in the Mix :

TEST	AASHTO	ASTM
Sampling of Aggregate	T 2	D 75
Sieve Analysis of fine and coarse aggt.	T 27	C 136
Sieve Analysis of mineral filler	T 37	D 546
Plastic Fines in graded aggregates & soils (Sand Equivalent Test)	T 176	–
Los Angeles Abrasion Test	T 96	C 131
Soundness of Aggregates by use of Sodium Sulphate or Magnesium Sulfate	T 104	C 88
Spec. gravity & Absorption of coarse Aggt.	T 85	C 127
Spec. gravity & Absorption of fine Aggt.	T 84	C 128

3.5 Bitumonous Mixtures :

Marshall Test	–	D 1559
Bulk spec. gravity of compacted Bituminous Mixture	T 166	–
Quantitative Extracation of Bitumen from Bituminous Paving Mixtures	T 164	D 2172
Swell – Test	T 101	–

3.6 Asphalts for Bituminous Surfacing : The asphalt shall be the product of crude petrolium, uniform in character and free from water. It shall not foam when heated upto 176.7°C. It will be grades 60-70 penetration or 85-100 penetration as directed by the Engineer conforming to the following standard specifications resulting from tests mentioned in mix design criteria :–

DESCRIPTION OF TEST	SPECIFICATIONS	
Penetration, 25°C, 100 grams, 5 seconds	60 – 70	85 – 100
Ductility – At 25°C	+ 100	+ 100
Flash Point (Cleveland open cup), °C	232.2	232.2

Solubility in carbon tetrachloride, per cent	99.5	99.5
Thin Film Oven Test		
a) Loss in weight, per cent maximum	0.80	1.00
b) Penetration of residue at 25°C – 5 second - 200 grams, per cent minimum	+ 52	– 47

3.7 Mineral Aggregates : Mineral aggregate for asphaltic concrete shall consist of coarse aggregate, fine aggregate and filler material. All of these materials shall comply with the following requirements :–

3.8 Coarse Aggregate : Coarse gaggregate which is the material retained on an AASHTO 4.75 mm (No.4) sieve, shall consist of crushed rock or crush gravel. It shall be of well proportioned sides, free from an excess of flat elongated pieces (in no case more than ten (10) per cent) and shall be of such character that when coated with asphalt shall pass a stripping test performed in accordance with AASHTO T 182.

3.9 Crushed gravel for use as coarse aggregate shall consist of at least ninety (90) per cent by weight of the pieces with at least one (1) mechanically fractured face and when tested for stability for bituminous mixes shows satisfactory stability.

3.10 The percentage of wear as determined by Los Angeles Test shall not exceed 40% for all mixes. When preparing the different sizes of the aggregate in order to form the grading specified, each size will be piled separately at the site of the mixing plant.

3.11 Fine Aggregate : Fine aggregate shall consist of that portion of the total aggregate that passes a standard AASHTO 4.75 mm (No.4) sieve. It should be well graded from 8 mesh to 200 mesh and should consist of crushed screening, natural sand or a mixture of the two. It shall be clean and free from dirt, organic materials and any minor deleterious substances. When tested for soundness by sodium sulphate (5 cycles in sodium sulphate), percentage of loss shall not be more than 15%. When two kinds of sand are provided, each kind shall be dumped separately at the site of mixing plant, and mixing of two kinds shall be done with the permission of the supervising Engineer. Fine aggregate (sand) shall have no plasticity. Should natural material passing the AASHTO No.4 sieve be included in the mixture, this material shall be fed to the dryer as a separate aggregate and the amount used shall be so limited that the mixture of fine aggregates will contain not less than twenty-five (25) per cent by weight of the crushed aggregates.

3.12 Filler : When the combined grading of the coarse and fine aggregates is deficient in

material passing the AASHTO 0.075 mm (No.200) sieve mineral filler shall be added as approved by the Engineer. Mineral filler shall consist of finely divided mineral matter such as rock dust including limestone dust, slag dust, hydrated lime or portland cement. At the time of use it shall be sufficiently dry to flow freely and essentially free from agglomerations. Filler material shall conform to the requirement of AASHTO M 17. Gradation requirements are as follows :

SEIVE	Per Cent Passing (By Weight)
No. 30 (0.600 mm)	100
No. 50 (0.300 mm)	95 – 100
No. 200 (0.075 mm)	70 – 100

3.13 Combined Mineral Aggregate : The combined mineral aggregate shall consist of clean, tough, durable, sharp angle fragments free of any excess of thin or elongated pieces, and reasonably free of soft, disintegrated or decomposed stone, dirt or other deleterious matter. It shall also conform to the following physical requirements :–

(a) Sand Equivalant :
(AASHTO T 176) determined after all processing except for addition of asphalt binder — 45 minimum

(b) Plasticity Index (AASHTO T 90) — 3 maximum

(c) Loss of Marshall stability by submerging in water at 60°C for twenty four (24) hours as compared to stability measured after submersion in water at 60°C for twenty (20) minutes — 25 per cent maximum

(d) Los Angeles Abrasion Test
(AASHTO T 96) Loss in weight — 40 per cent maximum.

3.14 GRADATION FOR DIFFERENT ASPHALTIC MIXES

Before using any asphaltic mixture, the contractor, under the supervision of the Engineer, shall prepare a job-mix formula which may conform to the following gradings, or any other grading suggested by the Engineer, for each course.

Type of Mix		Binder Course		Levelling Course		Surface Course	
Type of Gradation		A	B	C	D	E	F
Thickness of Course After Compaction		4.0-7.5 Cms	4.0-6.0 Cms	2.5-5.0 Cms	2.5-5.0 Cms	3.0-5.0 Cms	4.0-6.0 Cms
U.S.A. Std. Sieve Design	Nominal Size MM	Total Percentage Passing Including Filler					By WT
1.5"	37.50	–	–	–	–	–	–
1"	25.00	100	100	–	–	–	100
3/4"	19.00	75-100	80-100	100	100	100	20-100
1/2"	12.50	–	–	85-100	–	80-100	–
3/8"	9.50	45-70	60-80	–	85-100	70-90	60-80
No. 4	4.75	30.50	48-65	65-80	–	50-70	48-65
No. 8	2.36	20-35	35-50	50-65	65-80	35-50	35-50
No.16	1.18	–	–	–	47-68	–	–
No.30	0.600	5-20	19-30	25-40	30-55	18-29	19-30
No.50	10.300	3-12	13-23	–	20-40	13-23	13-23
No.100	0.150	2- 8	7-15	10-20	10-25	8-16	7-15
No.200	0.075	1- 4	1- 8	3-10	3- 8	4 10	4- 8
Bitumen Content (P.H.A)	–	5.0-6.5	5.5-6.50 (P.H.A)	5.5-7.5	6.5-8.5	6.0-7.0	6.0-7.0

Notes (a) All bitumen contents are given in parts by wright of bitumen per 100 parts by weight of aggregates (P.H.A)

(b) The grading limits specified are based on materials of uniform specific gravity and shall be adjusted by the Engineer to compensate for any variations in the specific gravity of the individual sizes.

(c) The type of grading for different courses will be approved by the Engineer on the basis of Marshall Tests to obtain optimum values for various parameters of Marshall design criteria.

(d) The information of binder content, as mentioned herein, provides only a general guide. The optimum amount of the binder content shall be decided by the Engineer on the basis of the Marshall Tests.

4.00 JOB MIX FORMULA

4.1 The job-mix formula will be prepared by the contractor under the supervision of the Engineer in the project laboratory. The job-mix formula shall combine the mineral aggregate and asphalt in proportions as specified. When tested according to Marshall Method, the bituminous mixture shall conform to the following requirements.

4.2 Mix Design-Criteria :

	Binder Course	Surface Course
Marshall Stability (kilograms)	600 (minimum)	700 (minimum)
Marshall Flow (millimeters)	2 – 4	2 – 4
Voids in total Mix (Per Cent)	3 – 8	3 – 5
Voids filled with asphalt (Per Cent)	70 – 80	70 – 80

4.3 Upon receiving the approved job-mix formula, the contractor shall adjust his plant to the proportion in the individual aggregates. Mineral filler and asphalt to produce a final mix that when compared to job-mix formula, shall be within the following limits.

4.4 Maximum Variations of Per-Centage of Materials Passing

Seive No. 4 or larger	8	30	200	Asphalt
Percentages ±5	± 4	± 3	± 1	± 0.3

4.5 The Engineer will test the mix periodically and, if necessary, the contractor to re-adjust the plant to maintain conformity to the job-mix formula. If during production, the grading of the aggregates alters, the mix shall be redesigned and the plant readjusted.

5. EQUIPMENT :

5.1 All equipment required in connection with the manufacturing, transporting, placing, and compacting or used in any other operation connected with bituminous material shall be according to the type and numbers approved by the Engineer, before starting the work.

5.2 In addition to the above requirements, trucks used for hauling asphaltic concrete shall have tight, clean, smooth, metal beds which have been thinly coated with a minimum amount of paraffin oil, lime solution, or other approved material to prevent the mixture from adhering to the beds. When required by the supervising Engineer, each vehicle shall be equipped with a cover of canvas or other suitable material of such size as to protect the mixture from the weather.

6. MANUFACTURING OF ASPHALTIC CONCRETE :

6.1 Preparation of Asphalt Cement : Asphalt cement (binder) shall be heated within a temperature range of 135°C to 165°C at the time of mixing. All materials reheated more than 42 degrees centigrade above the maximum shown shall be considered overheated and shall be rejected until the material can be resampled and tested. The reacceptance or rejection will be based on the same requirements as established for the original material. Asphalt cement received from the refinery at temperatures in excess of 163°C but not exceeding 191°C, may be used.

6.2 The temperature of the aggregate largely controls the temperature of the mix, and as a general rule the difference in temperature between aggregate and asphalt should not exceed 15°C. Apart from other considerations which may affect mixing temperature, the most effective temperaturefor plant mixing is that at which the bitumen has a viscosity of 75–150 Sec. Saybolt Furol (150–300 centistokes). If information regarding the temperature/viscosity relationship is not available regarding the particular grade of bitumen being used, the following table gives a reasonable guide for mixing temperature.

40/50 Pen.	160 –	175
60/70	150 –	165
80/100	140 –	160
130/150	135 –	155
180/200	130 –	150

6.3. Preparation of Mineral Aggregate: The aggregate shall be in a surface dry condition prior to mixing. Each aggregate ingredient shall be heated and dried so that the temperature as recorded in the hot fines bin after screening shall not exceed 165°C. If the aggregates contain sufficient moisture to cause foaming in the mixture, or if their temperature is in access of 165°C, they shall be removed from the bins and returned to their respective stockpiles.

6.3.1 Immediately after heating, the aggregate or aggregates shall be screened into at least three (3) sizes and conveyed into separate bins ready for batching and mixing with bituminous material. When the aggregates furnished are of such size and grading that separating into three bins is impracticable, the number of required seperations may be reduced to two (2) with the approval of the Engineer. The efficiency of screening operations shall be sufficient to produce, at plant operating capacity, gradations in each of the sizes of heated and dried aggregates which are reasonably uniform and result in the production of a mixture complying with the limits specified for the aggregate.

6.4 Preparation of Bituminous Mixture: Dried aggregate as specified for bituminous construction and prepared as prescribed above shall be combined in the plant in the proportionate amounts as approved. Asphalt cement shall be introduced into the mixture in the proportionate amount determined by the Engineer in accordance with the Job Mix Formula.

6.5 Mixing Time: The then film of bitumen on the aggretate is hardened by exposure to air and heat and, therefore, mixing time should be the minimum needed to give uniform coating of the aggregate particles. Mixing time will depend on the speed of rotation and the arrangement of the paddles and also to some extent on the type of aggregate and bitumen being used. An average time for normal modern mixing plant is about 15 sec. mixing for dried aggregate followed by another 30 – 45 sec. after the bitumen has been added. On older plants where the speed of rotation is lower the mixing time wll be larger.

6.5.1 The length of mixing time for continuous plants will be determined by the following formula or other approved methods.

Mixing Time in seconds] = Pug mill dead capacity in kilograms / Pug mill output in kilograms/second.

6.5.2 However, the initial mixing time will be designated by the Engineer. Mixing time may be increased by the Engineer if additional time is necessary to obtain a homogeneous mixture and satisfactory coating.

6.6 quality Control Tests: Routine tests which should be carried out at regular intervals at the plant in order to control uniformity of production can be listed as follows:

6.6.1 Cold Feed: Checks should be made of the aggregate gradings in the various stock piles to ensure that there are no great variations from those used in determining the job-mix formula. If new aggregates with different gradings are supplied, the whole mix will have to be redesigned. Checks on the moisture content of the fine aggregate will also be found useful, as if there is a big change in moisture content bulking may occur which may mean that the cold feed should be adjusted in order to maintain the correct flow into the plant.

6.6.2 Hot Bins: Gradings should be carried out on the aggregates in the various hot storage bins, say, twics daily. VAriations here may be due to changes in the aggregates being fed into the plant but this should already have been discovered by the test at the cold feed. It is more likely that any differences will be due to over loading, blocking or wear on the screens.

6.6.3 Temperature: Regular checks should be made on the temperature of the aggregate at the exit from the drier and in the storage bins. A constant check should also be kept on the temperature of the bitumen in the storage tanks.

6.6.4 Mixed Materials: Regular checks should be made on samples of the mix; the number of samples taken for testing will depend on the capacity of the plant but about one per 100–150 tons production is suggested.

6.6.5 Samples should be taken from a lorry at the asphalt plant site as it is being loaded with mix -and then that lorry marked so that the foreman in charge of the laying site knows which loads have been sampled. Care should be taken in sampling to ensure that the sample taken is truly representative. It is preferable, therefore, to take material from a number of batches as they run into the lorry and then combine them into the sized samples required. Shovelfuls taken from the side of a full lorry may not be representative, as there may have been some segregation during discharge.

6.6.6 The size of sample required to carry out a full analysis will be about 30 lb. (15 kg). The temperature of the mix at the time of sampling should be recorded, and if Marshall tests are being carried out specimens should be compacted immediately before the mix has had time to cool.

If for any reason it has to be kept for a while, insulated boxes should be used in which to store the mix Compaction of Marshall specimens should take place on a standard pedestal mounted on a firm base, otherwise abnormally low compacted densities may be obtained.

6.6.7 Tests which should be carried out on the mixed material are as follows:

Marshall test –	Density
	Stability
	Flow
Extraction test –	Grading
	Bitumen content

By calculation other data regarding the mix can be obtained.

6.6.8 For the extraction test fresh material should be used and not the same sample as has been used in the Marshall test or cut from the paving, as such material may have been crushed slightly during compaction or absorbed some of any tack coat that may have been used.

6.7 Diagnosis of Unsatisfactory Mixes: The following brief notes may assist the Engineer in diagnosing unsatisfactory mixes.

6.7.1 Excess Bitumen: This is usually indicated by a sloppy mix which slumps too readily in the lorry. It can also sometimes be detected by a very fat appearance of the mix behind the screed on the finisher.

6.7.2 Lack of Bitumen: Such mixes have a dry lean appearnace lacking the typical shiny black lustre of a well coated mix On the road they may be harsh to spread and difficult to roll, with transverse cracks appearing under the roller which do not readily heal up.

6.7.3 Over-heated Mix: Excess blue smoke rising from the mix usually indicates over-heating and the temperature should be checked before laying. After laying, such a mix can often be detected by a brown dull burnt appearnace of the surface.

6.7.4 Mix too Cold: Such mixes are usually stiff and difficult to handle; the larger particles may also not be properly coated. Spreading will be difficult with a tendency for the mix to tear under the screed.

6.7.5 Excess Moisture: Mixes with too much moisture often have an appearance similar to ones with excess bitumen, in that they are sloppy and tend to slump in the lorry. The fact that moisture is the cause of the trouble can be detected by steam rising from the mix, and also sometimes the mix may appear to be bubbling as if it was boiling.

6.7.6 Poor Mixing: This will show up, particularly when the mix is laid, with some areas appearing lean and brown and others shiny and black where there is excess bitumen. Such mixes are often difficult to spot at the mixing plant or in the lorry.

6.7.7 Poor Grading: If there is too much coarse aggregate the mix may appear too rich and workability will be poor and it will appear rough and open-textured when laid. Too much fine aggregate on the other hand is often shown up by the mix appearing lean and too finely graded when laid.

7. SURFACE PREPARATION:

7.1 Before spreading the asphaltic concrete, the surface of sub-grade, sub-base or granular base-course shall be well prepared. The lines and grades shall be conforming to the contract drawings. The surface must be clean, dry, uniform and free of any undulations or loose materials.

7.2 Prime Coat: Prior to the placing of the asphalt mixtures, a liquid asphalt prime coat shall be applied on previously constructed, – earth sub-grade, water-bound base-course, shoulders and concrete bridge decks, or concrete pavement in accordance with the specifications.

7.2.1 The Bituminous prime-coat (medium-curing cutback asphalt) shall consist of an asphaltic base fluxed with suitable petrolium distillates. The product shall be free of water, show no separations prior to use and shall conform to all the requirements of the grade (MC-0 or MC-I) as specified in the contract or directed by the Engineer.

7.2.2 The rate of application of prime material shall be specified by the Engineer within the limits shown below as determined from field trials conducted on a test section or sections. The contractor shall, prior to the time he intends to begin his priming operation, prepare a test strip of an approved length for the determination of the rate of application for the prime coat. On projects when surfaces to be primed are constructed of different materials, a test section for each type of material shall be prepared by the contractor. The Engineer may order subsequent test sections and or alter the previously established rate or rates of application when he deems it necessary.

Application Rates

Type of Surface	Bituminous Material	
	Liter MC-I per square meter	
	Minimum	Maximum
a) Earth surfaces, water bound base-courses	0.65	1.75
b) Bridge wearing surfaces, concrete pavements	0.10	0.30
c) Other surfaces	As determined from test	

7.2.3 No asphaltic concrete will be apread on the bituminous prime coat before 48 hours after it has been sprayed, so as to make it sure that all the light volatile hydrocarbons have evaporated.

7.3 Tack Coat: Where apshaltic concrete is to be placed on existing bituminous surface, the surface of the existing layer shall be swept clean with a power broom, or by other means as approved by the Engineer and a tack coat of the specified grade of the Rapid-Curing (RC) liquid asphalts shall be applied.

7.3.1 A tack coat shall not be required between two lifts of bituminous courses when the previous lift is less than two days old or as directed by the Engineer.

7.3.2 When a tack coat is required the applkcation shall be very light (0.10 – 0.15 liters per square meter). Excess asphalt will seriously affect the life of the pavement.

8. TRANSPORT AND LAYING:

8.1 Transport of Mix: The mix must reach the laying site in much the same condition as it left the mixer; in particular, segregation of the aggregate and loss of temperature must be avoided.

8.1.1 The mix should be transported from the plant to the laying site in metal-lined lorries. To prevent the mix sticking to the inside of the lorry, the sides and bottom may be very lightly smeared with thin oil or a solution of time water, but care must be taken not to use an excess as this will have a damaging effect in the film of binder on the aggregate.

8.1.2 In hot climates and where the distance between the plant and laying site is short, the mix may be transported in open lorries, but in colder climates or on long hauls where there is likely to be any appreciable loss of temperature, the mix should be sheeted over to prevent loss of heat. The use of insulated lorries is often advantageous in this respect.

8.1.3 It is most important that the mix should arrive on the laying site at the correct temperature for laying and often the mixing temperature must be adjusted with this in mind. It is difficult to lay down fixed temperatures for laying as this will depend on the type of mix, and the weather conditions on site.

For example if there is a cold wind blowing then the mix will lose heat very rapidly and hence may be required on site at a higher temperature than would be the case on a mild windless day.

8.2 Laying: For laying, mechanical finishers are now normally used. They are designed to produce a level and even running surface and should be able to correct automatically minor irregularities in the base. The finisher should be operated at a constant speed suited to the type of mix being laid and the rate of supply. If the latter is insufficient to keep the machine working at peak capacity it is better for it to work at a low operating speed so as to maintain continuous laying, as frequent stopping and starting can be a cause of surface irregularities.

8.2.1 The ideal is to have a load of mix always ready to tip into the hopper of the finisher. Assuming the width of strip being laid is 8 ft., and the speed of the finisher is 15 ft./min., it will cover 800 yds^2 hour and if the mix being laid is 1 1/2 in. thick having a density of 2.4 about 60 tons of mix per hour will be needed to keep the finisher going continuously.

8.2.2 The lorry transporting the mix should be halted just in front of the finisher so that the finisher moves up to it, makes contact evenly with its rollers on to the rear wheels of the lorry and then pushes it forward. If the lorry is allowed to back up against the finisher while it is operating it can result in a distinct bump in the finished surface. Similarly if the lorry is not aligned properly with both rear wheels touching the finisher's rollers, the latter tends to move out of alignment and continual correction by the operator results in an uneven edge which makes good joints difficult to achieve.

8.2.3 An even flow of mix must be fed from the hopper across the full width of the screed and at intervals, depending on the type of mix, the hopper should be almost emptied in

order to prevent cooling of the mix on the sides of the hopper. Finishers are designed to lay varying widths so it is necessary to plan the lanes to be laid appropriate to the job. Extensions to the width are available on most machines and advantage should be taken of these to reduce the number of joints; on the other hand cut-off shoes are available to reduce the width of strip.

8.2.4 When working on gradients it is better to work uphill in order to prevent mix spilling out of the hopper and also to help control the finisher and the lorries supplying the mix If heating equipment for the screed is available this should be put into operation before laying starts to prevent mix sticking to the screed plate, and heat should also be applied during laying as and when required.

8.2.5 Nowadays, particularly for motor roads and airfield runway a very high standard of riding quality is required and tolerances of 1/8 in. in 10 ft. are frequently specified. This is difficult to achieve and requires special care in laying. It should be remembered that with any mechanical finishers it takes from 8 to 15 ft. before the effect of any alteration of the thickness control screw is felt, and therefore correction in levels must be made in good time. Turning the control handle 2 1/2 times will cause about 1 in. change in thickness and a good rule of thumb is to limit thickness control to 1/4 turn at any time as this ensures an even change in grade.

8.2.6 To obtain an accurate finish, particularly on long stretches of motorway or runway, it is a good idea to set up a grade line by means of a wire or guide rail for the finisher to follow. A metal pointer attached to the screed and extending in front of it is set to follow the grade line; this gives the operator the chance to anticipate in advance any change in grade and adjust the screed accordingly.

8.3 Joints: Good joints are essential if a satisfactory riding surface is to be obtained; poor joints can be a weakness in the pavement. Joints in the surfacing course should be staggered with those in the binder course and must be kept straight. It is impossible to get a good longitudinal joint if the finisher does not keep to a reasonably straight line when laying. When making longitudianl joints the finisher should overlap the existing strip by about 2 in., and sufficient depth of material should be left on the overlap to allow for compaction. Excess material should be removed by careful brooming or raking but care must be taken to avoid over-raking as this may result in an accumulation of coarse particles along the joint. Immediately after the finisher has passed and raking is completed the joint should be well rolled. Rolling should start at the joint, and when this is thoruoughly compacted the roller should then start at the other side of the strip laid, so as to roll the balance of the mix into the joint.

8.3.1 When the abutting lane is not placed the same day or if the edge of the first strip has been distorted by traffic, the joint should be cut back to an even line. This cutting back can be done manually or by means of a cutting blade attached to the rear of the roller. The joint should then be given a very light paint coat of bitumen before the next strip is placed.

8.4 Compaction: After spreading, the mix should be thoroughly compacted by rolling. It is preferable to use a 3-wheel roller for initial "break - down" rolling, followed by a tandem roller for finishing. The weight of the roller should be specified as applied wieght per in. width of rear wheel and suggested figures are 250-350 lb. width.

8.4.1 Rollers should proceed on to fresh material with the rear or driven wheels leading as the greater weight of the driven wheel in conjunction with the turning force tends to tuck the material under the wheel without pushing. Also, when the roller is reversed at the end of a pass, the steering wheel is on compacted material and its movement in changing direction will not displace the mix

8.4.2 After the longitudinal joint has been compacted, rolling should start longitudinally at the side and proceed towards the centre of the carpet, except on super-elevated curves where rolling should begin on the low side and progress to the high side. Each pass of the roller should overlap the preceding one by about one half width of the rear roller wheel. Alternate passes of the roller should be of slightly varying length and should not finish in a straight line across the road; this enables the roller on its next pass to take out any depressions or pushing which may have occured during the reverse pass of the roller. Rolling speed should be slightly slower than normal walking speed, i.e. about 2 miles per hour. The number of passes required will depend to a large extent on the thickness of the mix being laid, but as a general guide five to six passes over the same area should give the required density.

8.4.3 The roller wheels should be clean and smooth and to prevent adhesion of the mix the wheels should be kept slightly moistened with wate Excessive use of the water sprays must be avoided as this causes rapid cooling of the upper crust of the mix and fine haircracks may then develop as the roller passes.

8.4.4 It is difficult to lay down any hard and fast ruling as to the interval between spreading and rolling as it will depend on the type of mix, climatic conditions, type and weight of roller, etc. In general, however, rolling should commence as soon as the freshly spread mix will bear the weight of the roller without any undue movement or displacement. Normally, with mechanical spreading where the mix is initially consolidated by the finisher, the roller can follow up immediately. On no account must the rollers be allowed to stand on the finished surface until it has thoroughly cooled.

8.4.5 Immediately following initial rolling, the surface should be checked with a straight edge to ensure it meets the smoothness requirements. Minor variation can be corrected by rolling, but larger imperfections need to be corrected by adding or taking away mix while it is still hot and workable.

8.4.6 For airfield surfacings and motorways carrying very heavy traffic it is sometimes difficult to compact asphaltic concrete, particularly lean mixes, with ordinary steel tyred rollers so that further densification does not occur under heavy channelized traffic. In some cases this further densification under traffic leads to objectionable rutting in the traffic lane.

8.4.7 To achieve the very high initial densities which will help to eliminate this problem it is good practice to use pneumatic tyred rollers. These should be of the self-propelled type with a weight of 15-30 tons and tyre pressures which can be varied between 75-120 lb./ $in.^2$.

8.4.8 This pneumatic tyred rolling should be carried out immediately following the initial "breakdown" rolling with the 3-wheel roller and while the mix is still warm, say, 175-250°F. (80-120°C.) The final finish again being given by a tandem roller.

8.4.9 One of the most common causes of unsatisfactory compaction of asphaltic concrete work nowadays is the use of too few rollers for the tonnage being laid. At least two rollers should always be used, and additional rollers may be necessary to get the required density. As a rough guide one roller can compact about 300 $yes.^2$ per hour or on a tonnage basis two rollers for upto, say, 50 tons of mix per hour and one additional roller for each additional 30 tons or fraction thereof. In warm weather back-rolling the following day will help to increase the density of the paving if tests have shown initial rolling has not been adequate.

.5 Density Requirements: Experience has shown that for satisfactory quality work the compaced paving should have a density of not less than 98% of the laboratory Marshal density. This standard of compaction is not difficult to obtain provided rolling technique is correct.

5.1 The voids in the compacted paving are related to the density and it has been shown that for each 1 % drop in density the voids in the mix increase by anout 1%. So a mix with a designed V.I.M. of 4% and compacted to 98% density will in fact have a V.I.M. of about 6% when laid.

5.2 Under traffic, densification occurs fairly rapidly but in a well designed mix it should then

level off at about the designed voids content and not density much further. For very heavy trafficked roads, and runways and taxi-tracks carrying channelized traffic, this resistance to further densification is of great importance. It is better to design a mix with a fairly low V.I.M. that densifies slowly than to try to obtain the same results by starting with a high original V.I.M.

8.6 Density and Thickness Determination: The samples shall be cut with an approved saw or core drill from the compacted paving for the determination of the field densities and thicknesses. The field density shall be determined by weighing the sample in air and than in water (AASHTO T-166).

8.6.1 The compacted thickness of any layer of paving shall not vary more than ten(10) per cent of the thickness requried for each course, or more than five milimeters (+ 5 mm), whichever is smaller. The full depth of any course shall be replaced, as outlined in paragraph 9.7.2 below, over all areas on which tolerances are exceeded.

8.7 Surface Tolerances: The surface will be tested with a three (3) meter straightedge by the supervising Engineer at selected locations. The variation of the surface from the testing edge of the straightedge between any two (2) contacts with the surface when placed on or parallel to the centreline or when placed perpendicular to the centreline shall at no point exceed.

For surface course – 3 mm
For binder or regulating course – 6 mm

8.7.1 Neither the top of the binder course nor the top of the surface course shall vary from rhe required elevation more than five (5) millimeters above or below.

8.7.2 All the humps and depressions exceeding the specified tolerance shall be corrected by removing the defective work and replacing it with new material as directed by the Engineer. The full depth of Binder Course or surface course shall be removed and replaced with fresh material laid and compacted as specified. Where the surface level of binder course or surface course is too high or too low, the area corrected shall be the – full width of the paving laid in one operation and at least five (5) meters long if binder course or fifteen (15) meters long if surface course.

ii) OUR EXPERIENCE ON THE EXECUTION OF LAHORE – PATTOKI SECTION OF THIRD HIGHWAY PROJECT

MISCELLANEOUS

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B.O.Q. items of the Contract Lahore – Pattoki Sahiwal Section are discussed as executed by the contractor with difficulties & suggested remedies.

R.E's Office, Camp & Maintenance

a) Instead of rented office accomodation, construction camp be constructed by the contractor and maintained so as to provide all amenities to the supervisory staff.

b) All the furniture & equipment be arranged thru the contractor.

c) Transport be provided thru the contractor & maintained thru the contractor's workshop.

d) Base Lab. building be constructed thru the contractor & made part of the construction camp.

e) Furniture & equipment be arranged thru the contractor. The testing equipment, in this case, was provided by the client since most of the equipment was available with the client. Ordinarily, if arranged thru the contractor gets delayed for some reason or the other. The arrangement worked well and lacking equipment was imported thru the contractor.

f) Maintenance of traffic during construction :
As it is a rehabiliation project, C of old and newly constructed highway being the same (except for reach from Akhtarabad to Sahiwal), the contractor was required to maintain the traffic during construction. Keeping in view various phases of construction of sub-grade, sub-base laying & preparation, laying asphalting base and wearing course etc, an optimum length of 5 Kms of detour was considered to be most appropriate, detailed as under :–

a)	Stretch under Clearing & Grubbing	=	1 Kms
b)	NSL compaction	=	1 -do-
c)	Sub-grade preparation	=	2 -do-
d)	Sub-base preparation	=	0.50 Kms.
e)	Laying of asphaltic base	=	0.50 -do-
f)	Laying of Wearing Course (on completion of asphaltic base)	=	1 Kms.

Maintenance of traffic for 5 Kms stretch was excessive (for 5 – 6 months) initially at

the start of work but it reduced to 5 – 6 weeks at the completion of contracts both for 3 & 4. In case, detour exceeds 5 Kms length, maintenance of detour is difficult by the contractor so as to check riding quality & dust-free surface. Arrangement of traffic police be done through the client so as to ensure adequate traffic control.

HANDING OVER OF SITE

It was a problem to hand over the site to the contractor on account of the following obstructions in the highway R.O.W.

i) Trees belonging to the Forest Department
ii) Telephoen lines & poles of T & T Department
iii) Power lines of WAPDA
iv) Water course flowing along highway & etc.

i) Trees

To start with, the trees could not be cut right away due to the completion of official formalities and the approval of the Government. Sometimes, the trees cannot be cut/felled because of proximity of utility lines when the Forest Department required the client/co-ordinator for removal of utility lines first.

ii) Telephone Lines & Poles

Telephone lines are installed in the highway R.O.W. on their own without getting any approval from the Owner/Highway department. The telephone lines are not relocated unless deposit is made by the client as per the deposit estimate submitted by the T & T Department. It is unnecessary botheration to the Engineer & unnecessary expense to the client. Highway R.O.W. should not be used by T&T Department.

iii) Power Lines

a) Parallel to C of highway

Same as above for telephone lines

b) Transverse to Centre Line of Highway

Nowmally, it is so in urban limits or sometimes in open areas for connection

to tube-well's etc. Vertical clearance of such lines was found less than allowable after contrruction of highway as it requred about 3' raising in Contract No. 3 & an average of 4.5' raising in Contract No.4, thus necessitating raising of such transverse lines. Again the power lines should be allowed to cross the highway with approval of the Owner/NHB/Highway Department.

iv) Water Courses

a) Flowing parallel to Centre Line of Highway

Earthen water courses are very dangerous to the highway and should be got relocated outside highway R.O.W.

To summarise above, highway R.O.W. should be used solely by the highway for its future maintenance & expansion as such utility lines be located outside the R.O.W:–

g) Repair to Existing Structures – Bridges & Culverts

It was a cause of lot of discussion between the supervisor and the contractor. The condition of bridges was mostly satisfactory in contract Nos. 3 & 4 at the time of preparation of contract documents of the project; the condition as assessed at the time of construction after a lapse of about 4–5 years was different & embarrasing for the supervising Engineer. The client, as such, decided to review the condition of bridges, existing on minors, distributaries and canals and allowed new construction on a few. But for culverts, it was decided by the client to re-construct 100% which was mostly followed by use of 2.0' dia extra strength R.C. concrete pipes, or combination thereof, for ease in maintenance in future.

II EARTHWORK

a) Clearing & Grubbing

The Engineer must ensure that the cross-sections of NSL have been recorded before the start of this activity. Cross-sections of the original NSL be taken jointly with the contractor's representative to avoid any dispute, in future, for quantity calculation of earthwork.

b) Stripping

The contractor must submit the location of borrow area marked on print of the

standard drawing duly plotted to scale. Similarly, borrow area be demarcated in the field. Top 30 cm of the borrow area be removed & checked with levelling for a grid of 20M interval each side. As depth of the borrow area was limited to 1.2 m, and the no. of borrow areas was spread over the entire length of the project, stripping was allowed 33% of the embankment quantity laid in place. Grass roots were observed, soon after the decision, as noted above which was conveyed to the contractor. However, the above decision facilitated our surveyor's duties who was employed usefully elsewhere on the project execution.

c) Compaction of Natural Ground

NSL compaction was resorted to in whole of Contract No.3 and 1/5 of Contract No.4 upto Akhtarabad. Mostly A-4 soil was encountered which was compacted to 98% of standard Proctor AASHTO T–99. Checking of field compaction was done by sand cone method AASHTO T–191 upto a depth of 15 cm.

d) Structural Excavation in Common Material

There was no problem in Contract No.3 However, in Contract No.4, difficulty was encountered beyond Renala when excavation was started for storm drainage structure in monsoon season. The soil was too wet and lean concrete of 30 cm (1 foot) depth was poured on which the culvert construction was accomplished.

e) Formation of Embankment & preparation of Sub-Grade

Stepts involved are

a) Designation of borrow areas by the contractor.

b) Checking of M.D.D. and O.M.C. by the method AASHTO T–99, C.B.R. by AASHTO T–193, Atterberg's limits and Classification of the above soil by AASHTO M–145–73.

c) Checking of field compaction by sand cone method. Earth is compacted in 15 cm layers. Top two layers are compacted upto a min. of 100% of the M.D.D. determined in the lab. by ASSHTO T–99 and the lower layers upto 98% compaction of the same. C.B.R. required is 3% or more. The soil available along the project is generally A–4 (4–6) type with M.D.D. usually tranging between 1.82 g/c.c. to 1.88 g/c.c according to AASHTO T–99.

Frequency of tests is 100 C.M/Test.

f) Sub-grade Preparation in Earth Cut/Existing Ground

As estimated, very little quantities was encountered against this item viz at

i) B.S. Link canal between Bhai Pheru & Pattoki.
ii) Level crossing at Gamber/Okara Cantt. Railway station.

Fill from approved borrow area was used for 60 cm (2') depth for both (i) and (ii) above.

g) Excavation of Unsuitable Common Material

Certain stretches were found to be having slush which were required to be removed. It was primarily due to the accomulation of water from the water courses flowing parallel to the highway and leaking of culverts etc. The slush between Akhtarabad and Sahiwal is mainly due to rising of sub-soil water level and excessive seepage thru canal network used for irrigating the adjoining areas where sand core with earthen dowels was adopted for highway construction.

III & IV – SUB-BASE, BASE AND SURFACE COURSE

a) The Improved Sub-Grade (ISG) & Improved Sub-Grade using Gradation 'F' Material

Improved sub-grade (ISG) consists of a mixture of soil from the adjoining fields beside the R.O.W. edge mixed with sand in 70 : 30 ratio.

The sand is obtained from the river bank flowing along the highway. Similarly, the Gradation "F" material consists of :

1) 3% CBR Soil
2) Sand
3) Stone Dust

All of which was mixed in ratio of 70 : 20 : 10 respectively.

Mixing of materials for the improved sub grade and Gradation "F" material was not achievable by the contractor and if achieved, accasionally required greater effort as such on both the improved sub grade & Gradation "F" was replaced by soil having 7% CBR

requirement which is available in selected borrow areas especially near the high bank of the River Ravi flowing close by. Overall design of the embankment for this project was, therefore, revised.

In general, the design of embankment requires an improved subgrade earth-fill of 3% CBR material overlaid with 15cm (6") layer of an improved subgrade and 15 Cm layer of Gradation "F" materials requiring 7% and 10% CBR requirement respectively.

b) Sub-Base from Old Pavement

It was planned to obtain sub-base material from ripping the old pavment. The crushed stone could not be separated from the top crust containing bituminous material as such was considered unfit for use in sub base. All the material obtained from ripping the old pavment was used for construction of topping of the detour and behaved very well under the traffic.

c) Granular Sub Base from Imported Material

15 Cm compacted thick crushed stone, having window drains placed 10M apart staggered at 5M on each side of the road, consists of a mixture of crushed stone, sand and stone dust in the ratio of 70 : 20 : 10 as a drainage layer laid over the embankment. Sub-base laid-in-place to required line and grade is compacted to 100% modified density as per AASHTO T–180 method 'D' i.e. modified method. Stone dust is haulte from the crushers which are installed at the quarry site located about 250 Kms from the work site.

Asphaltic Base and Wearing Course

Asphaltic Base laid in 14Cm–thick layer over the primed surface of sub-base consists of the following :

i) Well graded crushed stone passing 1½" (9-37.5 mm)
ii) Fine Aggregate – Sand (5 – mm)
iii) Stone dust (0 – 5 mm)
iv) Bitumen (80 – 100) penetration

Aggregate proposed for hot bin gradation was generally in the ratio of 42 : 27 : 31 respectively and bitumen (80 – 100) penetration at 4.255 by weight of the mix

Similarly, constituents of the wearing course are identical to the asphaltic base, dif-

ference being in size of the aggregate which is passing 1" size. Crushed stone and stone dust are imported from Sikhanwala quarry located 250Kms, on the average, from the project site. Sand is haulted at a distance of 50 Kms, on the average, from the project site.

CRUSHED STONE

Crushed stone is a vital component of the asphalt mix and the nearby Sikhanwali quarry was auctioned in open public to the contractor, as per the Country's law at a very high bid which ordinarily was auctioned in a couple of thousands of rupees for excessive stone requirement. It is amazingly correct that the contractor could arrange up to hundred cubic meters of stone/day at a cheaper rate than thousands of cubic meter of stone supply/day which quantity was an absolute must for timely completion of the project.

The above conditions required the contractor to install his own jaw crushers at the quarry site with requisite screens to cope with the project requirements. The crushers installed at the quarry site by others did not produce crushed stone of any grading but used for crushing stone only & do not meet any grading requirement. The installation of crushers by the contractor are of utmost importance to cope with the :

i) Quality stone
ii) Requisite quantity
iii) Grading
iv) Low cost

SUPPLY OF BITUMEN

Bitumen, 80 – 100, penetration, though produced in small quantities within the country, is insufficient and is required to be imported from abroad, the cost of bitumen at the start of the Project (or at the time of preparation of the Project estimates about 4 – 5 years back was $150/MT (Rs.2200/MT) and now at the time of completion of the Project is $240/MT (Rs.3300/MT). The increased cost of the supply of bitumen is being subsidised by the Government.

STONE DUST

Stone dust is available in large quantities at various quarries situated in Sikhanwali. It is a cheap material since it is obtained as a surplus material from the crushers.

SAND

Sand for the project use is obtained from the River Ravi flowing close–by or from Chunian at a distance of about 15 Kms from Pattoki end of the Project.

V STRUCTURE

a) Concrete class A & Lean Concrete

The contractor was required to prepare test cylinders from the materials available/ stockpiled for making the concrete. The trial mixes as well as the test cylinders were prepared to test at 7 & 28 days. The required ratio was then obtained to be used on construction of culverts as a whole.

For construction of 4 Nos bridges between Renala & Sahiwal, testing of test cylinders was considered more important as such those were tested at two different compression machiens in order to confirm the results and avoid any errors by the testing machine. Handling of test cylinders from the worksite to the base lab. and the testing machine is a delicate affair which should be given due attention.

VI DRAINAGE AND EROSION WORKS

For extension of bridges on the irrigation minor or to account for the storm drainage, 90 Cm dia pipe was used. For construction of culverts on water courses, 60 Cm dia pipe was considered adequate or combination thereof. In no case, 45 Cm dia pipe was used to cross the drainage under the highway because of the difficulty of cleaning, removal of silt etc. in the short diameter pipe.

In the urban areas, 60 Cm dia pipes have been provided in-consultation with the municipality concerned, P.H.E.D., T & T & WAPDA to cross their utility lines in future except for storm drainage for which special 60 Cm dia pipe is provided.

BRICK PAVING

It is an additional work which covers 1.7 M of shoulder width with bricks laid at 4½" edge. 9" x 4½ x 3" bricks are available at the site of work in abundance since a number of kilns located all along the road produce bricks of required quality.

VII ANCILLARY WORKS

a) Urban Drain

The drainage is provided in urban areas/villages which are located on the main highway. Cleaning of this drain has become a problem since the villages/small townships lack organized local body. In most of the urban areas no stram/Nallah was available to drain off the local drainage as such drain was not provided.

b) Pavment Marking

Non-reflective paint is used for lines to mark on pavment which needs to be maintained after 4 months.

VIII SPECIAL ITEMS

a) Removal of Old Pavment

Removal of lod pavment was necessary in order to rehabilitate the project on the original centre line. The ripped-up material was solely used for construction of detour on the whole and the top crust was used as topping of detour. D–8 bulldozer was used to rip-up the road and its progress was about 1 Km per day (8 hours).

IX UNFORESEEN ITEMS

a) Sand filling in tree-pits after the trees were removed by Forest Department.

b) Sand filling in slushy areas and NSL sand filling in water-logged area from Akhtarabad area to Sahiwal.

c) Sand filling in Akhtarabad to Sahiwal.

d) Covering of Urban drain in front of Shops

All shop keepers requested to cover the drain in front of their shops.

Quality control – see last page.

SITTING OF ASPHALT PLANT

Lahore–Pattoki Contract No.3 and Pattoki–Sahiwal Section Contract No.4 were awarded to M/s Saadullah Khan & Brothers in June, 1980. On receipt of the mobilization advance and completion of other formalities, the contractor imported only one asphalt plant for both the projects

of 100 ton/hr. capacity. To start with, one used asphalt plant of Barber Greene make was also arranged locally thru the Ministry of Housing and Physical Planning at Lahore; This used plant was procured and installed almost at mid-point of Contract No.3. The old asphalt plant was used for three months or four but was not working efficiently. In the meanwhile, new asphalt plant, plant No.1 which was imported from Germany, arrived and was installed beside zero point of Contract No.4; but about 6 Kms from the contractor's construction camp, for ease in maintenance and closer to Lahore. Construction of both the Contracts viz 3 & 4 could not be accomplished because of one asphalt plant of 100 ton/hr. capacity for both the projects as explained below :–

Asplant concrete requirement/Km	=	4000 Ton
Monthly progress for both Contracts 3 & 4	=	2 x 3 = 6 Kms
Average daily production Max lead being 57 Kms)	=	600 – 700 tons
Average monthly production (20 working days – 16 days breakdown.)	=	12000 – 14000 tons.

The contractor was thus advised of the necessity and requirement of another asphalt plant (Plant No.2) which was imported and installed again at the mid-point of remaining portion of the project Contract No.3, as work on the other section contract No.4 was suspended in the meanwhile. On completion of Contract No.3, by working at two No. worksites in this section, remaining project length of 31.8 Kms was completed in 6 (six) months thus achieving an average of 5.3 Kms/month with a peak production of 6.8 & 8.9 Kms in December, 1983 and Janaury, 1984 respectively. Remaining length of Contract No.4 of 67.5 Kms was taken in hand in February, 1984, thus again with 2 worksites :–

i) From Akhtarabad to Okara city 29 Kms/stretch

ii) From Okara Town (Sahiwal end) to Sahiwal 34 Kms stretch Asphalt plant No.2 was thus installed at Sahiwal end of Okara town. Thus asphalt No. 1 installed at Pattoki (Km 69) was successfully used for asphalting upto Km 96 beyond Renala Khurd. Lead being excessive, it was planned to shift asphalt plant No.1 from Km 69 to Km 141. Thus at this stage, asphalt plant No.2 was used to asphalt from Km 96 to Km 131/132 average lead of 18.Kms on both ends and asphalt plant No.1 was used to asphalt remaining portion from Km 131/132 to Km 149. (Average lead of 9/10 Kms). As such, contract No.4 was completed. In Contract No.4, average monthly production was 15000 tons wth peak production of 30400 and 25000 tons in Jan. 1985/Feb. 1985 respect-

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ively.

Procurement of Spares

Both the asphalt plants were on some accasions out of order simultaneously just because of deiay in procurement of spares from abroad. Local agents had no spares in stock and arranged to import as per request from the customer. Even such supplies, by air, took 3 – 4 weeks to reach the destination as such the asphalt plant could not work in that duration. Wherever the reach was ready to receive asphalt, the asphalt plant which was in working order was used to supply asphalt concrete irrespective of its haulage. In some case this lead was found to be around 30 Kms.

Completion of Project

After completion of project, following points are observed :–

a) Raising of Plinth

In Wan Radha Ram & Okara City, the highway is raised by 4 to 5 feet from the original level. On completion of new highway, the shop keepers have reconstructed their shops by about 2 feet above the finished road level as such drain from the shop is always towards the main highway. It should be checked so that none changes the topography in the highway R.O.W.

b) Reduced Capacity

Due to the movement of slow moving tractor trolly carrying sugar-cane, hay and fodder etc having width about 2.5 m – 4.5 m, the capacity of highway is reduced considerably thus affecting the highway speed, as a whole.

c) Drainage of new developments

New developments keep on growing as such these drain off towards main road in the R.O.W. of highway. As the drainage can not be drained thru local stream/ Nallah flowing it remains close-by there, thus affecting adversly the road em-bankment.

d) Installation of utility lines

The R.O.W. of highway be checked strictly so as not to allow the utility lines within

within the R.O.W. of highway unless allowed by the owner/NHB/Highway Department. Even transverse crossings of utility lines be approved by the owner/ NHB/Highway so as to have sufficient vertical clearance.

QUALITY CONTROL

Quality control on various B.O.Q. items of the project was maintained at all phases of various activities. Constant vigilance is necessary so as to have the requisite standard of work. Quality control standards were kept tight in the beginning and as the work progressed, the standards were relaxed in view of better progress care as regards the aggregates, quality of asphalt concrete and laying precision which was checked fortnightly/daily as required. As soon as the quality of crushed stone, grading or source of aggregate was changed, new JMF was prepared jointly with the contractor for the change as opposed to the previous JMF. In order to achieve good riding quality, one surveyor of the supervisory staff was especially deputed to control the laying of asphalt for all the two layers of asphaltic base and top layer of wearing course since the laid asphalt is difficult to rectify later on.