PDAAU-603

Government of the People's Republic of Bangladesh

Rural Employment Sector Programme - Bangladesh

FINAL REPORT ON ROAD SURFACING TRIAL, 1986 IN RAJBARI DISTRICT

PART-I: MAIN TEXT

BCL
Bangladesh Consultants Ltd
Consulting Engineers & Architects
4 Dhanmondi RA, Road 14
Dhaka-9

For
TECHNICAL ASSISTANCE TEAM
TO THE I D P HQ UNIT

MARCH 1987

DANIDA
NORAD
SIDA

Road Surfacing Trial Project, Rajbari

C O N T E N T S

PART-I: MAIN TEXT

		Page
	SUMMARY	
Section 1 :	Introduction	I/1
Section 2 :	Surface Types	I/1
Section 3 :	Final Design & Selection of Materials	I/3
Section 4 :	Costing, Tendering and Execution	I/5
Section 5 :	Selection of Materials, Quality Control and Supervision of Construction	I/7
Section 6 :	As-built Conditions at the end of Construction	I/8
Section 7 :	Asphalt Emulsion	I/10
Section 8 :	Comments on Possibilities of Constructing Low-cost Road	I/11
Section 9 :	Post-construction Monitoring Programme	I/12
Section 10 :	Analysis of Results Observed during Monitoring	I/13
Section 11 :	Cost Considerations	I/26
Section 12 :	Performance Efficiency of Low-cost Surface Treatment	I/30
Section 13 :	Maintenance	I/33
Section 14 :	Miscellaneous Considerations	I/42
Section 15 :	Conclusions & Recommendations	I/49
	ANNEXURES	
Annexure 1 :	Project Location Map	I/54
Annexure 2a to 2g :	Typical Cross-section of Each Type of Trial Section	I/55
Annexure 3a :	Cost Estimate at Present Market Rate (Faridpur)	I/62

Annexure 3b :	Assumed Rates of Labour and Materials in Cost Estimates	I/63
Annexure 4a and 4b :	Planned vs Actual Progress of Work for Group A & B	I/64
Annexure 5a & 5b :	Histogram Showing Fluctuation of Labour Employed for Group A & B	I/67
Annexure 6a :	Measure of Performance of Labour	I/68
Annexure 6b :	Measure of Performance of Equipments	I/70
Annexure 7 :	Programme of Investigation and Testing for Quality Control of Materials and Works	I/71
Annexure 8a to 8j :	Variations Between As-built Longitudinal Profile along CL and Monitored Profile (after six months)	I/74
Annexure 9a to 9c :	Test Results of Asphalt Emulsion	I/84
Annexure 10 :	Maintenance Schedule	I/85
Annexure 11 :	Recommended Pavement Structure	I/88

PART-II: APPENDICES

Appendix 1 :	Design Criteria vs Field Test Results of Sub-base and Base Courses	II/1
Appendix 2 :	Summary of Field Test Results	II/16
Appendix 3 :	Number and Types of Tests Performed during Construction	II/18
Appendix 4 :	As-built Levels vs the Level Recorded during the 6-month Monitoring Programme	II/19
Appendix 5 :	Record of Observation during Monitoring Period	II/27
Appendix 6 :	Summary of the 5-day Traffic Count	II/37
Appendix 7 :	Location and RL of Flood Level Gauges and GI Stand-pipes	II/38
Appendix 8 :	General Comments from Monthly Monitoring Reports	II/39
	PHOTOGRAPHS	II/51

SUMMARY

1.0 Introduction

1.1 The object of the trial was to study and find one or more type(s) of labour intensive, low technology, low cost, semi-pucca, all-weather road suitable for rural Bangladesh. This was to be achieved through literature survey, investigation, design and construction of a number of road types, each 100m long, and then monitoring their performance under normal traffic with the object of determining which type(s) stand up best in terms of cost, deterioration and maintenance.

1.2 Ten types of sections were chosen for trial falling under three broad categories:

a) HBB Brick Roads

Type 1: With single brick flat soling over sand sub-base

Type 2: Over sand-soil sub-base but without the brick flat soling

Type 3: Over aggregate-sand-soil sub-base but without the brick flat soling

b) Water Bound Macadam (WBM) Roads

Type 4: Over sand sub-base and surface dressing with asphalt emulsion and pea-gravels

Type 5: Over sand-soil sub-base and surface painting with asphalt emulsion

Type 6: Over sand-soil sub-base and surface dressing with asphalt emulsion and pea-gravels

c) Aggregate Stabilised Soil (ASS) Roads

Type 7: With aggregate-sand-soil base over sand-soil sub-base and surface painting with asphalt emulsion

Type 8: Same as Type 7 except for surface dressing with asphalt emulsion and pea-gravels

Type 9: With aggr-sand-soil base topped with brick aggregate grafting, sand-soil sub-base and surface painting with asphalt emulsion

Type 10: Same as Type 9 except for surface dressing with asphalt emulsion and pea-gravels

2.0 HBB Brick Roads

2.1 HBB brick road Type 1 is a conventional road type and widely used in Bangladesh. Types 2 and 3 attempted to assess the effect of omitting the standard single brickflat soling and the sand sub-base and using in their place a sand-soil sub-base in Type 2 and an aggr-sand-soil sub-base in Type 3. Also, it was intended to test if by sealing the joints between the bricks by asphalt emulsion the moisture content of the sub-base can be maintained within acceptable limits.

2.2 It was observed that the depressions along the trackways of Types 2 and 3 were more than those in Type 1 and also moisture content of the sub-base was higher. The latter was caused by ineffictive sealing of the joints by asphalt emulsion resulting in ingress of rain water.

2.3 Due to this failure of joint sealing it became difficult to draw any definitive conclusion except that perhaps, if the sealing is effective, the single brickflat soling can be omitted and the cheaper sand-soil or aggr-sand-soil sub-base can be used. However, these can only be confirmed after further trials.

3.0 WBM Roads

3.1 WBM road, Type 4, is also a conventional road type, widely used in Bangladesh - but with bituminous carpeting which makes it a much too expensive a proposition when considered for use as rural roads. This trial, therefore, attempted to assess the performance of cheaper forms of WBM roads by, one, using cheaper forms of surface treatment and, two, by omitting the conventional sand sub-base with cheaper sand-soil sub-base as in Types 5 and 6.

3.2 It was observed that:

a) the pavement settlement in all three types were of similar magnitude;

b) the moisture content of the sub-base, at the end of the monsoon, was also similar in all three cases;

c) the surface painting treatment, in Type 5, cracked extensively and there was also moderate loss of painting from the surface;

d) the surface dressing, in Types 4 and 6, exhibited satisfactory performance as the sealing remained more or less in tact, except for loss of pea-gravels which remained uncoated during surface dressing.

3.3 As a result, it can be concluded that

a) the cheaper types of sub-bases can replace the conventional sand sub-base;

b) the cheaper surface treatment consisting of surface dressing with asphalt emulsion and pea-gravels can replace the conventional bituminous carpeting, but will require regular and timely maintenance. However, further trials are required to confirm these findings.

4.0 ASS Roads

4.1 The Aggregate Stabilised Soil (ASS) Road was an innovative type, not previously used in Bangladesh - though, from literature, it appears to have been used widely in India. The main advantage of this type is that it reduces considerably the use of bricks which forms the single largest component of cost of conventional pavements. Four variations of ASS roads were tried with varying base courses and surface treatments as given in para 1.2 above.

4.2 Although the costs of the pavement structures of ASS roads (i.e. excluding the surface treatment) were considerably lower than those of the other two catagrories, the ASS roads exhibited characteristics which compared favourably with those of HBB and WBM catagories.

4.3 All the ASS roads had the same pavement structure but the performance varied from type to type for reasons explained below:

a) Type 7 had surface painting which had cracked and peeled off from scattered areas due to inconsistent quality of the asphalt emulsion. These deteriorations, along with some depressions, occurred gradually and also patch repair to some damaged spots were done which prevented sudden and severe damage from developing. A resurfacing with bitumen and pea-gravels at the end of the monsoon restored the surface to its as-built condition.

b) Type 8 had surface dressing with asphalt emulsion and pea-gravels which was effective in sealing the surface. As such, moisture content of the sub-base remained close to as-built condition. Except for a few small localised areas from where pea-gravels were lost, no other deterioration occurred and repair/maintenance requirement was minimal.

c) Type 9 had surface painting which developed extensive cracks and lost a large part of the painting in the very first month after construction. This was due to poor quality of the asphalt emulsion (more about that in para

5.2 below). Depressions developed which, due to almost complete lack of maintenance, quickly aggrevated into extensive damages until in the third month ruttings, 100 mm deep, developed along the trackways. The whole trial section had to be repaired through scarifying the base, recompacting and resurfacing with bitumen and pea-gravels to restore it to the as-built condition. Had timely and effective maintenance been undertaken the damages could have been avoided with resulting saving of expensive repairs.

d) Type 10 had the same pavement structure as Type 9 except for surface dressing with asphalt emulsion and pea-gravels in place of surfacing painting. Like in the case of Type 9 a small damaged portion, about 3 sqm, remained unrepaired which, during the heavy rains of Sep-Oct, 1986, spread quickly over a length of about 34m. Expensive repairs, like in Type 9, restored it to as-built condition. In the rest 66m of the trial section, except for scattered cracks in the surface dressing, no other deterioration was observed and the pavement remained in good condition, like Type 8, till the end of the six-month monitoring period.

4.4 Conclusions drawn regarding ASS roads are as follows:

a) Given an effective surface sealing their performance can be equally good as the WBM roads and better than HBB roads

b) In terms of initial investment cost, ASS roads average about 37% cheaper than HBB roads and 32% cheaper than WBM roads. These are based on cost of pavement only.

c) Also, construction of ASS roads involves a more labour intensive method than for the other two catagories. This, together with (b) above, was one of the objectives of this trial.

d) In terms of maintenance cost also it appears that ASS roads have advantage over the other catagories

e) However, ASS roads would require timely and effective maintenance otherwise deterioration is likely to be rapid and damaging.

f) Also, during its construction it is necessary to have a measure of quality control in order to ensure an aggr-sand-soil mix as per design.

5.0 General

5.1 The conclusions drawn above are based on a single trial and are, therefore, necessarily of tentative nature - particularly so due to the unpredictable behaviour of asphalt emulsion. Nevertheless, these trials have succeeded in throwing up some promising lines of investigation through further trials.

5.2 One of the main reasons for the tentative nature of the conclusions is that the asphalt emulsion used were of variable quality - the bulk of it falling outside the range of specification. Owing to its high viscocity it had no penetration effect and limited adhesion to the base course. This resulted in development of cracks in the surfacing and loss of painting which distorted the performance of the different pavement types.

5.3 Section 15 elaborates the findings, conclusions and recommendations in greater details.

FINAL REPORT
ON
ROAD SURFACING TRIAL PROJECT, RAJBARI

1.0 INTRODUCTION

In April, 1985 Bangladesh Consultants Ltd were requested by Sir M MacDonald & Partners Ltd, under IRWP (presently RESP, but referred to in this Report as IRWP), to submit proposals for undertaking two Road Surfacing Trial Projects, one in Faridpur and the other at any other suitable location. The purpose of the Trials was to study and find one or more type(s) of labour intensive, low technology, low cost, semi-pucca, all-weather road surface(s) suitable for rural roads in Bangladesh. As per ToR, this was to be achieved through design and construction of a number of road types, each 100m long, and then monitoring their performance under normal traffic with the object of determining which type(s) stand up best both in terms of minimum deterioration and requiring minimum maintenance.

After negotiations, a contract was signed between Bangladesh Consultants Ltd (herein referred to as the Consultants) and Sir M MacDonalds & Partners Ltd on 3rd August, 1985 under which it was agreed that a single Trial at Rajbari, on the Rajbari-Baliakandi road, would be taken up. Location map of the Trial strip is included as Annexure-1.

2.0 SURFACE TYPES

As a basis for discussion, the Consultants, on 11th September, 1985, submitted preliminary recommendations consisting of 16 different surface types including two with cement stabilised base. After detailed discussion, the Project Coordination Committee finally recommended that the following 10 types of pavements be constructed and tested for performance:

a) HBB Brick Road

Type-1: HBB Brick Road with single brick flat soling and sand sub-base. This type is presently used in Faridpur ZRMI Project.

Type-2: HBB Brick Road with sand-soil sub-base.

Type-3: HBB Brick Road with aggregate-sand-soil sub-base.

Type-1 was to be compared with Type-2 and Type-3 in respect of performance efficiency.

In both Types 2 and 3, the costly item of brick flat soling was omitted and the joints of HBB brick pavement were designed to be sealed with asphalt emulsion in an attempt to make the surface pavement water tight and thus to maintain the sub-base materials more or less consistent in its functional properties. It was to be observed and determined during the monitoring phase of the project if it resulted in longer life expectancy and/or lower maintenance cost.

b) Water Bound Macadam Road

Type-4: Water Bound Macadam (WBM) Road with sand sub-base and surface dressing with asphalt emulsion and pea-gravels.

Type-5: Water Bound Macadam Road with sand-soil sub-base and surface painting with asphalt emulsion and sand blindage.

Type-6: Water Bound Macadam Road with sand-soil sub-base and surface dressing with asphalt emulsion and pea-gravels.

Type-4 was to be compared with Types 5 and 6 in respect to their performance efficiencies. In Types 5 and 6, the costly item of pure sand sub-base was replaced with a mixture of 50:50 sand-soil sub-base which is less expensive. Further, inclusion of some clayey materials with sand does reduce the voids, improves the bonding in sub-base materials, ensuring a more compacted mass and it was hoped that it would demonstrate better performance efficiency than the purely sand sub-base.

c) Aggregate Stabilised Soil Roads

Type-7: Aggregate Stabilised Soil (ASS) Road with sand-soil sub-base and surface painting with asphalt emulsion and sand blindage.

Type-8: Aggregate Stabilised Soil Road with sand-soil sub-base and surface dressing with asphalt emulsion and pea-gravels.

Type-9: Aggregate Stabilised Soil Road with brick aggregate grafting and sand-soil sub-base and surface painting with asphalt emulsion and sand blindage.

Type-10: Aggregate Stabilised Soil Road with brick aggregate grafting and sand-soil sub-base and surface dressing with asphalt emulsion and pea-gravels.

V

All types of Aggregate Stabilised Soil Roads surfaces were to be treated with some kinds of sealing materials. Premixed bituminous carpetting, which is expensive, would have been the best way of sealing the surface for the best performance, but the basic objective of the project being to develop a low-cost, low-technology, semi-pucca road, this expensive sealing with bituminous carpetting was altogether omitted and a low cost sealing process was adopted as mentioned above, although this sealing would require regular maintenance for its satisfactory performance under traffic.

Cross-section of each of the above type is given in Annexures-2A to 2G. The cement stabilised sections were dropped considering involvement of higher technology and necessity of very high degree of quality control which may not be achieveable under normal construction conditions in rural areas.

3.0 FINAL DESIGN & SELECTION OF MATERIALS

3.1 Basis of Design

The Consultants started work by undertaking a reconnaissance of the project area to familiarise themselves of the area and to identify, among others, sources of construction materials available in the vicinity. The trial strip, 1000m long, started 280m from the northern end of Horai Bridge and ended 1280m towards Rajbari. Work plan was drawn up according to which traffic survey, topographic survey and soil investigation were undertaken.

Since the objective of the Trial was to develop low-cost roads which can be replicated under normal rural conditions, emphasis was placed on evolving designs which utilised locally available materials. For this, materials survey together with requisite testing were undertaken to form the basis of different relevant parameters for design mixes.

For pavement design the following codes/publications were followed:

a) Road Note 29 and 31 of TRRL, UK

b) IRC publications No. IRC: 28-1967

c) Standard Laboratory Testing Procedures, BRRL.

d) BS Specifications and codes.

3.2 Philosophy of Design

The ten sections selected fell under the following three broad categories:

a) HBB Brick Road (Types 1 to 3)

b) Water Bound Macadam Road (Types 4 to 6)

c) Aggregate Stabilised Soil Road (Types 7 to 10)

The selection of these three broad categories was made with the following considerations:

a) HBB Brick Road

In rural road projects of the country, HBB has been the most widely used method of road surfacing. Use of HBB as a first stage construction on newly built embankment has definite advantage in respect of technicality and initial cost, when budget constraint in road sector has been a chronic problem. When non-availability of adequate compacting equipments cannot ensure requisite compaction of new embankments, time consolidation becomes a necessity. HBB pavements provide the advantage that the moving traffic adds to natural time consolidation. So, three types of HBB Brick Road with varying components of sub-base materials were selected for trial.

b) Water Bound Macadam (WBM) Road

Water Bound Macadam Road serves better as a second stage construction. It is expensive as a first stage construction. Re-use of bricks from HBB makes it relatively less expensive for second stage construction.

So, three types of WBM Road with different components of sub-base materials and different types of surface treatment were selected for construction and for testing their relative performance.

c) Aggregate Stabilised Soil (ASS) Roads

These types are more or less a new exercise in the road construction process in Bangladesh. These are encouragingly low-cost pavements as compared to others and labour intensive with low-technology. Hand-mixing of different ingredients in design proportions needs only moderate vigilance at the work site to achieve acceptable quality control. These types of pavements have been successfully constructed and widely used in India (refer to IRC Journal 28, 1967). Thus, four types of Aggregate Stabilised Soil Roads were selected

with similar sub-base and with slightly varying base but different surface treatments to study their comparative performance efficiencies.

3.3 Stress on Use of Local Materials

The main objective of the project was to design a low-cost pavement with the best possible utilisation of locally available construction materials but maintaining the quality of finished job within acceptable limit, as per design and specifications. Thus, locally available sands from different sources, local soils from the box-cut areas and the road-side borrow-pits and the bricks burnt by local indigenous fuel by the local manufacturers were selected after laboratory testing and careful investigations to meet the design criteria. Proportion of different ingredients in each type of pavement was also selected to achieve the maximum dry density and serviceability with minimum cost involvement for different components of the pavement structure.

4.0 COSTING, TENDERING AND EXECUTIONS

4.1 Costing

In preparing the cost estimates, the Consultants adopted the Schedule of Rates of Faridpur Zila Parishad, 1984-85 and current market rates at Faridpur, September 1985. Cost estimates were prepared for 100m strip of each type of pavement. In order to have a comparative study, cost estimates were prepared for both smaller and larger volume of works, spliting up, in each case, the cost of materials and labour. Comparative statement of cost estimates and assumed rates of labour and materials are included in this Report as Annexure-3a and 3b.

4.2 Tendering and Contract details

Tender documents, including specification of works and materials, were prepared by the Consultants. In consultation with IRWP and LGEB personnel, the work was divided into two groups with the intent being to complete the work within a shorter time so as to achieve completion of construction before the advent of monsoon. Trial sections 1 to 4 were included in Group-A and those from 5 to 10 were included in Group-B. Before inviting tender, six contractors were prequalified on basis of recommendation of a committee consisting of (a) Executive Engineer, LGEB, Rajbari, (b) Executive Engineer, LGEB, Faridpur, (c) Resident Engineer, ZRMIP, Faridpur, (d) Addl FO, Faridpur, (e) Executive Engineer (FR), Dhaka and (f) Representative of the Consultants. Among the prequalified contractors Mr Kh. Enayet Hossain and Mr Md Akbar Ali stood lowest for Group-A and B respectively. But their

quoted rates were 50% higher than the estimated costs. After scrutinizing the tenders and on recommendation of the tender committee, the works were awarded to the lowest tenderers at 25% higher rate than the estimated costs. Contract details are as below:

Group and Name of Contractor	Trial Type	Contracted		Actual *	
		Amount	Period	Amount	Period
Group-A Mr Kh. Enayet Hossain	1 to 4 400m	Tk 466,309	90 days	Tk 454,494	142 days including 15 days for mobilisation
Group-B Mr Md Akbar Ali	5 to 10 600m	Tk 605,724	90 days	Tk 593,603	-ditto-

* Actual construction cost and time for completed volume of works.

4.3 Contractor's Mobilisation

Though Work Order was issued to the Contractors by the Executive Engineer, LGEB, Rajbari on 09 Feb 1986, they could not start the works physically until 25 Feb 1986. During these two weeks, the Contractors mobilised labour, constructed labour sheds at site and submitted samples of construction materials such as sand, soil and bricks from different sources for testing their suitability as required under the Contracts. For such intensive quality-control-test-oriented-construction-project, this minimum period for mobilisation was essential and which should be considered in future too, while estimating time for execution of similar projects.

4.4 Contractors' Performances and Progress

The nature of the Road Surfacing Trial Project was completely new to the Contractors and they were not clearly aware of the requirements of intensive and random quality control tests at every stage of construction. Contractors had no technical persons and surveyors for checking pre-section and giving layout for stage construction. The work was supervised by non-technical staff of the Contractors. Due to the above, the Contractors could not plan ahead and make programme of works. The Consultants had to prepare schedule of works for the Contractors. Even then the Contractors could not

properly follow the schedule of works prepared and supplied by the Consultants. Programme of work versus actual progress achieved is included as Annexure-4a & 4b.

Contractors engaged local labourers. to whom these works were not at all familiar. The Consultants' staff, therefore, had to take necessary steps to motivate the Contractors as well as their labourers to make them understand the works and importance of quality control necessary for successful execution of the project. At the initial stages the work of the Contractors were not unsatisfactory but due to lack of technical knowledge and mismanagement of labourers their progress was inconsistent. Annexures 5a and 5b are histograms showing wide fluctuation of labour employed under the two contracts. The progress was delayed and hampered to some extent due to rain and more so due to worsening attitude examplified by the Contractors' gradually increasing disregard towards the advice and instructions of the Consultants. However, considering the almost complete absence of technical knowhow and resources of the Contractors, their achievement is not inconsiderable. Measure of performance of labour and equipments are included in Annexures 6a and 6b.

5.0 SELECTION OF MATERIALS, QUALITY CONTROL AND SUPERVISION OF CONSTRUCTION

5.1 Quality Control of Materials

Materials like sand, soil and bricks were selected by careful investigations of all local sources. The qualities of all these materials were controlled under random sampling from site and intensive testing in the laboratory as per programme of testing. See Annexure-7 for programme of investigation and testing for quality control of materials and works.

Some problems were encountered in getting well graded sand and bricks of specified size, shape and strength. Local sands were not readily usable due to poor gradation. This problem of sand was overcome by blending sands from different sources and accepting a little lower FM and thus it was also possible to replace the use of costly Sylhet sand with much cheaper local sand, saving time and money.

In locating bricks from local manufacturers of Faridpur and Rajbari, it was observed that the specified strength requirement of 1800 psi could not be met in 100% cases. As such, a recommendation to revise the acceptable strength of bricks was made to the Project Director, IRWP, Dhaka, who, in consultation with the Executive Engineer, LGEB, Faridpur, modified the acceptable strength to 1500 psi. Inspite of this revised strength criteria, all possible

efforts were made to select bricks of higher strength available in the locality. In doing so, ultimately, it was observed that in only about 10% cases, the bricks were below 1800 psi. But, in general, the bricks were not uniform in shape and size. However, considering the overall conditions of locally available bricks, priority was given to the strength criteria rather than to the shape and size. As such, in the HBB brick pavement, the finished surface achieved was not even.

Problems were also encountered regarding gradation of traditional hand broken aggregates. To overcome this problem, contractors were motivated by practical demonstration about the required size of the aggregates and also to prepare separate stock piles of different sizes of aggregates. Individual grading of these stock piles were frequently checked and blended as per selected proportions to achieve the requisite combined gradation.

5.2 Mix Designs

Prior to constructing the sub-base and base-courses, several trial mixes were done in the laboratory to fix the mixing proportion of different ingredients to meet the specification requirements in respect of gradation, CBR and compactibility of the mix. In doing so and for best utilization of cheaper materials and to satisfy specification requirements, sand and soil proportion had to be adjusted. Details of design criteria for all types of sub-base and base courses versus the actual field test results are included in the Appendix-1.

5.3 Supervision of Construction

The whole process of construction was supervised constantly and closely as per programme for monitoring of construction works. The quality of works was controlled through monitoring at every stage of the works by checking mixing and laying procedures, moisture content prior to compaction, taking samples from placed-layer to check their conformity with the design requirements and performing field density tests and level checks after completion of each layer. Quality control test results of construction process are included in the report as Summary of Field Test Results in Appendix-2 and the number and types of tests performed is given in Appendix-3.

6.0 AS-BUILT CONDITIONS AT THE END OF CONSTRUCTION

Each layer of pavement structure in every type has been constructed under careful supervision and close to specification requirement. As-built condition of each type, immediately after construction and before starting of monitoring, has been described below.

4

6.1 Traditional Type of HBB Road

HBB over single brick flat soling and sand sub-base in Type-1 is a traditional type of pavement. Inspite of inconsistent quality of bricks in shape and size the surface finishing, camber and levels were found not unsatisfactory due to constant and close supervision.

6.2 New Type of HBB Brick Road

HBB brick pavement over sand-soil sub-base in Type-2 and over aggregate-sand-soil sub-base in Type-3 were completely new types of pavement construction. In both types the pavement surface, grade, camber and levels were satisfactory. However, it was apprehended that joint sealing of HBB with asphalt emulsion may not function properly as the emulsion had very little adhesion to the bricks and there were chances for individual movement of the bricks due to irregularities in shape and size.

6.3 WBM Road

WBM base courses over sand sub-base in Type 4 is a traditional type of construction. But sand-soil sub-base in Types 5 and 6 were new types of pavement structure. The as-built surface condition, camber, levels and compaction were all quite satisfactory. In surface dressing of Types 4 and 6, cover aggregates were not fully embedded and about 50% of the aggregates remained loose over the surface. The surface, however, was sealed and appeared to be functioning properly.

Surface painting in Type 5 looked apparently good at the end of construction and was functioning well. But in both the cases of surface painting and surface dressing, i.e. Types 5 and 6, there was very little penetration of the asphalt emulsion into the underlying surface due to inconsistent quality of the emulsion for which its serviceability could not be guaranteed. See Section-7 for more details regarding quality of the asphalt emulsion.

6.4 Aggregate Stabilized Soil Road

Aggregate-sand-soil stabilized road bases in Types 7 to 10 over sand-soil sub-base were completely new types of pavement in all respects. As-built conditions of these types were satisfactory in respect of compaction, surface finishing, camber, grade and levels. These pavements appeared to be stable and were behaving well under the traffic. Surface painting in Types 7 and 9 appeared to be functioning well but there was no penetration of the asphalt emulsion as mentioned earlier for which the painting might easily be damaged.

Surface dressing in Types 8 and 10 were apparently satisfactory except the cover aggregates which could not be fully embedded. Had the cover aggregates been fully embedded, it would have made the surface more stable and protected from wearing and effects of rain.

Comparison of the as-built levels with those obtaining at the end of the six-month post-construction monitoring period is shown graphically in Annexure 8a to 8j. Details of changes in levels monitored month-wise are given in Appendix-4.

6.5 Granular Shoulder

Granular shoulder, 2'-6" wide on either sides, were constructed and appeared to be functioning well. It had added to the stability to the edge of the pavement. But it was felt that if wider granular shoulder was provided, and in thicker layer, it could have served the purpose better.

6.6 Embankment Side Slope and Turfing

Compaction and trimming of side slopes had not been done satisfactorily. Earth on side slope appeared loose and slope uneven. Turfing also had not been done properly. In fact, it was found that it was very difficult to achieve satisfactory compaction on embankment side slopes by hand tampering. The situation might improve by using small vibratory roller (plate vibrator) for this purpose. Plate vibrator is widely used in many countries for compacting embankment side slopes and back-fill of bridges. Plate vibrator is not a costly equipment particularly in view of its benefits.

7.0 ASPHALT EMULSION

The asphalt emulsion was very much inconsistent in quality. The first sample supplied by the Contractors from the manufacturer (M/s Zakir Industries) was of acceptable quality as tested in Central Testing Laboratory, Tejgaon, Dhaka, see Annexure-9a for test results. It will be noted that viscosity at 20°C was 6.61 against an acceptable limit of 6 to 9. On the basis of this sample test, the contractor was allowed to carry the bulk quantity of emulsion of similar quality to the work site. New samplings were done from those quantities brought to site and tested again in the same Laboratory. In this case, out of seven samples tested in two lots, only one sample was found to have viscosity within the specified range (even that at the extreme edge of limit) while the other six samples had viscosity outside the specified range, see Annexures 9b and 9c for test results. The emulsion was found to be highly viscous and so it had no penetration and thus the performance of surface treatment seemed to be very doubtful.

10

Even though the emulsion was out of specification, the Contractors were allowed to use the same under instruction of IRWP officials possibly considering:

a) that time was running out as monsoon had already set in and so the surface needed immediate treatment.

b) that it was highly unlikely to settle the case of unspecified emulsion material between the Contractors and the supplier within a reasonable time.

It may therefore be concluded that it would not be proper to use this emulsion again unless the manufacturer can give guarantee about the specified quality of his product.

8.0 COMMENTS ON POSSIBILITIES OF CONSTRUCTING LOW-COST ROAD

Road Surfacing Trial Project was constructed under Local Government Engineering Bureau (LGEB) with the objective to study, design and construct low-cost, low-technology, labour-intensive, all-weather, semi-pucca road pavements for rural areas of Bangladesh. Considering the acute problem and backwardness in communication of rural areas and high cost involvement for road construction, this attempt by LGEB to find a low-cost semi-pucca road was a note-worthy undertaking and its success will be of national interest and can open a new horizon in the construction of low-cost rural roads in the country. Throughout the construction period, Consultants' staff exerted their efforts to get the works done as per specification and, accordingly, the works were completed successfully. The assistance from IRWP and LGEB personnel were also considerable and is hereby acknowledged.

This project being the first of its kind there are reasons for not being optimistic about its complete success and it may be difficult to draw a definitive conclusion about the best type of pavement. Some more trials, with other possibilities of pavement structures, are essential to achieve the objective.

It may, however, be concluded that such innovative type of work are possible with local contractors using locally available construction materials and local labourers, both male and female, nominal equipments like small vibratory rollers and some limited use of big rollers (8-10 ton) but under strict supervision by personnels having sound technical knowledge, specialised in materials engineering, able to fix design criteria through laboratory testing and monitoring the construction activities through intensive field testing for quality control.

9.0 POST-CONSTRUCTION MONITORING PROGRAMME

The post-construction monitoring was aimed at closely observing the performance of the different types of trial sections. For this the Consultants chalked out a six-month monitoring programme which, after discussion with the Client, was approved.

The monitoring programme consisted of six once-a-month inspection visits by the Consultants - usually in the last week of each month, starting Jul 1986 through to Dec 1986. During the monitoring visits the following observations and recordings were made:

a) Traffic Count

A traffic count was made during Aug 1986 (same month as the pre-construction count). The count was taken for 16 hours on five days - two days on market (haat) days and the rest on non-market days. The purpose of the count was to determine the growth in traffic resulting from improvement of the pavement - see Table-1 and Appendix-6.

b) Level Survey

Cross-sectional spot levels at 25m interval were taken every month to compare with the as-built elevations and to see the rate of change of road profile. See Annexure 8 and Appendix 4.

c) Pavement Deterioration

Types of deterioration to be observed was agreed upon and recorded monthly on the proforma given in Appendix-5, supported by photographs, where appropriate.

d) Shoulder Deterioration

Observations were made once every month and recorded in the same format as that for pavement deterioration.

e) Slope Deterioration

Observations were made once every month and recorded in a format similar to that for pavement deterioration except that the following types of deterioration were observed:

- raincut
- sliding
- rat holes
- fox holes
- any other types

f) Moisture Content (MC)

At the end of monsoon, during late Sep 1986, moisture contents where checked in sub-base and base courses, in the granular shoulders and sand drains to compare with as-built moisture contents in order to see the effectiveness of design and construction of different components of the pavements - see Table-5.

g) Flood Level and Ground Water Table

These levels were recorded daily by observation of the flood level gauges and the GI standpipes sunk along the shoulders of the road. The comparison gave the differential elevation between flood water and ground water table which gave an measure of the apparent and actual free board.

Monthly Monitoring Reports (MMR) were prepared every month and submitted to the Client. Summarised general comments extracted from the six MMRs are given as Appendix-8.

10.0 ANALYSIS OF RESULTS OBSERVED DURING MONITORING

10.1 Traffic Count

The Table-1 below gives a comparative statement of traffic data collected in Aug, 1985 (pre-design) and Aug, 1986 (post-construction):

Table-1: Comparative Statement of Traffic Data

Description	Average Daily Traffic(ADT) Commercial Veh (No)	All Motor Veh (No)	Design ADT (CVD)	Rate of growth (Com Veh)	Remarks
Initial Traffic Data in Aug'85	Truck =18 Bus =22 Total =40	Com Veh =40 Car,Jeep= 3 Total =43	40x1.33 = 53	8%	Design growth rate
Traffic Data in Aug'86	Truck =12 Bus =37 Total =49	Com Veh =49 Car,Jeep= 2 Total =51		22.5%	Observed growth rate

From the traffic survey during the off-peak season in Aug 1985 the initial traffic was 40 CVD. For design purposes, 33% increase in commercial vehicles was considered during the peak period of winter season. Thus, design ADT = 40x1.33 = 53 CVD with an assumed 8% growth rate, whereas the actual rate of growth of commercial vehicles during one year has been found 22.5% during the count taken in Aug 1986. Even this increased ADT of 49 CV after one year was less than the design ADT of 53 CV. Thus design ADT was adequate.

Summary of the five-day traffic count taken during monitoring period (Aug'86) is presented in Appendix-6.

10.2 Level Survey

Variation of monitored elevations from as-built elevations, at every 25m interval, is given graphically in Annexure-9 and in a tabular form in Appendix-4.

Table-2 below gives a general trend of settlement of the whole pavement cross-section for each of the pavement types. It will be noticed that settlements are more along the pavement edges than along the centre line. This is due to the fact that the road being single lane the trackways fall nearer the edges of the pavement than the centre.

Table-2: Settlement of Pavement Cross-section at end of Monitoring Period

Pave-ment Type		Level variations in mm along Centre line			Edges of pavement			Overall Settle-ment
		Maximum	Minimum	Actual Average	Maximum	Minimum	Actual Average	
1		[illegible]	1*	9	23	6	15	13
2	HBB	34	6	17	29	7	16	16
3		34	13	22	40	10	28	26
4		31	11	19	37	6	21	23
5	WBM	35	11	22	41	20	31	28
6		34	16	25	41	16	31	27
7	Aggr	24	1	15	72	24	42	33
8	Stab	47	8	20	59	20	40	33
9	Soil	34	2*	14	49	5	33	27
10		35	4*	12	30	5	24	20

* Higher than as-built elevation.

These settlements along the centre line of the aggregate stabilised soil road are slightly less than those for WBM road and slightly more than those for HBB brick road. But, along the edges, these settlements for aggregate stabilised soil road are slightly higher than those for WBM road and noticeably higher than for HBB brick road.

14

These settlements in HBB brick roads are due to the settlement/consolidation of sub-base, while in WBM road, this is mainly due to the settlement/consolidation of sub-base and only partly due to the embedment of WBM base into the sub-base. In aggregate stabilised soil road this was due to the settlement/consolidation of both the sub-base (sand-soil) and base-course (aggregate-sand-soil mix). So, the relative settlement is higher for the latter category, but the differences are not remarkable between WBM and aggregate stabilised soil road.

It is important to note that the settlement for pavement cross-section in the different types within each of the three categories were consistent. This consistent settlement of the entire pavement cross-section for whole length in each type is not an indication of pavement failure as the relative performances of the pavement remained unaffected.

Therefore, the aggregate stabilised soil road, which had almost similar degree of settlement as WBM road, is expected to perform equally satisfactorily as the WBM road.

10.3 Pavement Deterioration

Pavement deterioration occured mainly in the form of depression and ruttings. Table-3 below summarises the extent of deterioration in each type while Appendix-5 presents the information in more detail:

Table-3: Pavement Deterioration (Summary)

Type		Ruttings/Depressions in mm Maximum	Minimum	Remarks
1	HBB road	25	15	Depression along trackway over 13% of length
2		25	15	" 80% of length
3		20	15	" 70% of length
4	WBM road			Negligible local depressions only
5				
6				
7	Aggr Stab Soil road	15	10	Local depressions along edging
8		20	15	" " "
9		100	50	Rutting along trackway and localised depressions
10		75	50	

In HBB brick roads (Types 1, 2 and 3) depressions measuring 15 to 25mm deep occurred along the trackways.

In WBM roads (Types 4, 5 and 6) only negligible local depressions occurred.

In full length of the aggregate stabilised soil (ASS) road Type 9 and 34m of Type 10 were damaged for reasons explained below. However, ASS roads Types 7 and 8 exhibited only a few local depressions of between 10 and 20mm depth leading, tentatively, to the conclusion that resistance of ASS roads against surface deterioration under traffic is about the same as WBM roads and better than HBB brick roads.

In Type 10, at the end of the section, a small weak spongy area of about 3 sqm was noticed in the first month after the completion of the construction. This weak spot, under traffic, spread to an area of about 12m×1m, causing cracks and depressions as observed during the second monitoring visit in Aug 1986. It warranted immediate repair to arrest further spreading of the damage, but as the repair works were not taken up in time, these damages, during the unusual two-week heavy rains in Sep/Oct 1986, spread upto 34m along the trackways causing deep ruts. (For details please refer to the third Monthly Monitoring Report).

The initial damage of 3 sqm at the last stretch of Type 10 was caused due to the presence of excess moisture (beyond optimum moisture content) in the base course, which fact was confirmed during the repair activities of the damaged area in Oct/Nov 1986 when the sub-base was found in good condition and did not require any rectification. It may also be stated that this last stretch of 10m of Type 10 was in a shaded portion under trees.

During the third monitoring visit in Sep 1986 deep ruttings, upto 100mm in depth, were observed along the trackways to ASS road Type 9. Possibly these ruttings started at the beginning of Sep 1986 but no repair works were undertaken during the month. Since the monitoring visits took place in the last week of every month the actual start of the damage and its course could not be established. It is, perhaps, therefore necessary that in future trials more intensive monitoring of damage and investigation of remedial measures be taken in hand more expeditiously and on more scientific basis.

Reports on the damages in Types 9 and 10 are given in Appendix-5, Record of Observation, as also in General Comments from Monthly Monitoring Reports (Appendix-8).

It is important to note here that Types 7, 8, 9 and 10 had identical pavement structures with varying surface treatments with asphalt emulsion. Type 8 and 66m of Type 10 performed well under traffic. Also Type 7 performed quite satisfactorily with only a few local depressions which developed during the two-week unseasonal heavy rain in Sep/Oct 1986.

Thus, if an effective surface treatment can be provided, aggregate stabilised soil roads may be equally good as WBM roads and better than HBB roads but **will need timely maintenance for efficient performance.**

10.4 The Granular Shoulder

The 2'-6" wide granular shoulder constructed on both sides of the pavement provided the following advantages to the traffic:

a) An additional width of 5'-0" (2x2'-6") of sub-base standard

b) A stronger support to the pavement edges increasing its stability and resistance against deterioration by breaking at edges

c) Facilities of easier maneuvering for passing and/or overtaking traffic

10.5 Shoulder Deterioration

The extent of deteriorations observed to the granular shoulder and earthen shoulder during the six-month monitoring period are summarised below in the Table-4.

Table-4: Deteriorations to Shoulders

Type of Shoulder	Type of Deterioration	Remarks
Granular shoulder	Aggregates exposed by washing away of sand and soil by rain water	Surface sealing may be provided
Earthen shoulder	Depression, localised and in long stretches ,observed, accumulating rain water during wet weather	Regular maintenance strongly recommended

For granular shoulder, no other remarkable deteriorations than mentioned above was observed. If this granular shoulder can be sealed with simple surface painting, such

loss of sand and soil from the granular materials can be reduced with better performance of the granular shoulder.

10.6 Embankment Slopes

The embankment side slopes were treated with grass turf to protect against raincuts and erosions during the wet weather. Turfing was found quite effective except in a few location where raincuts were deep and sliding of earth from side slopes occured in a place or two. These happened mainly due to the fact that the extra earth works done on the side slopes were not compacted properly. Although it is difficult to properly compact the side slopes, it is quite possible to improve the degree of compaction by hand ramming with better co-operation from the construction contractor.

It is also possible to improve the degree of compaction by using a small plate vibrator which would be held on the slope by one person and be pulled up the slope by another two persons from the road shoulder. But it is preferred to use local labour for such compaction to make the construction process labour-intensive.

Turfing is very cheap and effective if the compaction in earth work is proper. It was found that the grass sods placed on the side slopes at noticeable gaps spread around within a month or two during the monsoon covering all the gaps. Grass was found covering even the entire earthen shoulder after the first monsoon even though there was no turfing placed during construction. Jute mesh may be tried for slope protection, but it would be considerably more expensive than grass turfing.

It is thus recommended that:

a) Particular attention be given to attain the requisite level of compaction of the earthfill on side slopes using labour intensive hand ramming process.

b) Turfing be used on compacted side slopes for slope protection.

c) Intensive maintenance be taken up at least once a year, after the monsoon, to restore the side slopes to original conditions.

10.7 Moisture Content

The moisture contents in base, sub-base, granular shoulders and sand drains were checked during 27 Sep to 09 Oct 1986, a period which experienced unseasonal heavy rain. Table-5 gives a statement showing monitored moisture content versus design OMC and as-built moisture content:

Table-5: Statement Showing Monitored Moisture Content, Design OMC and As-built Moisture Content

Pavement Type	Layer	Monitored MC in % Normal spot	Damaged spot	As-built MS in % (average)	Design OMC in %	Difference (3-5) or (4-5)
1	2	3	4	5	6	7
1	Sand sub-base	13.59		12.63	13.75	+0.96
	Gr shoulder	16.76 LHS 18.89 RHS		14.45	14.09	+3.37(av)
	Sand drain	18.89 & 19.51 LHS 19.43 & 18.37 RHS		12.63	13.75	+6.42(av)
2	Sand-soil sub-base	15.05		11.21	11.50	+3.84
	Gr shoulder	15.51 LHS 16.96 RHS		13.04	14.09	+3.20(av)
	Sand drain	18.28 & 20.83 LHS 21.42 & 18.58 RHS		12.63	13.75	+7.15(av)
3	Aggr-sand-soil-sub-base	14.85		13.11	14.09	+1.74
	Gr shoulder	16.08 LHS 16.58 RHS		13.51	14.09	+2.82(av)
	Sand drain	20.15 & 19.72 LHS 17.07 & 19.07 RHS		12.63	13.75	+6.37(av)
4	Sand sub-base	10.79		13.15	14.40	-2.36
	Gr shoulder	15.05 LHS 18.05 RHS		14.71	14.09	+1.84(av)
	Sand drain	19.77 & 19.60 LHS 17.79 & 20.20 RHS		13.15	14.40	+6.19(av)

5	Sand-soil sub-base	10.76		11.52	12.08	-0.76
	Gr shoulder	19.79 LHS 17.94 RHS		15.16	14.09	+3.71(av)
	Sand drain	18.92 & 17.68 LHS 21.58 & 21.67 RHS		13.15	14.40	+6.81(av)
6	Sand-soil sub-base	12.02		12.20	12.08	-0.18
	Gr shoulder	20.10 LHS 20.91 RHS		15.45	14.09	+5.05(av)
	Sand drain	20.50 & 19.80 LHS 20.11 & 20.11 RHS		13.15	14.40	+6.98(av)
7	Aggr-sand-soil-base	14.41	21.24	12.22 12.22	13.08	+2.19 +9.02
	Sand-soil sub-base	14.60	20.00	12.82 12.82	12.20	+1.78 +7.18
	Gr shoulder	20.20 LHS 19.43 RHS		16.80	14.09	+3.02(av)
	Sand drain	21.02 & 20.52 LHS 18.61 & 20.88 RHS		13.15	14.40	+7.11(av)
8	Aggr-sand-soil base	12.13		13.26	13.50	-1.13
	Sand-soil sub-base	12.75		12.25	11.93	+0.50
	Gr shoulder	18.82 LHS 19.07 RHS		16.64	14.09	+2.31(av)
	Sand drain	20.46 & 17.84 LHS 20.60 & 19.50 RHS		13.15	14.40	+6.45(av)

9	Aggr-sand-soil-base	15.03*	22.64	14.05 14.05	13.36	+0.98 +8.59
	Sand-soil sub-base	15.63*	20.45	13.51 13.51	12.04	+2.12 +6.94
	Gr shoulder	20.21 LHS 21.35 RHS		17.05	14.09	+3.73(av)
	Sand drain	20.71 & 18.52 LHS 18.90 & 20.66 RHS		13.15	14.40	+6.55(av)
10	Aggr-sand-soil-base	15.37*	22.31	14.05 14.05	13.25	+1.32 +8.26
	Sand-soil sub-base	15.63*	19.75	12.88 12.88	12.25	+2.75 +6.87
	Gr shoulder	17.46 LHS 20.60 RHS		16.00	14.09	+3.03(av)
	Sand drain	19.61 & 21.70 LHS 21.83 & 21.55 RHS	13.00	13.15	14.40	+8.02(av)

* There were small cracks in the test locations.

Observations and Findings
of Moisture Content Check

a) Increase in moisture content of sand sub-base of Type 1 is not noticeable. It is an HBB brick pavement over brick soling. Increase in moisture content of sand-soil sub-base of Type 2 is more noticeable as compared to Type 1 and slightly higher than the acceptable range whereas for Type 3, the increase in moisture content of aggr-sand-soil sub-base is also noticeable but within the acceptable range. It may be stated that both Type 2 and Type 3 are HBB brick pavements without brick soling, so the increase in moisture content of sub-base for both the types should have been similar.

However, it was noticed that 100% of the joint sealing by asphalt emulsion for Type 2 had cracked and opened up whereas for Type 3 such deterioration had been

about 75%. This differential performance of joint sealing (due to inconsistent quality of asphalt emulsion) had caused differential rate of infiltration of rain water to the sub-base and thus the increase in moisture content of sub-base for Type 2 is greater than that for Type 3.

Perhaps it can, therefore, be concluded that the performances of sand-soil and aggregate-sand-soil sub-base under HBB brick pavement, without brick soling, may be assured within the design criteria **if effective sealing to the HBB brick joints can be provided. This, however, needs further investigation.**

b) A general trend in decrease in moisture content of sub-bases of all the three types of WBM (Types 4, 5 and 6) had been observed. The decrease in MC in sand sub-base of Type 4 is relatively much higher than those for Types 5 and 6 having sand-soil sub-base. As moisture retaining capacity within sand materials is less than that of sand-soil mix (due to lesser voids and thus lesser permeability of sand-soil) such reduction in MC is logical. So, the as-built moisture in the sand sub-base had been loosing moisture to the sub-grade and surrounding soil at a greater rate than that for sand-soil sub-base. Further, as the WBM is a denser base course having surface treatment with surface painting and surface dressing, there had not been appreciable infiltration of rain water into the sub-base through this dense base, although there had developed some cracks in surface painting of Type 5 and loss of coated pea-gravels from surface dressing of Type 4 and Type 6 in very small scattered areas.

The reduction in MC of sub-bases in Types 5 and 6 is very negligible and remained almost near to as-built MC whereas that for Type 4 is remarkable for being less than the lower limit of allowable range.

So again, perhaps, it may be concluded that the performance efficiency of sand-soil sub-base is satisfactory and better than sand sub-base under WBM base.

c) Types 7 and 8 have similar base courses with varying surface treatment. Increased MC was noticed for Type 7 having surface painting with asphalt emulsion. This surface painting had developed cracks (due to inconsistant quality of asphalt emulsion) through which rain water had infiltrated and thus increased the MC. Due to the same reason increased MC had been observed in the sand-soil sub-base also, whereas the base course for Type 8 having surface treatment with pea-gravels and asphalt emulsion showed a reduction in moisture content. It is likely that the surface

treatment was effective that prevented the infiltration of rain water into the base; but a certain part of the moisture from the aggr-sand-soil base (which is a permeable mix) had been loosing moisture to the sub-base, reducing the MC in the base and increasing the MC in the sand-soil sub-base. It may be noted that such increase in MC in the sand-soil sub-base is negligible and the MC is very near to the as-built conditions.

From the above findings of Types 7 and 8, it may be concluded that, if the surface of the pavement structure can be treated effectively against infiltration of rain water, it is expected that the pavement structure with aggr-sand-soil base and sand-soil sub-base will function satisfactorily.

d) Types 9 and 10 have similar pavement structure (aggr-sand-soil base with aggr grafting and sand-soil sub-base) with varying surface treatment. Increased moisture content in base and sub-base had been noticed for both the types. The surface painting and surface dressing had developed cracks (due to inconsistant quality of asphalt emulsion) through which rain water has infiltrated and thus increased the moisture content. It may be noted that the increase in moisture content is within the acceptable range.

If the surface of the above pavement structures can be treated effectively against infiltration of rain water, it is expected that the pavement structures will function satisfactorily.

e) Increase of moisture content in granular shoulder was generally noticed, ranging from 1.84% to 5.05%. This increase in moisture content was obviously due to untreated open surface. The variation in increase of moisture content was due to improper slope and depressions on shoulder which had developed with time after the completion of construction.

It may be concluded that if the granular shoulder can be maintained in proper slope for quick drainage of surface water, the increase of MC will be more consistant and within acceptable range.

f) Increase in moisture content in sand drain was quite remarkable which clearly indicated that the sand drains had been functioning properly and effectively.

In summary it appears that the above reflect some positive advantages that could be achieved by using sand-soil sub-base and aggregate-sand-soil base.

The aggregate stabilised soil road with sand-soil sub-base in Type 8 had surface dressing with pea-gravels and asphalt emulsion. During this period when the moisture content was checked the surface dressing was found in good condition without any remarkable deterioration. Thus, the surface treatment was satisfactory. Due to this satisfactory surface treatment, rain water could not infiltrate into the base and sub-base and so the moisture contents in base and sub-base did not change appreciably, rather they were very near to as-built moisture content. This situation ensured the satisfactory performance of the aggregate stabilised soil road, Type 8, even at the end of six-month monitoring period.

Thus, it can be inferred that aggregate stabilised soil road with sand-soil sub-base can perhaps replace the more expensive WBM and HBB brick pavement structures in respect of performance efficiency, provided it had an effective surface sealing against ingress of rain water into the pavement structure. More trials are however indicated before a firm conclusion can be reached.

10.7 Flood Level and Ground Water Table

Three flood level gauges were installed near the borrow pits and three GI standpipes were installed at the edges of the shoulders to monitor the flood water level and ground water table. Appendix-7 gives the location and RL of the gauges and the standpipes.

Table-6 below gives the montly readings of flood level and GWT taken during the monitoring visits:

Table-6: Flood Level and Ground Water Table during Monitoring Visits

Station	Date of observation	Fl. in metre	GWT in metre	Difference in level	Remarks
a	b	c	d	e =(d-c)	f
		13.006*	16.411*		
I	29 07 86	13.056	13.538	0.482	
	27 08 86	13.105	13.548	0.443	
	02 10 86	14.066	14.187	0.121	
	28 10 86	13.014	13.360	0.346	
	25 11 86	**	13.292	--	
	30 12 86	**	12.780	--	
		14.143*	16.603*		
II	29 07 86	14.313	14.373	0.060	GWT is higher than flood level due to capillary action
	27 08 86	14.346	14.488	0.142	
	02 10 86	14.343	14.480	0.137	
	28 10 86	14.163	14.183	0.020	
	25 11 86	14.209	14.171	-0.038	
	30 12 86	**	13.751	--	
		13.992*	16.200*		
III	29 07 86	14.562	14.581	0.019	
	27 08 86	14.622	14.645	0.023	
	02 10 86	14.656	14.798	0.142	
	28 10 86	14.392	14.440	0.048	
	25 11 86	14.399	14.494	0.095	
	30 12 86	14.209	14.244	0.035	

* Base Rl for Flood Level gauge and Top Rl of GWT pipe

** Flood Water in the borrowpit around Station I had completely dried

The inconsistent difference between levels of flood water and ground water table may have been due to the observed difference in water level on two sides of the embankment and the variation in the consistency of embankment soil characteristics which influences the capillary rise.

There was no abnormal flooding in the surrounding areas of the trial stretch; only normal rain water accumulated on both the sides of the road. There was enough free-board as seen from the following table:

Table-7: Available Free Board

Station No.	Chainage (m)	Maximum Flood Level (m)	Shoulder Edge Level (m)	Available Free Board (m)	Remarks
I	0+196.5(L)	14.066	16.15	2.084 !	Adequate
II	0+700.0(R)	14.346	16.42	2.074 !	freeboard
III	1+039.5(R)	14.656	16.00	1.344 !	

11.0 COST CONSIDERATIONS

Comparison of cost of different types of pavement, splitting into constituent components of materials and labour, shows that the aggregate stabilised soil road has a pavement structure which is the cheapest of all the three broad categories, as is evident from Table-8.

Regarding the involvement of labour and construction materials in the pavement structure, aggregate stabilised soil road provides maximum involvement of labour and minimum use of bricks, the major expensive component of construction materials. Also, the innovative construction technique involved was found easily adapted by the local labour and headmen utilising only nominal equipments like a small vibratory roller and a 8-10 ton steel roller.

As seen from Table-8, the involvement of labour in aggregate stabilised soil road is 43.78% against 29.37% in WBM road and 29% in HBB brick road while the involvement of bricks in aggregate stabilised soil road is only 25.17% against 37.98% in WBM road and in HBB brick road this is as high as 47.78% of the total cost of the pavement structure (without surfacing).

In other words, as far as the requirement of bricks in the pavement structure is concerned, WBM road (Type 4) requires 2.2 times and HBB brick road (Type 1) requires 3 times more bricks than aggregate stabilised soil road (Types 7 and 8). In the prevalent road construction system, bricks form the major cost component of the construction materials in the pavement structure.

Thus, extensive use of bricks makes the road more expensive. Also, the manufacturing of bricks necessiates the use of agricultural land and local firewood or coal for burning. Major dependence on bricks as a construction

Road Surfacing Trial Project, Rajbari

TABLE-8: COST COMPARISON BY MAJOR PAVEMENT TYPES EXCLUDING SURFACE TREATMENT

Type	Descriptions	Cost/mile without surfacing (Tk)	Cost/mile for pavement structure for				Remarks
			Labour	Materials		Others (Tk)*	
				Bricks (Tk)	Sands (Tk)		
1.	HBB+single brick soling+sand sub-base	14,24,270 (100%)	4,13,303 (29%)	6,80,500 (47.78%)	1,73,880 (12.22%)	1,56,587 (11%)	HBB brick road
4.	WBM+Sand sub-base	13,15,177 (100%)	3,86,318 (29.37%)	4,99,503 (37.98%)	2,32,500 (17.68%)	1,96,856 (14.97%)	WBM road
7 & 8	Agr-sand-soil base+ sand-soil sub-base	8,99,459 (100%)	3,93,790 (43.78%)	2,26,350 (25.17%)	1,36,206 (15.14%)	1,43,113 (15.91%)	Aggregate stabilised soil road

Notes: a) In all the three categories of road, the pavement structure in Type-1, of HBB brick road, requires maximum quantity of bricks while that in Types 7 and 8, Aggregate Stabilised Soil Road, requires minimum quantity of bricks, the major expensive component of construction materials.

b) Aggregate Stabilised Soil Road (Types 7 and 8) has the cheapest pavement structure on initial cost considerations and is 37% cheaper than HBB Brick Road and 32% cheaper than WBM Road.

* Equipment cost + profit, etc.

TABLE-9: COST COMPARISON BETWEEN INDIVIDUAL PAVEMENT STRUCTURE (EXCLUDING SURFACE TREATMENT)

Trial Type	Description of Trial-Type	Total Cost* per mile (Tk)	For Pavement Structure only**			Remarks
			Cost/mile (Tk)	Labour (Tk)	Mat.+Others (Tk)	
1.	HBB+single brick soling+ sand sub-base	14,24,270	14,24,270	4,13,303 (29%)	10,10,967 (71%)	
2.	HBB+Sand-Soil sub-base+ Joint sealing	12,12,169	11,52,583	3,87,372 (33.60%)	7,65,211 (66.40%)	
3.	HBB+Aggr-Sand-soil sub-base+Joint sealing	14,45,635	13,86,049	4,74,490 (34.23%)	9,11,559 (65.77%)	
4.	WBM+sand-sub-base+ surfacing dressing	15,34,491	13,15,177	3,86,318 (29.37%)	9,28,859 (70.63%)	
5.	WBM+Sand-soil sub-base+ surface painting	13,07,513	12,32,084	4,22,770 (34.31%)	8,09,314 (65.69%)	Pavement structure of Type-7 and 8 are cheapest and labour intensive; labour involvement is about 44% of the cost of pavement structure
6.	WBM+sand-soil sub-base+ surface dressing	14,51,399	12,32,084	4,22,770 (34.31%)	8,09,314 (65.69%)	
7.	Aggr-Sand-soil base+ Sand-soil sub-base+ surface painting	9,97,073	8,99,459	3,93,790 (43.78%)	5,05,669 (56.22%)	
8.	Aggr-Sand-soil Base+ sand-soil sub-base+ surface dressing	11,50,409	8,99,459	3,93,790 (43.78%)	5,05,669 (56.22%)	
9.	Aggr-Sand-soil base+Aggr grafting+sand-soil sub-base+surface painting	10,79,618	9,82,004	4,14,605 (42.22%)	5,67,399 (57.78%)	
10	Aggr-sand-soil base+Aggr grafting+sand-soil sub-base+surface dressing	12,33,002	9,82,004	4,14,605 (42.22%)	5,67,399 (57.78%)	

* Total cost calculated on the basis of rates for larger volume of works with surfaces treatment

** Pavement structure does not include surface treatment.

TABLE-10: COST COMPARISON BETWEEN INDIVIDUAL PAVEMENT TYPES INCLUDING SURFACE TREATMENT

Trial Type	Description of Trial-Type	Total Cost* per mile (Tk)	Break up cost per mile (Tk)		Relative cost w.r.t. Type-4	Remarks
			Labour (Tk)	Mat.+Others (Tk)		
1.	HBB+single brick soling+ sand sub-base	14,24,270	3,63,474 (25.52%)	10,60,796 (74.48%)	92.80%	a) Type-7 appears cheapest of all the ten types.
2.	HBB+Sand-Soil sub-base+ Joint sealing	12,12,169	3,97,251 (32.77%)	8,14,918 (67.23%)	79%	b) Type-7 is also the most labour intensive
3.	HBB+Aggr-Sand-soil sub-base+joint sealing	14,45,635	4,84,369 (33.51%)	9,61,266 (66.49%)	94%	
4.	WBM+sand-sub-base+ surface dressing	15,34,491	3,89,652 (25.40%)	11,44,839 (74.60%)	100%	
5.	WBM+Sand-soil sub-base+ surface painting	13,07,513	4,25,185 (32.52%)	8,82,328 (67.48%)	85.20%	
6.	WBM+Sand-soil sub-base+ Surface dressing	14,51,399	4,26,070 (29.36%)	10,25,329 (70.64%)	94.60%	
7.	Aggr-Sand-soil base+ Sand-soil sub-base+ surface painting	9,97,073	3,96,334 (39.75%)	6,00,739 (60.25%)	65%	
8.	Aggr-Sand-soil Base+ sand-soil sub-base+ surface dressing	11,50,409	3,97,606 (34.56%)	7,52,803 (65.44%)	75%	
9.	Aggr-Sand-soil base+Aggr grafting+sand-soil sub-base+surface painting	10,79,618	4,17,151 (38.64%)	6,62,467 (61.36%)	70.40%	
10	Aggr-sand-soil base+Aggr grafting+sand-soil sub-base +surface dressing	12,33,002	4,18,423 (33.94%)	8,14,579 (66.06%)	80.40%	

* Total cost calculated on the basis of rates for larger volume of works.
Total cost = cost of pavement structure + cost of surface treatment.

materials for road construction in rural areas of the country will have a negative impact on the availability of agricultural land and also utilise scarce energy resources like local firewood, accelerating the deforestation process.

Considering the above, it is imperative to find ways and means to reduce dependence on bricks as a construction material.

It is evident from Tables-8 that the aggregate stabilised soil road shows promise of providing economy in the use of bricks and fuel. Also, it has been found to have the cheapest pavement structure and is the most labour intensive - characteristics which will bring all-round benefit.

Tables 9 and 10 give comparisons of different components of investment costs for all the 10 trial sections, excluding and including surface treatment respectively.

12.0 PERFORMANCE EFFICIENCY OF LOW-COST SURFACE TREATMENT

12.1 Three types of pavement surface treatments have been tried, namely:

a) Joints-sealing in HBB brick pavement with asphalt emulsion

b) Surface painting with asphalt emulsion and sand blindage

c) Single surface dressing with asphalt emulsion and pea-gravels.

For HBB brick road, in Types 2 and 3, 100% of joint-sealing cracked and opened up as observed at the end of the third month of monitoring for Type 2 and at the end of fifth month for Type 3. This may have been due to the inconsistent quality of asphalt emulsion (viscosity not as per specification) and the increased movement of the bricks, with passage of time, under traffic. Thus, the joint sealing was not effective which was also evident from the increased moisture content in the sub-base of Types 2 and 3 as seen from Table-5.

Surface treatment by painting with asphalt emulsion and sand blindage was also found not very effective. This surface painting was found cracking and damaged in scattered spots at the end of second month of monitoring in Type 5 (WBM road) and Type 7 (aggregate stabilised soil road) and more widely in Type 9 just at the end of first month of monitoring. These damages and cracks increased with time.

Surface treatment by single surface dressing with asphalt emulsion and pea-gravels was found satisfactory as seen from monitoring records of Types 4 and 6 (WBM road) and Types 8 and 10 (aggregate stabilised soil road). The only deficiency observed in this type of surface treatment was that the entire quantity of pea-gravels was not coated with asphalt emulsion (for lack of requisite viscosity). Thus, a certain percentage of pea-gravels were loose. These uncoated loose pea-gravels were totally lost within 2 to 3 months after the construction. Some of the emulsion coated pea-gravels were also lost from some 2 to 3% scattered areas but this was not so significant.

Surface painting on the pavement surface forms a very thin protective layer whose relative resistance against wear and tear under traffic was much less than the thicker and stronger protective layer formed by the surface dressing with pea-gravels and asphalt emulsion. So, the relative performance of pavement surface with surface dressing was found better than those with surface painting as was seen with aggregate stabilised soil road, Type 8, where the trial section with surface dressing functioned quite satisfactorily under regular traffic during the whole monitoring period of six months. So, it is recommended that the approved pavement structure may be treated with single surface dressing in an attempt to seal the pavement surface against ingress of water and thus to give the pavement a low-cost semi-pucca character, but timely maintenance shall have to be ensured for continued satisfactory performance.

12.2 Suitability of Asphalt Emulsion As a Surfacing Material:

In this Trial, asphalt emulsion, instead of bitumen, was recommended for its ready-use advantage. The quality of asphalt emulsion during sample testing from the Central Testing Laboratory was found meeting the specifications. But, when the bulk supply was taken by the Contractors from the manufacturer it was found, after random sampling and testing in the same laboratory, that the quality of the asphalt emulsion in the bulk supply was unsatisfactory in respect of viscosity as seen from the test results, Annexures 9a to 9c (only one sample out of seven was within range of specifications).

Thus, the quality of asphalt emulsion was inconsistent, with improper viscosity, due to which requisite penetration of the emulsion into the road-base was not achieved. This resulted in a weak bond with the road base with consequent early cracking of surface painting and loosening of pea-gravels in scattered areas.

The satisfactory performance of road surfacing with surface dressing in Type B, aggregate stabilised soil road, might have been due to the reason that the asphalt emulsion used here was of comparatively better specification.

Hence, it is expected that if the asphalt emulsion be of right quality, such early deteriorations in surface-painting and surface dressing, as observed, may not occur. Therefore, for rural roads, asphalt emulsion may be recommended for use for surface treatment due to its definite advantages over the bitumen as mentioned below:

- o Bitumen requires a heating process that involves:
  - a considerable quantity of fuel (usually local fire-wood)
  - a definite control on heating to retain its inherent properties, like viscosity, for its correct performance
- o Bitumen cannot be used on moist surface, so it does not have the all-weather facility.
- o There remains a chance of wastage as the labourers have a tendency to use a part of the bitumen as fuel for heating
- o Asphalt emulsion provides fuel economy as no heating is necessary
- o It provides a ready-use advantage
- o It can be used over moist surface, so it has the all-weather facility
- o It does not require on-site quality control over the manufactured quality.

Considering the above it appears that asphalt emulsion has certain advantages over bitumen which should make it an attractive alternative over conventional bitumen. However, quality shall have to be ensured as per specification for its satisfactory performance. As of now this is not the case.

It is suggested that the foreign donors actively assisting in construction of rural roads provide funds and/or technical assistance for improving the quality of the asphalt emulsion presently being produced in the country. The economic benefits are likely to be considerable.

13.0 MAINTENANCE

13.1 For low-cost semi-pucca road, the performance efficiency largely depends on how effective and timely is its maintenance. The maintenance system becomes all the more important for the single-lane semi-pucca road where the traffic is more channelised creating a tendency for the pavement to deteriorate along the trackways. However strong may be the pavement structure, if it is not protected with proper surfacing/sealing against ingress of rain water, the pavement structure cannot be protected against wear and tear and deteriorations under traffic. This is particularly so under monsoon conditions. So, it is particularly important to ensure timely repair and maintenance to any deterioration, otherwise, such deterioration will aggravate to the extent of severe damage requiring expensive total repair work.

The repair works to Type 9 and part of Type 10 are concrete examples of what may happen to a pavement structure if timely maintenance is ignored. In Type 10, the initial deterioration was confined to an area of 3 sqm which in two months time spread to an area of about 35 sqm.

For comparative maintenance cost estimations, we consider below the maintenance required to be taken up for the observed deteriorations during monitoring period for one single type of trial section from each of the three broad categories of pavement. For this we have compared the aggregate stabilised soil road, Type 8, with the standard HBB brick road Type 1 and the standard WBM road Type 4 for maintenance cost.

A) Maintenance Cost for HBB Brick Road, Type 1

As per six months monitoring report, average 10% of bricks in HBB had their corners and edges broken and hence will need replacement.

Area of 100m length, as per BOQ	=	3,662 sft
Area of 1 km length	=	36,620 sft
Cost of replacement of 10% of area over 1 km length	=	3,662 sft @ Tk 8.44/sft
	=	Tk 30,907.00

Such replacement will be needed twice in a year

The HBB Brick replacement cost/km/year

= 2xTk 30,907 = Tk 61,814.00 (a)

Cost of picking HBB Bricks

= 2x3,662 sft @ 0.26/sft = Tk 1,904.00 (b)

(a)+(b) = Tk 61,814.00 + Tk 1,904 = Tk 63,718.00

Assuming 75% salvage value of the damaged bricks:

Total salvage value = 2 x 3,662 sft x 488 bricks per 100 sft x Tk 1,200 per 1000 bricks x 0.75= Tk 32,167/-

Actual maintenance cost per km per year =
= Tk 63,718 - 32,167 = Tk 31,551.00
==========

B) Maintenance Cost for WBM Road, Type 4

Observed deterioration:

1) Surface crackings:

15m x 0.50m	=	7.5 sqm
25m x 0.50m	=	12.5 sqm
10m x 0.50m	=	5.0 sqm
Total	=	25.0 sqm
	=	269.0 sft

This will need treatment with asphalt emulsion and sand blindage @ Tk 1.21/sft

Maintenance cost = 269 sft x Tk 1.21/sft
= Tk 325.00/100m (a)

2) Loss of coated pea-gravels:

15m x 0.25m	=	3.75 sqm
10m x 0.20m	=	2.00 sqm
25m x 0.20m	=	5.00 sqm
Total	=	10.75 sqm
	=	116 sft

This will need fresh surface dressing @ Tk 3.47/sft

Maintenance cost = 116 sft x Tk 3.47/sft
= Tk 403/100m (b)

(a)+(b) = Tk 325 + Tk 403 = Tk 728/100m, i.e.
= Tk 7,280/km

Such maintenance will be needed twice in a year.
Total maintenance cost per year per km
= 2 x Tk 7,280
= Tk 14,560.00
==========

C) Maintenance Cost for Aggregate Stabilised Soil Road, Type 8

Observed deteriorations:

1) Local depressions: 20m×0.25m×(15mm) = 5 sqm
10m×0.5m×(15mm to 20mm) = 5 sqm

Total =10 sqm

This shall be corrected by surface dressing.

2) Loss of coated pea-gravels: 5 sqm area

This shall also be corrected by surface dressing.

Total area to be treated= 10+5=15 sqm= 161 sft

This 161 sft area to be corrected by surface dressing @ Tk 3.98/sft = 161 sft×Tk 3.98/sft, i.e. Tk 641/100m
Cost per km = Tk 6,410.00

Such maintenance will be needed twice in a year.
Total maintenance cost/km/year = Tk 6,410×2
= Tk 12,820.00

D) Maintenance Cost of Shoulder and Side Slopes:

For shoulder: To drain water and to fill the depressions, etc.

Manpower required: 1 (one) labour per day per km for 3 (three) months scattered throughout the year @ Tk 30/day/labour
= Tk 30×3×30 = Tk 2,700.00 (a)

For Slopes: To fill raincuts, holes, eroded embankment slopes including ramming, dressing the earth and turfing as necessary, after the wet weather and during the winter.

Manpower required: 5 (five) labourers and 1 (one) supervisor for fifteen days.
5 labour @ Tk 30/day/labour =
5×15×30 = Tk 2,250.00 (b)

1 Supervisor @ Tk 50/day =
1×15×50 = Tk 750.00 (c)

35

Total (a+b+c) = Tk (2,700+2,250+750)
= Tk 5,700.00

Total maintenance cost to shoulder and side slope
= Tk 5,700.00/km/year

Table-11: Comparative Maintenance Cost Estimate

Type of trial sec	Description	Maintenance Cost/km/year for Pavement (Tk)	Shoulder and side slope (Tk)	Contin-gency 5% (Tk)	Total Per km/yr	Per mile/yr
1.	HBB Brick Road with sand sub-base	31,551	5,700	1,863	39,114	62,974
2.	WBM Road with sand sub-base	14,560	5,700	1,013	21,273	34,250
3.	Aggregate stabilised soil road with sand-soil sub-base	12,820	5,700	926	19,446	31,308

Thus, the maintenance cost for aggregate stabilised soil road and WBM road are of similar magnitude and considerably lower than that of HBB brick road.

Table-12 gives the comparative cost of the three types of roads taken over a cycle of three years including the initial investment cost.

Thus, from above Table-12, Type 8 with low-cost surfacing and 3-year maintenance has the following savings:

a) Savings Over 1-1/2" Bituminous Surfacing with Similar Pavement Structure of Type 8

$$\text{Initial savings} = \frac{\text{Tk } 4,82,758}{\text{Tk } 11,50,409} \times 100 = 42\%$$

$$\text{Final savings after 3-year} = \frac{\text{Tk } 4,17,742}{\text{Tk } 12,44,333} \times 100 = 33.6\%$$

b) **Savings Over Conventional WBM Road with 1-1/2" Bituminous Surfacings**

$$\text{Initial savings} = \frac{\text{Tk } 8,98,477}{\text{Tk } 11,50,409} \times 100 = 78.10\%$$

$$\text{Final savings after 3-year} = \frac{\text{Tk } 8,33,461}{\text{Tk } 12,44,333} \times 100 = 67\%$$

c) **Savings Over Conventional HBB Brick Road**

$$\text{Initial savings} = \frac{\text{Tk } 2,73,861}{\text{Tk } 11,50,409} \times 100 = 23.8\%$$

$$\text{Final savings} = \frac{\text{Tk } 3,68,859}{\text{Tk } 12,44,333} \times 100 = 29.6\%$$

Aggregate stabilised soil road with surface dressing (Type 8) with 3-year maintenance therefore appears to provide an initial saving of 78.10% and a final saving of 67% over conventional WBM road with 1-1/2" bituminous surfacings and an initial saving of 23.8% and a final saving of 29.6% over conventional HBB road. It may be mentioned here that for rural areas, 1-1/2" bituminous surfacing may not require maintenance for the first 3-year. But after 3 years, it will require heavy maintenance to repair pot-holes and may even require costly overlay making it all the more expensive.

Thus, initially, instead of constructing 100 km of WBM road with conventional 1-1/2" thick bituminous surfacing, 178 km of aggregate stabilised soil road with single course surface dressing can be constructed. Even considering three years' maintenance cost, the total investment on 100 km of WBM road is about the same as that for 167 km of ASS road which, therefore, on the basis of this trial appears to be the most economic pavement type with satisfactory performances as observed in six months of monitoring (see Table 12).

Comparative cost of the three catagories of pavements, HBB, WBM and ASS, is shown in a bar chart on page I/39.

Road Surfacing Trial Project, Rajbari

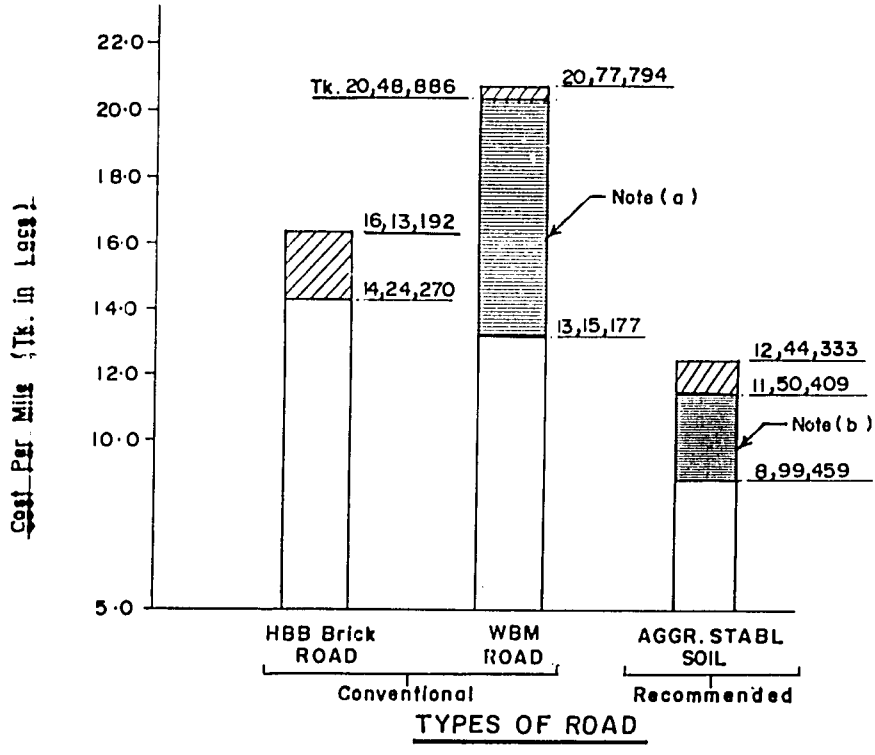
TABLE-12: COMPARISON OF COST TAKEN OVER THREE YEARS INCLUDING THE INITIAL INVESTMENT COST

Sl No	Description	Cost/Mile of pavement structure (Tk)	Cost/Mile of Surfacing (Tk)	Initial Investment Cost/Mile (Tk)	Cost/Mile of Maintenance for 1st three years (Tk)	Total Cost/Mile in Three years (Tk)	Additional Cost/Mile over Type-8		Remarks
							Initial (Tk)	Final after 3 years (Tk)	
1	2	3	4	5=3+4	6	7=5+6	8	9	10
1.	Aggregate stabilised soil road and surface dressing with asphalt emulsion and pea-gravels, Type-8	8,99,459	2,50,950	11,50,409 (a=100)	93,924	12,44,333 (b=100)			Recommended type of pavement
2.	Aggregate stabilised soil road + 1½" thick conventional bituminous surfacing	8,99,459	7,33,708	16,33,167	28,908	16,62,075	4,82,758 (42%)	4,17,742 (33.6%)	Additional cost as compared to the recommended type-8
3.	WBM road + 1½" thick conventional bituminous surfacing	13,15,177	7,33,708	20,48,885 (c=1.78a)	28,908*	20,77,794 (d=1.67b)	8,98,477	8,33,461	Additional cost as compared to the recommended type-8
4.	BBG brick road Type-1	14,24,270	-	14,24,270	1,88,922**	16,13,192	2,73,861 (23.8%)	3,68,859 (29.6%)	Additional cost as compared to the recommended type-8

Note: *Only Maintenance cost for shoulder and side slopes have been taken, with 5% allowance for contigency i.e. Tk 5700 per km x 1.05 x 1.61 x 3 = Tk 28,908

**Taken from Table 11

COST OF THREE CATAGORIES OF PAVEMENTS



LEGEND :-

- Cost of Pavment Structure
- Cost of Surfacing
- Cost of Maintenance for 3 Years

NOTE :- (a) Surfacing with 1½" thick bituminous carpetting.

(b) Surface dressing with pea-gravels & asphalt emulsion.

Project:-	Consultant:-	Drawing No.
ROAD SURFACING TRIAL PROJECT RAJBARI	BANGLADESH CONSULTANTS LTD. House No. 4, Road No. 14 (New) Dhanmondi R.A, Dhaka - 9.	Date. 15-1-87

13.2 Maintenance Programme

As stated earlier, effective timely maintenance is a pre-requisite for satisfactory performance of low-cost roads. From the type and extent of deteriorations to the road sections as observed during the six-month monitoring period, the following maintenance programme is suggested for the recommended pavement Type 8, i.e. aggregate stabilised soil road.

a) Maintenance of Pavement Surface

1) Surface cracks shall be treated by sealing with asphalt emulsion and sand blindage.

2) Areas from where coated pea-gravels are lost shall be treated with fresh surface dressing by spreading asphalt emulsion and pea-gravels and thereafter hand ramming. For the above maintenance one labour per km length for a period of three months, scattered throughout the year in the following break-up, is recommended:

During Jun-Oct (wet weather) - for 6 weeks
During Nov-Dec (post-wet ") - for 4 weeks
During Apr-May (pre-wet ") - for 2 weeks

b) Maintenance of Granular Shoulder

From about 50-60% area of the granular shoulder sand-soil had been washed away from the surface due to rain, exposing the aggregates.

It is recommended that the sand-soil mix (50:50) be spread over the exposed aggragates as blindage and then compacted by hand ramming.

For this maintenance two labours per km is recommended for a period of one month during Nov-Dec, when soil will be available from borrowpits.

c) Maintenance of Earthen Shoulder

Some local depressions and ruts were observed in earthen shoulders during wet weather, accumulating rain water. To drain this out by cutting cross drains, an average one labour per km for a period of three months scattered throughout the year is recommended in the following breakup:

During Jul-Sep (wet weather) - 6 weeks @ 1 labour for 2 km

During Nov-Jan (dry weather) - 4.5 weeks @ 2 labour for per km

d) Maintenance of Side Slopes

Some raincuts were observed on the side slopes. For maintenance five labours for a period of two weeks during Dec-Jan is recommended to make good all the raincuts and deficient areas by filling earth with hand ramming and grass-turfing the new areas.

All the above maintenance activities shall be duly looked after by a supervisor who will be responsible to control effectively the maintenance of about five km of road length. This maintenance schedule is shown in Annexure-10.

14.0 MISCELLANEOUS CONSIDERATIONS

14.1 Riding Quality

Riding quality in aggregate stabilised soil road was found to be equally good as on WBM road and much better than on HBB brick road due to the reasons outlined below. Local bricks are irregular in shape, size and strength. So, the use of whole bricks in HBB brick road cannot ensure smooth and even pavement surface. The movements of individual bricks under the traffic cannot be kept restricted, rather these movements of bricks increase with time due to loss of sand packing, causing breakage at the corners and edges of the bricks. This phenomenon greatly hampers the riding quality on HBB brick pavement. The breaking of corners and edges of bricks may be reduced by:

a) using bricks of consistent quality and uniform shape and size;

b) restricting the loss of sand packing by means of effective sealing of HBB brick joints with approved quality of bitumen or asphalt emulsion.

Considering these limitations it would be difficult to ensure satisfactory performance of HBB brick pavement in rural areas and hence the riding quality cannot be assured.

On the other hand, both the WBM roads and aggregate stabilised soil roads had only limited surface deterioration in the form of local depressions without any remarkable loss in riding quality.

14.2 Construction Technique

HBB brick roads and WBM roads are widely used in this country and their construction technique is well known among the conventional contractors. But this is not so with the aggregate stabilised soil road. Although the construction technique of aggragate stabilised soil road is somewhat new and unknown to the rural road construction system, yet in this trial project this innovative construction method was successfully implemented utilising 100% local materials and 100% local labours who were guided and motivated, at every stage of construction, by the Consultants with care and patience. Some resistance of the Contractors was inevitable specially because they were not accustommed to such vigorious quality control through intensive testing of materials and works. If properly initiated, one of the beneficial effects of adoption of ASS road would be introduction of testing for quality control - an aspect which is presently better known through its absence than use.

The Consultants are thus of the opinion that aggregate stabilised soil road, though new to the general contractors, can be constructed given a modicum of sincere effort and endeavour on part of supervisory personnel of both the client and the contractor. Further field testing is, however, required before this can be confirmed.

14.3 Relative Performance of Sub-base

Two new types of sub-base, namely, sand-soil sub-base and aggregate-sand-soil sub-base were tried to compare with the conventional sand sub-base for performance efficiency.

The extent of depressions/ruttings in the HBB brick pavement with sand-soil sub-base and aggregate sand-soil sub-base are almost the same but slightly more than that with sand sub-base, as seen from the Record of Observations, for Types 1, 2 and 3, refer Appendix-5.

Thus, sand-soil sub-base and aggregate-sand-soil sub-base are similar in performances, but the latter is more expensive.

The relative deterioration to the pavement Types 1 and 2 with sand sub-base and sand-soil sub-base respectively and those between Types 4 and 5 with sand sub-base and sand-soil sub-base respectively were almost similar. All the four types of aggregate stabilised soil roads (Types 7, 8, 9 and 10) had sand-soil sub-base in the pavement structure. The pavement deteriorations in Types 7 and 8 and 66m of Type 10 were negligible as seen from the monitoring reports. This indicates the satisfactory performance of the entire pavement structure i.e. both the base-course and the sub-base-course. Even in the damaged stretch of Type 10 (for 34m length), during the repair work it was observed that only the base-course was damaged but the sand-soil sub-base underneath was in good condition and the available degree of compaction in this sub-base under the damaged base was more than 95%. Similar were the observations for the sand-soil sub-base under the damaged base in Type 9.

Thus, it can be concluded that sand-soil sub-base is as good as sand sub-base but more economical and more labour intensive as will be seen from Tables 13 and 14.

Further, the following test results show how effective is the "sand-soil sub-base" as compared to "sand sub-base":

a) Properties of Local Sands

1) Alipur sand, Rajbari
FM = 1.30 to 1.40, poorly graded

2) Kamaldia sand, Rajbari
FM = 0.32 to 0.40, poorly graded

b) **Properties of Mixed sand Sub-base**

Alipur + Kamaldia sand = 80:20
Combined FM = 1.20
Combined Gradation = Nearly well graded
Maximum Dry Density (MDD) = 105 pcf
Optimum Moisture Content (OMC) = 13.75%
Soaked CBR (Lab-mix) = 24%
Soaked CBR (from field mix) = 23.33%
Efficiency of manual field mixing = 97%
(labour involvement = 15%)

c) **Properties of Mother Soil (from Box-cut)**

Soil classification: Sandy-Clayey-Silt (8%,10%, 82%)
LL = 30%, PI = 5%
MDD = 105 pcf, OMC = 17.70%
CBR = 3.8%, By DCP method

d) **Properties of Sand-soil Mix**
(Sand: Soil = 50:50)

Alipur sand = 50% (used as available naturally)
Mother soil = 50%
MDD = 122 pcf, OMC = 11.50%
Soaked CBR (Lab-mix) = 26.11%
Soaked CBR (from field mix) = 22.67%
Efficiency of manual field mixing = 87%
(labour involvement = 32%)

Table-13: Comparision of Cost and Labour Involvement in Preparation of Three Type of Sub-base

Type of Sub-base	Cost per cft (Tk)	Comparison (%)	Labour invol (%)	Comparison (%)	Remarks
a) Blended sand sub-base	5.87	128.45	19	100	Sand-soil sub-base is cheapest and most labour intensive
b) Sand-soil sub-base (50:50)	4.57	100	41	216	
c) Aggr-sand-soil sub-base (20:25:55)	8.58	187.75	38	205	

Table-14: Comparison of Properties of Three Types of Sub-base Materials

Type of Material used in sub-base	MDD (pcf)	Com-pari-son (%)	CBR (%)	Com-pari-son	OMC (%)	Com-pari-son (%)	Remarks
a) Mother soil	105	100	3.8	100	17.70	100	
b) Sand-soil sub-base (50:50)	122	116	22.67	596	11.50	65	Compared to (a)
c) Blended sand sub-base	105	86	23.33	103	13.75	120	Compared to (b)

Thus, it was concluded that:

a) On cost consideration, sand sub-base is about 28% more expensive than sand-soil sub-base and aggregate-sand-soil sub-base is about 88% more expensive, see Table-13.

b) The increased MDD (16%) at a lesser moisture content and increased CBR value (about 6 times) of sand-soil mix reveals that by addition of sand, the properties of mother soil can be improved to such an extent to make sand-soil mix suitable as a sub-base material, but at a reduced cost involving more labour and thus more employment.

c) With sand-soil sub-base the labour involvement is more than double compared to the conventional sand sub-base. It is thus more labour intensive and at the same time more economical.

d) Sand-soil sub-base is denser than sand sub-base at a lesser moisture content and both have almost similar CBR value. Therefore, both on technical and economic point of view, sand-soil sub-base is preferred to the conventional sand sub-base.

14.4 Effects of Ommission of Brick Flat Soling under HBB Brick Pavement

In Types 2 and 3 of HBB brick road, brick flat soling had been omitted to compare the performance efficiency with respect to Type 1 with brick flat soling. It was observed during monitoring that the ruttings along the trackways

were much more pronounced in Types 2 and 3 than in Type 1. This rutting was observed in 13% length along trackways for Type 1 against 80% for Type 2 and 70% for Type 3 although the depths of rutting were ranging from 15mm to 25mm in all the three cases. The ruttings started just after one month of the completion of construction and reached maximum limit in the 3rd to 4th month and thereafter remaining constant.

It is, therefore, concluded that for HBB brick road, brick flat soling should not be omitted, if effective sealing cannot be provided.

14.5 Maintenance During Post-construction Monitoring Period

It was decided in a project co-ordination committee meeting that during the post-construction monitoring period 50% of the each trial section would be maintained in an attempt to keep the road near to as-built conditions and 50% would be left unmaintained to assess the rate of deteriorations.

During the monitoring period it was observed that the maintenance activities of the Contractors were very minimal as will be seen from the General Comments from Monthly Monitoring Reports No. 1, 2 and 3. (reference Appendix 8). So, the basic objective of a comparative study between maintained and non-maintained stretches could not be made. But one aspect which become clear from the monitoring records was that timely and regular maintenance is the sine qua non for satisfactory serviceability of low cost roads like these trial sections.

Further, no record of the small scale maintenance activities done by the Contractors was available and so the extent of maintenance done during this period could not be assessed for monetary evaluation in order to arrive at the actual cost of the project.

However, for the assessment of maintenance costs, the observed deteriorations in the road sections of each trial category during the monitoring period were considered, analysed and evaluated in monetary terms and the approximate maintenance costs calculated to determine their impact, on the total costs. These are presented in Tables 11 and 12.

14.6 Effect of Adverse Weather Conditions during the Post-construction Monitoring Period

The post-construction monitoring period passed through an extreme wet spell when it rained heavily and continuously for a period of a fortnight.

On the one hand the damages induced due to lack of maintenance of small localised deteriorations in Type 9 and part of Type 10 aggregated to failure of the pavement. On the other hand Types 7 and 8, having same pavement structure as Types 9 and 10, proved quite satisfactory in performance under normal traffic during and after the wet spell.

The unseasonal heavy rains, therefore, came as a boon as it enabled a critical evaluation to be made of the performance of aggregate stabilised soil road, Types 7 and 8, proving that the pavement structure of this category, with a proper surface sealing such as single surface dressing, can be an effective pavement type of desired standard for the rural areas of Bangladesh. Further trials are, however, called for before adoption of this type of pavement for large scale construction.

14.7 Fluctuations in Labour Force

As per terms and conditions of contract, the contractors were supposed to complete the works within a period of 90 days which was not an unrealistic schedule considering the small volume of work. As the contractors did not have not any qualified technical person, the Consultants prepared detailed work plans for the contractors showing the starting and completion dates for individual items of work.

Due to their lack of requisite technical expertise and often slow and grudging adherence to the instructions of the Consultants the Project suffered a delayed completion. The total duration of the Project from the date of work order to the date of completion was 142 days against a contract period of 90 days.

Several factors were responsible. Among them the important ones were:

a) Delays in collection of materials

b) Problems associated with compaction of ASS base - this work being of a new nature for the contractors

c) Problems arising from supply or unspecified asphalt emulsion

d) Management lapses is planning and organising labour in-put to synchronise with materials availability.

Items (a) to (d) above are clearly illustrated in the histograms in Annexures 5a and 5b which show the wide fluctuations in total number of labourers employed on the jobs every week. The histograms have been drawn from the data given in Table-15.

Table-15: Total Numbers of Labourers Working During the Project Weeks

Week No	Period	Group A No. of Labour	Group A % of Total	Group B No. of Labour	Group B % of Total
1&2	09/02/86 - 24/02/86	Mobilisation period			
3	25/02/86 - 03/03/86	176	6.45	211	4.79
4	04/03/86 - 10/03/86	229	8.39	315	7.15
5	11/03/86 - 17/03/86	120	4.39	186	4.22
6	18/03/86 - 24/03/86	73	2.67	108	2.45
7	25/03/86 - 31/03/86	112	4.10	147	3.34
8	01/04/86 - 07/04/86	139	5.09	382	8.68
9	08/04/86 - 14/04/86	313	11.46	548	12.45
10	15/04/86 - 21/04/86	336	12.31	513	11.65
11	22/04/86 - 28/04/86	244	8.94	384	8.72
12	29/04/86 - 05/05/86	147	5.38	296	6.72
13	06/05/86 - 12/05/86	162	5.93	232	5.27
14	13/05/86 - 19/05/86	189	6.92	384	8.72
15	20/05/86 - 26/05/86	237	8.68	289	6.56
16	27/05/86 - 02/06/86	85	3.11	167	3.79
17	03/06/86 - 09/06/86	73	2.67	71	1.61
18	10/06/86 - 16/06/86	49	1.79	0	0
19	17/06/86 - 23/06/86	25	0.91	142	3.24
20	24/06/86 - 30/06/86	21	0.80	28	0.64
Total =		2730	100.00	4403	100.00

Note: Work Order was issued on 09 Feb 1986 whereas the contractor actually started the work on site from 25 Feb 1986. There was, thus, a mobilisation period of about two weeks.

14.8 Performance of Female Labour

It was interesting to observe that the contractors engaged female labour in many items of works, like local handling of construction materials, watering, mixing of sub-base and base course materials, etc. It is worth mentioning that mixing of sand-soil sub-base and aggregate-sand-soil base course materials with water was a comparatively exacting job where some female labourers were seen to work quite efficiently.

It was not possible to record the itemwise daily output of female labour due to their frequent migration within the Project and their partial involvement in related items of work. However, it was apparent that they performed quite satisfactorily and were more receptive to instructions and less prone to time wasting than their male counterpart.

15.0 CONCLUSIONS AND RECOMMENDATIONS

15.1 The Objective

The objective of the Project was to find one or more type(s) of labour intensive, low technology, low cost, semi-pucca, all-weather road surface(s) suitable for rural roads of Bangladesh.

15.2 The Conclusion

On the basis of data collected during the construction and monitoring periods, and their analysis, it appears, tentatively, that ASS Roads, Types 7 and 8, exhibited the most promising characteristics as listed below:

a) Least cost both in terms of initial investment and a three-year maintenance cycle (see Table-12);

b) Most labour intensive (see Table-10);

c) Minimum use of bricks (see Table-8) which is usually difficult to obtain in good quality in rural areas and whose manufacture requires use of agricultural land and also often requires burning of local firewood with consequent unfavourable environmental effect;

d) Comparatively lower requirement of capital intensive mechanical equipment like road-rollers (see third para, Section 8).

e) Adaptability of the contruction technique by local labour.

15.3 The Recommended Pavement Structure

This recommended pavement structure with sand-soil sub-base and agregate stabilised base-course is shown in Annexure-11. The approximate proportion of sand-soil in the sub-base should be 50:50 and those of bricks

aggregates, sand and soil in the base course should be approximately 33:22:45, the exact proportions to be fixed on the basis of test results of locally available individual components and the mix to meet the design criteria.

15.4 Sand-soil Sub-base

Comparative analysis on the relative performance of different types of sub-bases as outlined in sub-section 14.3, leads to an encouraging conclusion that the sand-soil sub-base:

a) is as good as conventional sand sub-base in technical performance;

b) is less expensive than conventional sand sub-base and thus provides economy;

c) is labour intensive, thus provides more employment;

d) is easy to mix manually and does not need mechanical mixing.

Therefore, it is appears that for rural roads, sand sub-base should be replaced with sand-soil sub-base for its low-cost, low-technology and labour intensive characteristics.

15.5 Low-cost Surfacing

In order to give the semi-pucca characteristic to the road, the pavement structure is recommended to be treated by single course surface dressing with pea-gravels and right quality of asphalt emulsion/bitumen with special emphasis on timely maintenance as and when situation warrants. Any surface deterioration shall have to be attended promptly so that the sealing on the pavement surface remains effective against ingress of water for all times to ensure the desired performance of the pavement.

Further, as discussed in Article 12.0, surface treatment by means of surface painting with asphalt emulsion and sand blindage was found deteriorating quickly and thus was ineffective. Hence, it is recommended that this type of surface painting should not be considered for any future road surfacing trial.

15.6 Pavement Cross-section

The pavement cross-section is recommended to have a modified cross slope of 4% on pavement and 6% on shoulder for quick drainage (see Annexure-11) with a stronger granular shoulder 8" thick in place of 6" constructed in this trial.

15.7 Traffic Survey

Traffic survey should be supplemented with axle load survey for which necessary arrangements for weigh bridges should be made. This is required to estimate the damaging effects of different commercial axles.

During post-construction monitoring programme, at least two traffic counts, one in peak period (winter season) and the other in off-peak (rainy season), should be made for better accuracy in assessing traffic growth rate resulting from improvement of the road.

15.8 Contractor's Mobilisation Period

Apart from the actual period of construction, the contractor should be awarded an adequate mobilisation period to establish his full set-up, such as acquisition of labours, equipments, construction of labour-sheds with water, sanitation facilities, etc.

15.9 Contractor's Site Engineer

It is recommended that the conditions of contract stipulate that the contractor maintain a whole-time qualified engineer at work site, having sufficient experience in the relevant field so that quality control measures by the contractor's staff become a regular and accepted requirement of future contracts.

15.10 Maintenance Programme

It is re-emphasised that effective and timely maintenance are pre-requisites for satisfactory performance of the recommended low-cost road. The maintenance programme, as outlined in Article 13.0 and Annexure-10 is recommended to be taken up with in-house or any other suitable arrangement designed in a way to provide sufficient incentive to the local population to keep the road in a satisfactory state of repair.

15.11 Post-construction Monitoring Period

For more accurate and effective assessment of pavement performance and deterioration, the post-construction monitoring period is recommended to be extended to one complete year instead of six months. Arrangements should be such that continuous and reliable recording of pavement deteriorations is made throughout the monitoring period.

15.12 Improvement of Quality of Asphalt Emulsion

In view of the advantages of asphalt emulsion over bitumen for use on rural road (see sub-section 12.2) it is recommended that the foreign donor agencies assisting in

construction of rural roads consider providing funds and/or technical assistance for improving the quality of the asphalt emulsion presently being produced in the country. The benefits may be considerable.

15.13 Necessity of Further Trials

The analysis and related findings of this first trial should not be considered to provide definitive conclusions. It has been mentioned more than once that owing to various factors the conclusions and recommendations contained herein should be considered as tentative. However, the investigations have opened up some promising lines which need to be confirmed through further trials - preferrably in different parts of the country under varying conditions of soil, climatic, traffic mix, labour, etc.

15.14 Proposal for Further Trial

As mentioned in the para above, further trials should be taken up to establish/confirm the above recommendations with additional data/information. The possibility of finding a better pavement structure than the recommended ASS road cannot altogether be ignored. Therefore, in the next trial it would be worthwhile to include cement modified soil (CMS) road for comparative study.

Thus, it is recommended that the following ten different types of road sections in four broad catagories be taken up for further trial - HBB, WBM, ASS and CMS:

a) HBB Brick Road

Three types of HBB brick roads, all with sand-soil sub-base (approx 50:50):

1) HBB brick road with single brickflat soling and sand-soil sub-base.

2) HBB brick road with sand-soil sub-base and joint sealing with asphalt emulsion/bitumen.

3) Same as (2) but without joint sealing.

Type (2) will be compared with type (1) and (3) in respect of performance and cost.

b) WBM Road

Three types of WBM roads, all with sand-soil sub-base (approx 50:50):

4) 10 cm WBM base over a single brick flat soling and sand-soil sub-base, with single surface dressing with pea-gravels and asphalt emulsion/bitumen.

5) 15 cm WBM base with sand-soil sub-base and single surface dressing as in (4).

6) 15 cm WBM base with sand-soil sub-base and premixed seal coat with pea-gravels and hot bitumen.

c) ASS Roads

Two types of ASS roads, both with sand-soil sub-base (approx 50:50):

7) 18 cm ASS base with sand soil sub-base and single surface dressing with pea-gravels and asphalt emulsion/bitumen.

8) Same as (7) but surfacing with premixed seal coat with pea-gravels and hot bitumen.

d) CMS Road

Two types of cement modified soil roads both with sand-soil sub-base (approx 50:50):

9) 18 cm cement modified soil-base with sand-soil sub base and single surface dressing with pea-gravels and asphalt emulsion/bitumen.

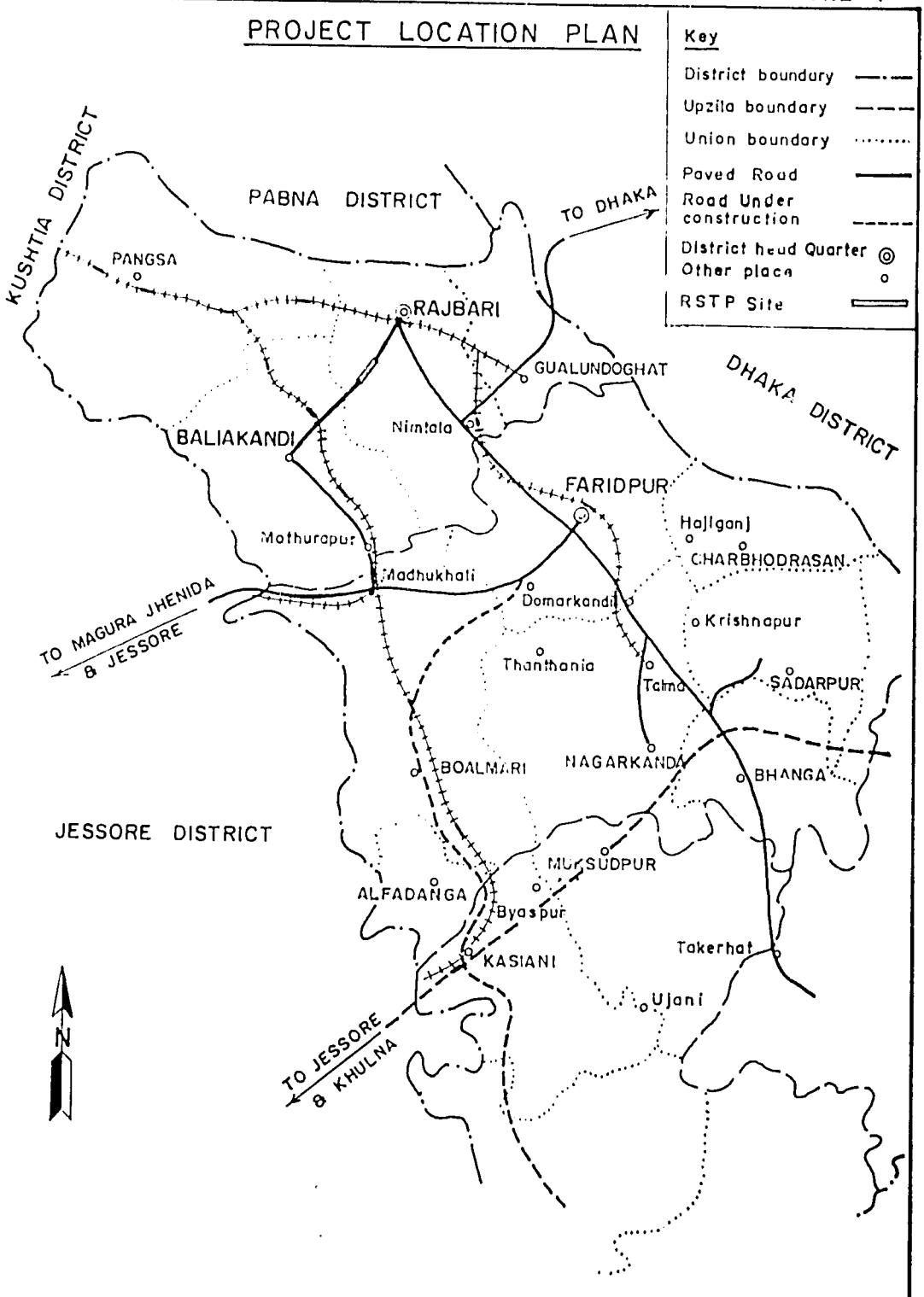
10) Same as (9) but surfacing with premixed seal coat with pea-gravels and hot bitumen.

The reason for trying with different types of bases as in (b), (c) and (d) above is to compare the ASS base and CMS base with the conventional WBM base in respect of performance and cost. Similarly, regarding surface treatment, single surface dressing will be compared with the conventional premixed seal coat in respect of performance and cost.

It needs be mentioned here that due to the satisfactory performance and relative economy of sand-soil sub-base as found and established in the first trial, all the pavement structures in the next trial are recommended to have the same types of sub-base i.e. sand-soil sub-base (approx 50:50).

Therefore, in the pavement structure, out of the three components, namely sub-base, base and surface course, only the latter two components will be kept as variables.

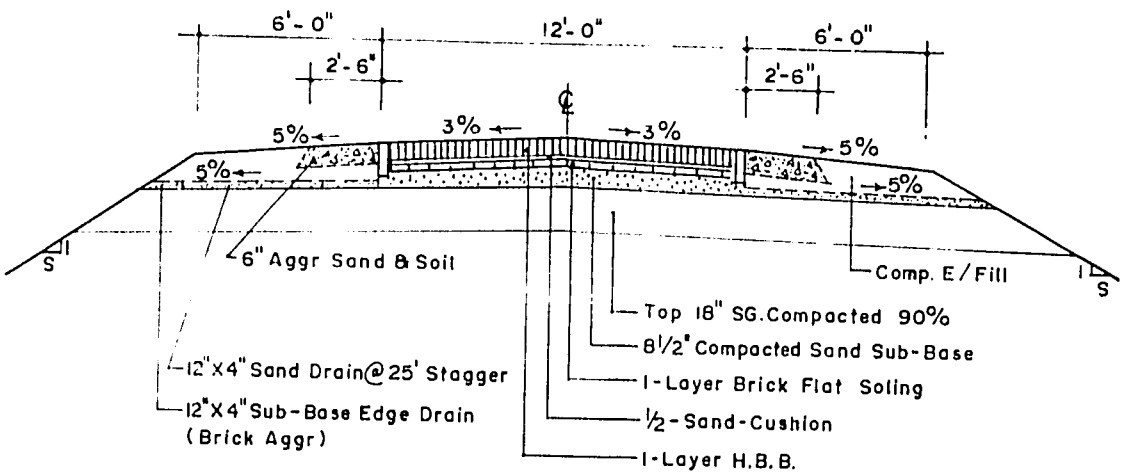
PROJECT LOCATION PLAN



Project :	Consultant :	Drawing No.
ROAD SURFACING TRIAL PROJECT RAJBARI	BANGLADESH CONSULTANTS LTD. House No. 4, Road No. 14 (New) Dhanmondi R. A. Dhaka — 9	Date : 17-2-87

HBB Road with single brick flat soling & sand sub-base

Presently used in Faridpur ZRMIP



S = 2·5 for H = 0 to 8 ft.

S = 3·00 for H > 8 ft. < 16 ft.

H = Clear height of fill at shoulder

Compaction requirements

a) Sub-Grade – 90% (Standard)

b) Sub-Base – 95% (")

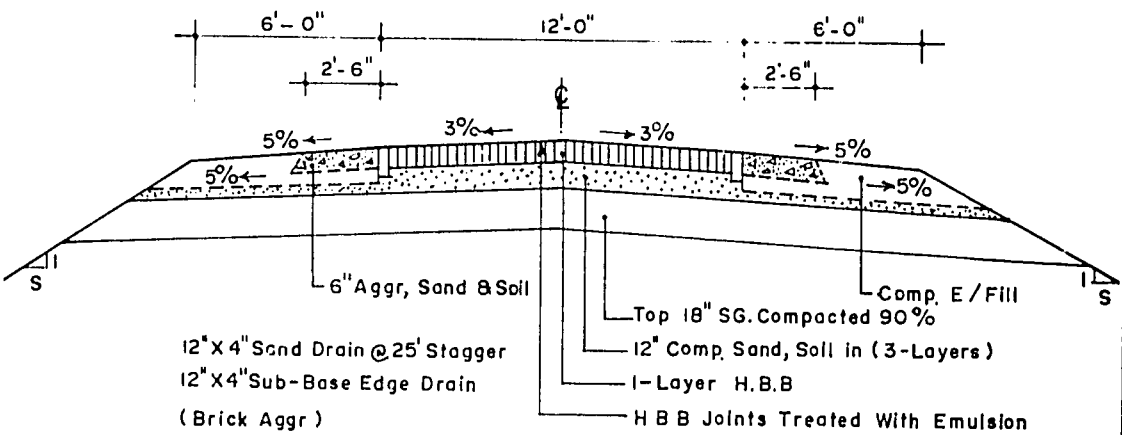
CBR requirments

Top 4" of Sub-Base ≮ 25%

ROAD SURFACING TRIAL – TYPE - (1)

Project : ROAD SURFACING TRIAL PROJECT RAJBARI	Consultant : BANGLADESH CONSULTANTS LTD. House No. 4, Road No. 14 (New) Dhanmondi R.A. Dhaka – 9	Drawing No.
		Date : 18-2-87

H.B.B. Road with soil-sand-sub-base



S = 2·5 for H = 0 to 8 ft.

S = 3·00 for H > 8 ft. < 16 ft.

H = Clear height of fill at shoulder

Compaction requirements

a) Sub-Grade – 90% (Standard)

b) Sub-Base – 95% (,,)

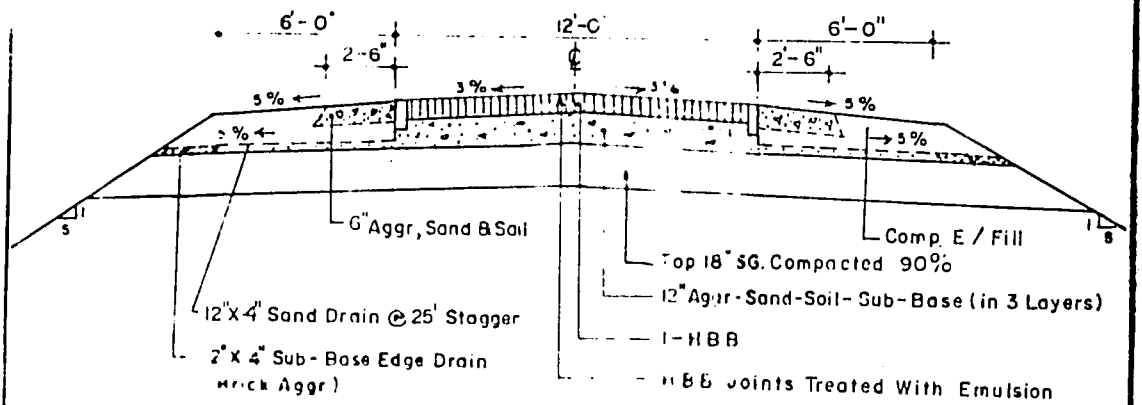
CBR requirments

Top 4" of Sub-Base ≮ 25%

ROAD SURFACING TRIAL – TYPE- ②

roject OAD SURFACING TRIAL PROJECT AJBARI	Consultant : BANGLADESH CONSULTANTS LTD. House No. 4, Road No. 14 (New) Dhanmondi R. A. Dhaka – 9	Drawing No. Date : 18-2-87

H.B.B Road With Aggr - Sand - Soil Sub-Base



For Sub-Base, Soil - 55 %, Sand - 25 %, Aggr - 20 %, impactvalue ≯50 (Aggr)

S = 2.5 For H = 0 to 8 Ft

S = 3.00 For H > 8 Ft. < 16 Ft.

H = Clear Height of Fill at Shoulder

Compaction Requirements

a) Sub-Grade — 90 % (Standard)

b) Sub-Base — 95 % (")

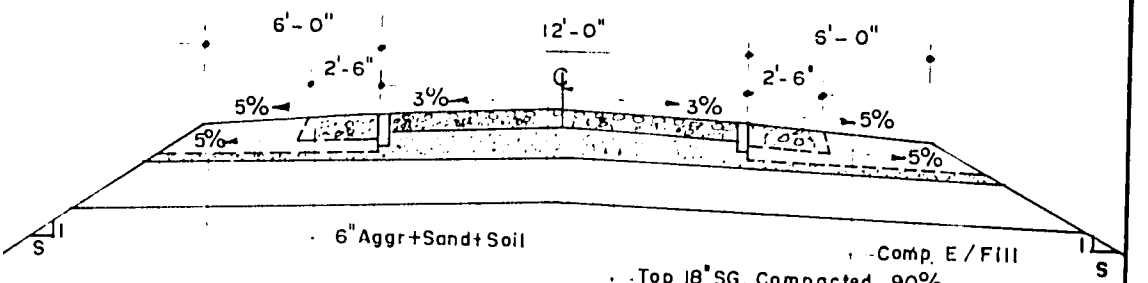
CBR Requirements

Top 4" of Sub-Base ≮25%

ROAD SURFACING TRIAL-TYPE-(3)

Project :	Consultant	Drawing No.
ROAD SURFACING TRIAL PROJECT RAJBARI	BANGLADESH CONSULTANTS LTD. House No. 4, Road No. 14 (New) Dhanmondi R. A. Dhaka — 9	Date: 12-9-85

Water bound macadam road with sand-sub-base



- Top 18" SG. Compacted 90%
- 11" Compacted Sand in (3 Layers)
- 6" W B M
- Surface Dressing / Painting

- 12"X4" Sand Drain, Stagger
- 12"X4" Sub-Base Edge Drain (Brick Aggr)

S = 2·5 for H = 0 to 8 ft.

S = 3·00 for H > 8 ft. < 16 ft.

H = Clear height of fill at shoulder

Compaction requirements

a) Sub-Grade – 90% (Standard)

b) Sub-Base – 95 % (")

c) Base – 100 % (")

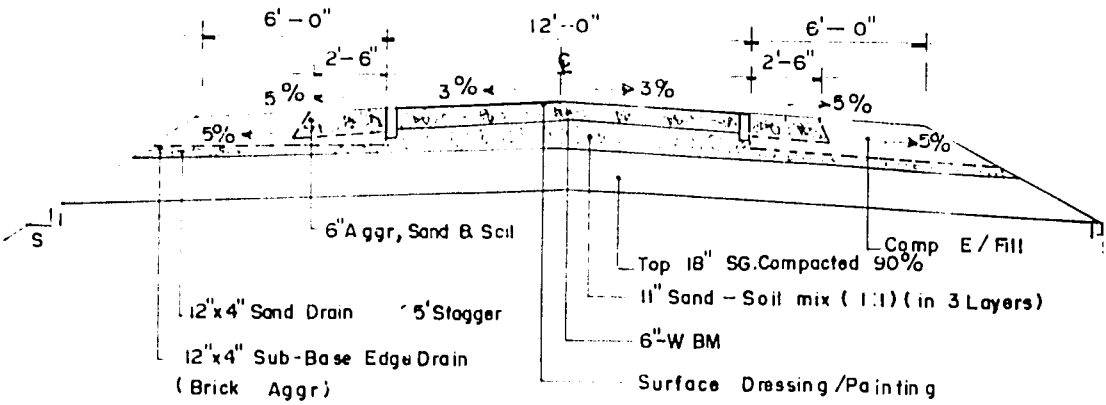
C B R requirments

Top 4" of Sub-Base ≮25%

ROAD SURFACING TRIAL – TYPE – 4

Project: ROAD SURFACING TRIAL PROJECT RAJBARI	Consultant: BANGLADESH CONSULTANTS LTD. House No. 4, Road No. 14 (New) Dhanmondi R.A. Dhaka – 9	Drawing No.
		Date : 18-2-87

Water Bound Macadam Road With Sand- Soil Sub- Base



S = 2·5, For H = 0 to 8 Ft

S = 3·00 For H > 8 Ft. < 16 Ft.

H = Clear Height of Fill at Shoulder

Compaction Requirements

a) Sub-Grade - 90 % (Standard)

b) Sub-Base — 95% (")

C) Base - 100 % (")

C.B.R Requirements

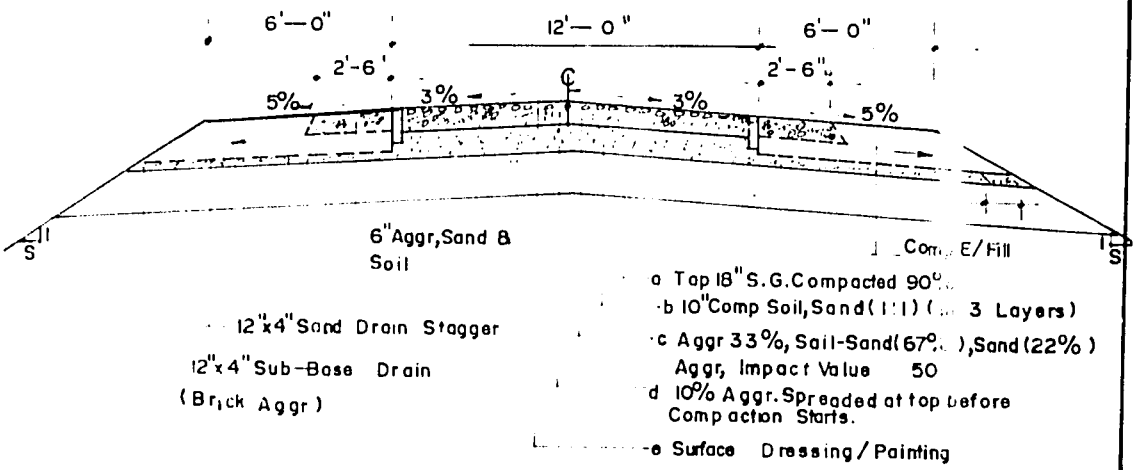
Top 4" of Sub-Base ≮ 25%

ROAD SURFACING TRIAL - TYPE - (5)
(WITH SURFACE PAINTING)

ROAD SURFACING TRIAL-TYPE - (6)
(WITH SURFACE DRESSING WITH PEA GRAVELS)

Project ROAD SURFACING TRIAL PROJECT RAJBARI	Consultant : BANGLADESH CONSULTANTS LTD. House No. 4, Road No 14 (New) Dhanmondi R. A Dhaka — 9	Drawing No. Date :

Aggregate Stabilised Soil Road With Soil-Sand Sub-Base



S = 2.5 For H = 0 to 8 Ft.
S = 3.00 For H = 8 Ft. 16 Ft.
H = Clear Height of Fill at Shoulder

Compaction Requirements

a) Sub-Grade — 90% (Standard)
b) Sub-Base — 95% (")
c) Base — 100% (")

C B R Requirements

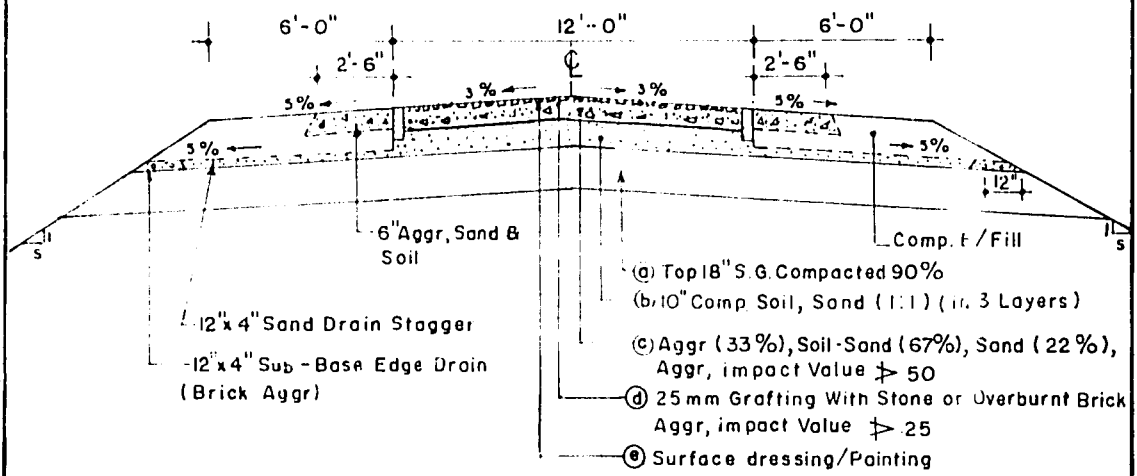
Top 4" of Sub-Base 25%

ROAD SURFACING TRIAL-TYPE-(7)
(WITH SURFACING PAINTING)

ROAD SURFACING TRIAL-TYPE-(8)
WITH SURFACING DRASSING WITH PEA GRAVELS

Project:	Consultant:	Drawing No.
ROAD SURFACING TRIAL PROJECT RAJBARI	BANGLADESH CONSULTANTS LTD. House No. 4 Road No. 14 (New) Dhanmondi R.A. Dhaka 9	Date

Aggregate-Stabilised Soil Road With Stone Grafting & Soil-Sand Sub Base



S = 2.50 For H = 0 to 8 Ft.

S = 3.00 For H = > 8 Ft. < 16 Ft.

H = Clear Height of Fill at Shoulder

Compaction Requirements

a) Sub-Grade -- 90 % (Standard)

b) Sub-Base — 95 % (")

c) Base -- 100 %

C B R Requirements

Top 4" of Sub-Base ≮ 25 %

ROAD SURFACING TRIAL-TYPE - (9)
(WITH SURFACE PAINTING)

ROAD SURFACING TRIAL-TYPE-(10)
(WITH SURFACE DRASSING WITH PEA GRAVELS)

Project:	Consultant	Drawing No.
ROAD SURFACING TRIAL PROJECT RAJBARI	BANGLADESH CONSULTANTS LTD. House No.4, Road No. 14 (New) Dhanmondi R.A. Dhaka — 9	Date: 12-9-85

Road Surfacing Trial Project, Rajbari

COST ESTIMATE AT PRESENT MARKET RATE (FARIDPUR)

Sl No	Pavement Type	Description of Pavement	For smaller vol of work cost per 100 meter	For larger vol of work cost per 100 meter	For larger vol of work cost per 1 mile	For smaller vol of work, cost per 100 meter		For larger vol of work, cost per 100 meter		For larger vol of work, cost per 1 mile	
						Labour	Materials	Labour	Materials	Labour	Materials
1.	1	HBB road with single brick flat soling, sand sub-base	93,946.00	88,464.00	14,24,270.00	31,153.00	62,793.00	25,671.00	62,793.00	4,13,303.00	10,10,967.00
2.	2	HBB road with soil-sand-sub-base and sealing joints of HBB with Asphalt Emulsion	81,120.00	75,290.00	12,12,169.00	34,365.00	46,755.00	28,555.00	46,755.00	4,59,414.00	7,52,755.00
3.	3	HBB road with [illegible]-sand-soil sub-base and sealing joints of HBB with Asphalt Emulsion	96,907.00	89,791.00	14,45,635.00	41,838.00	55,069.00	34,722.00	55,069.00	5,59,024.00	8,86,611.00
4.	4	Water Bond Macadam Road with sand-sub-base and surface treatment with pea gravels	1,01,074.00	95,310.00	15,34,491.00	35,471.00	65,603.00	29,707.00	65,603.00	4,78,283.00	10,56,208.00
5.	5	Water Bond Macadam Road with sand soil sub-base and surface painting	87,487.00	81,212.00	13,07,513.00	37,939.00	49,548.00	31,654.00	49,558.00	5,09,790.00	7,97,723.00
6.	6	Water Bond Macadam Road with sand soil sub-base and surface treatment with pea gravels	96,388.00	90,149.00	14,51,399.00	38,579.00	57,809.00	32,340.00	57,809.00	5,20,674.00	9,30,725.00
7.	7	Aggregate Stabilised Soil Road with soil sand sub-base and surface painting	67,760.00	61,930.00	9,97,073.00	36,843.00	30,917.00	31,015.00	30,917.00	4,99,309.00	4,97,763.00
8.	8	Aggregate Stabilised Soil Road with soil sand sub-base and surface treatment with pea gravels	77,284.00	71,454.00	11,50,409.00	36,111.00	41,173.00	30,261.00	41,173.00	4,87,524.00	6,62,885.00
9.	9	Aggregate Stabilised Soil Road with stone grafting and soil sand sub-base with surface painting	73,066.00	67,057.00	10,79,618.00	39,471.00	33,595.00	33,462.00	33,595.00	5,35,738.00	5,43,880.00
10.	10	Aggregate Stabilised Soil Road with stone grafting and soil sand sub-base and surface treatment with pea gravels	82,594.00	76,584.00	12,33,002.00	38,744.00	43,850.00	32,734.00	43,850.00	5,27,017.00	7,05,985.00
		Total cost for 1000 M (all ten sections) at current market price, Faridpur =	8,57,626.00	7,97,241.00							

Road Surfacing Trial Project, Rajbari

LABOUR & MATERIALS RATES ASSUMED IN COST ESTIMATES

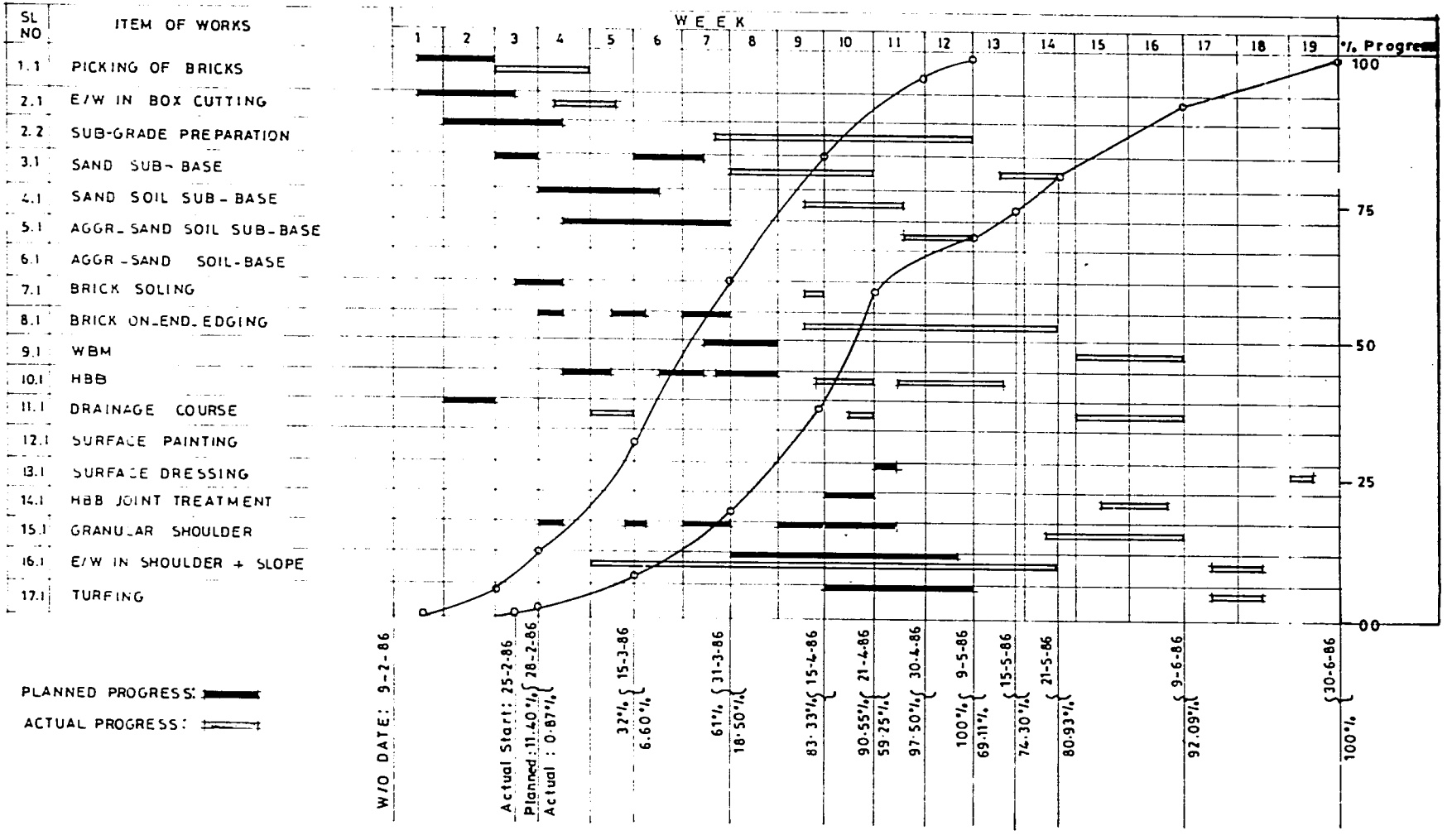
Sl No	Particulars	Present Market Price Tk		Z-P rate Schedule Tk.
		Smaller Vol of work	Larger Vol of work	
1.	Skilled labour/day	50.00	40.00	25.00
2.	Unskilled labour/day	30.00	25.00	20.00
3.	Materials			
	Bricks 1st class %o nos	1200.00	1200.00	1200.00
4.	Bats 1st class % cft including carrying	950.00	950.00	950.00
5.	Sand FM 1.20 % cft including carrying	300.00	300.00	300.00
6.	Bitumen/ton including carrying	10000.00	10000.00	10000.00
7.	Asphaltic emulsion per lbs including carrying	5.31	6.31	5.31
8.	Pea gravels % cft including carrying	2050.00	2050.00	2050.00
9.	Hire charge 8-10 ton roller per day	500.00	500.00	500.00
10.	Carrying for bricks per %o nos	100.00	100.00	-
11.	Sand FM 1.25 to 1.80 % cft including carrying	400.00	400.00	400.00

For any other rate, schedule of rates for Faridpur Zila Parishad 1984-85 shall be applicable.

Road Surfacing Trial Project, Rajbari

PLANNED VS ACTUAL PROGRESS OF WORK OF GROUP-A

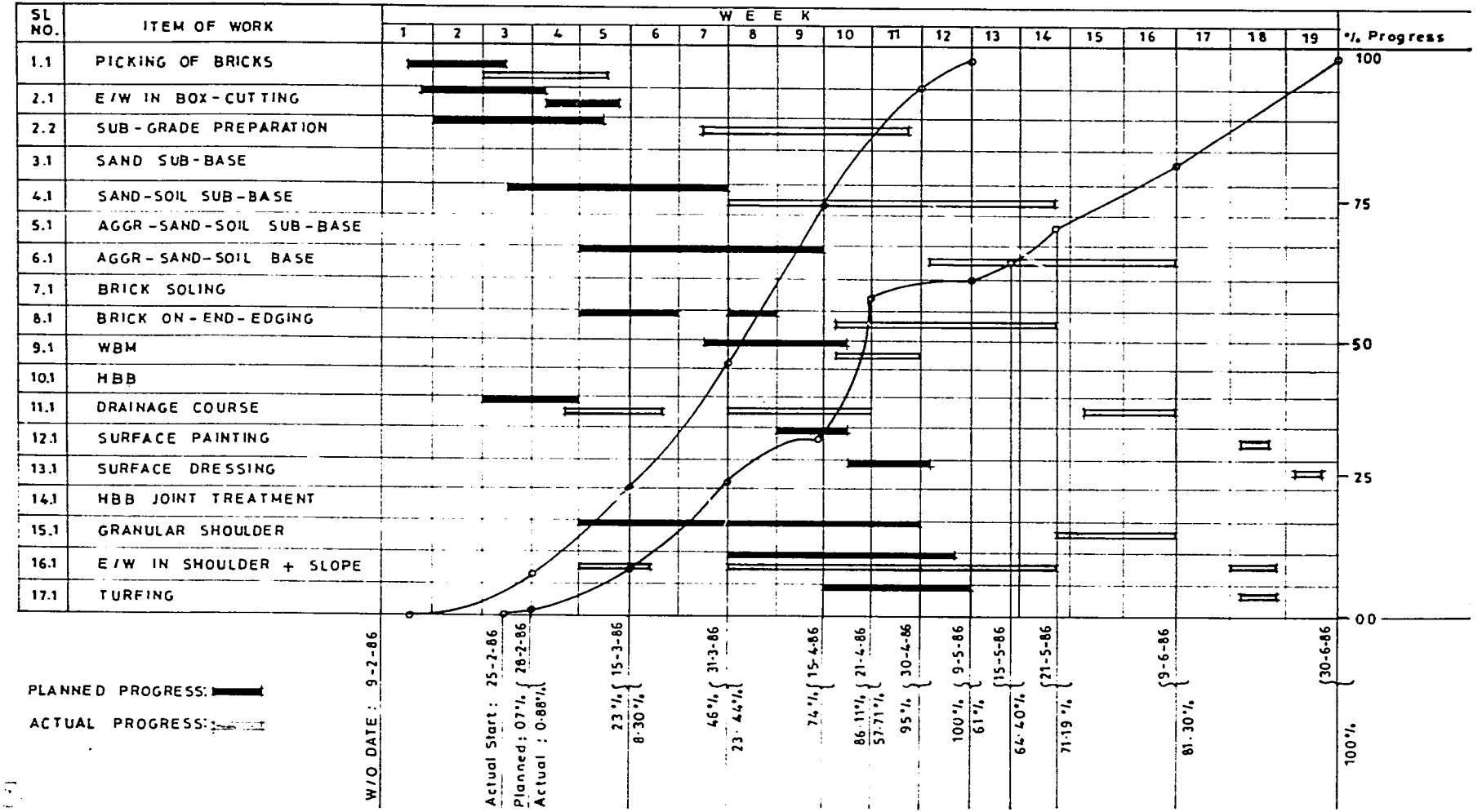
Annexure-4a



Road Surfacing Trial Project, Rajbari

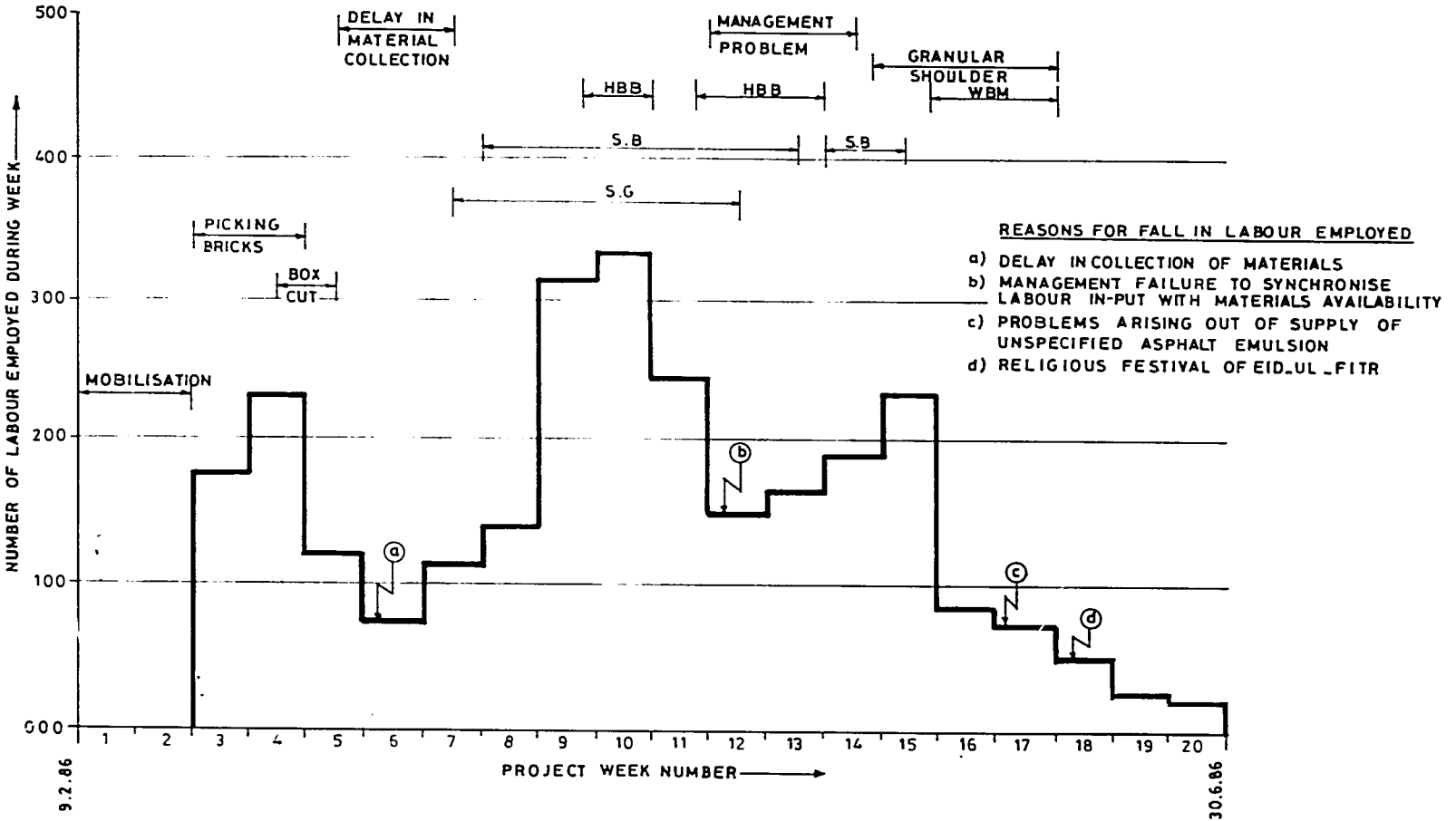
PLANNED VS ACTUAL PROGRESS OF WORK OF GROUP-B

Annexure-4b



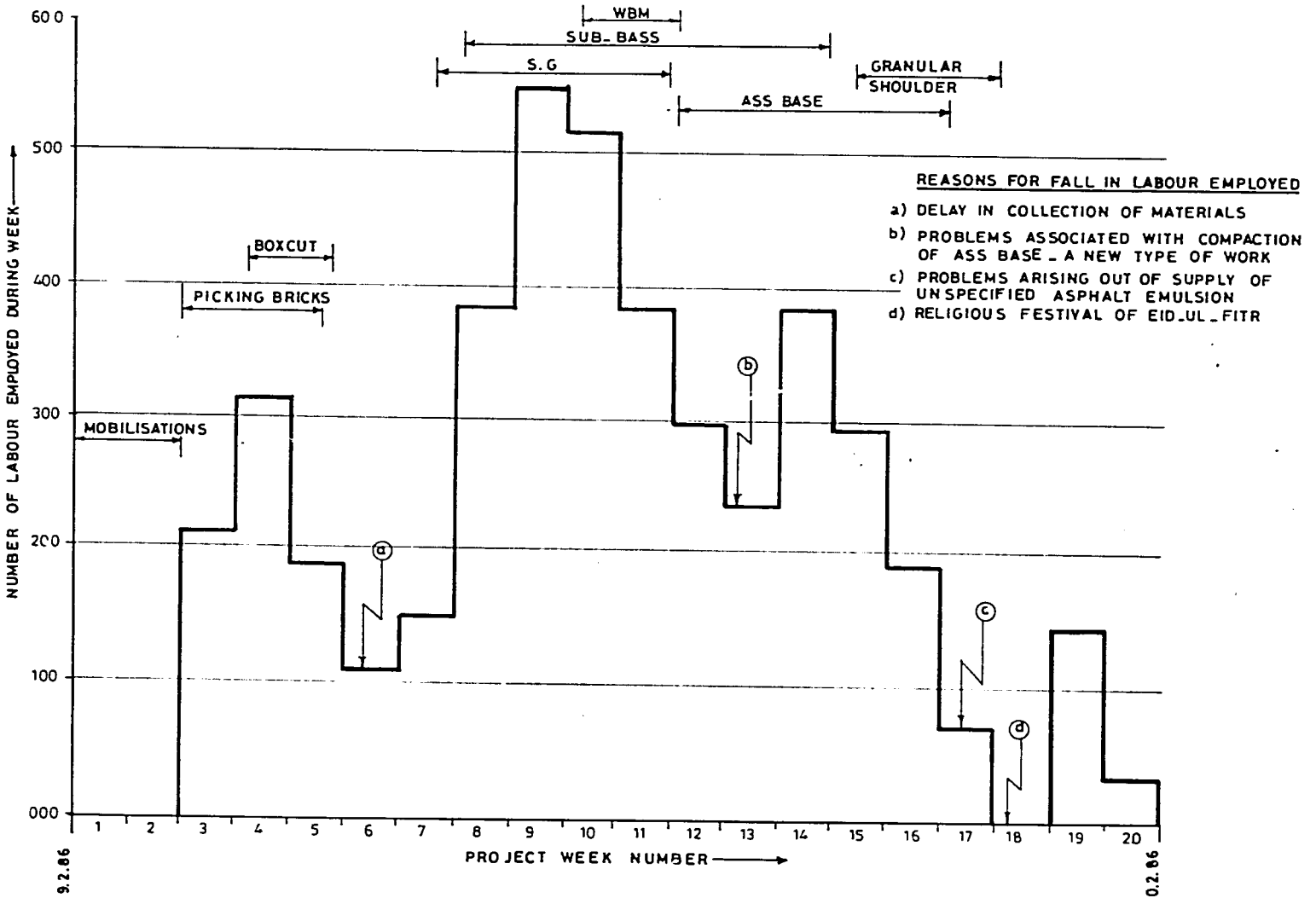
Road Surfacing Trial Project, Rajbari

HISTOGRAM SHOWING FLUCTUATION OF LABOUR EMPLOYED FOR GROUP A



Road Surfacing Trial Project, Rajbari

HISTOGRAM SHOWING FLUCTUATION OF LABOUR EMPLOYED FOR GROUP B



Road Surfacing Trial Project, Rajbari

MEASURE OF PERFORMANCE OF LABOURS: QUANTITY PER HEAD PER DAY

Spec No	Description of works	Maximum production	Minimum production	Actual average	Remarks
1.1(a)	Picking up of HBB bricks	176 sft	106 sft	142 sft	
1.1(b)	Picking up of flat soling bricks	432 sft	117 sft	230 sft	
1.1(c)	Picking up of end edging bricks	105 rft	20 rft	78 rft	
2.1	E/W in box-cutting upto required depth	341 sft	65 sft	100 sft	
3.1	Furnishing, placing and compacting of sand sub-base	39 cft	15 cft	25 cft	Mixing operation being completely n to the la ours. Out put is lo
4.1	Furnishing, placing and compacting of sand-soil sub-base	37 cft	13 cft	22 cft	
5.1	Furnishing, placing and compacting of Aggr-sand-soil sub-base	27 cft	13 cft	14 cft	
6.1	Furnishing, placing and compacting of Aggr-sand-soil base-course	131 sft	64 sft	96 sft	
7.1	Furnishing, placing and bedding of whole bricks for flat soling	131 sft	102 sft	114 sft	
8.1	Furnishing and placing of bricks on end edging	55 rft	22 rft	34 rft	
9.1	Furnishing, placing and compacting of brick aggregates for WBM, base-course	134 sft	42 sft	46 sft	
10.1	Furnishing and placing of bricks for HBB	102 sft	53 sft	82 sft	

Spec No	Description of works	Maximum production	Minimum production	Actual average	Remark
11.1	Providing sand sub-base drainage course	51 sft	36 sft	45 sft	i/c tre ing, pla sand ma rial an compact
12.1	Surfacing painting	328 sft	219 sft	283 sft	
13.1	Surface dressing with pea-gravels	492 sft	179 sft	321 sft	
14.1	HBB joint sealing with emulsion	246 sft	219 sft	232 sft	
15.1	Granular shoulder	54 sft	20 sft	34 sft	
16.1	E/W on side slope embankment	150 cft	45 cft	146 cft	
7.1	Turfing	1044 sft	598 sft	821 sft	

Road Surfacing Trial Project, Rajbari

MEASURE OF COMPACTION ACHIEVED BY DIFFERENT TYPES OF ROLLERS: QUANTITY PER HOUR

Spec No	Description of works	Maximum Production	Minimum Production	Actual Average	Remarks
3.1	Sand sub-base	175 cft	72 cft	130 cft	1 ton roller (Vibratory) layer thickness = 4"
4.1	Sand-soil Sub-base	232 / 189 cft	82 / 95 cft	137 / 123 cft	8-10 ton roller layer thickness = 4" / 1 ton roller, layer thickness = 4"
4.1	-do-	205 cft	131 cft	162 cft	8-10 ton roller layer thickness = 5"
5.1	Agg-sand-soil sub-base	175 cft	94 cft	117 cft	1 ton roller, layer thickness = 4"
6.1	Agg-sand-soil sub-base	219 cft	115 cft	175 cft	8-10 roller, layer thickness = 3½"
9.1	WBM	123 cft	89 cft	105 cft	8-10 roller, layer thickness = 3"

Conclusions drawn:

1. The expenditure for fuel and maintenance of the rollers being borne by the contractors, the accurate records were not available and hence a comparison of cost per hour could not be shown.

2. For WBM base and Agg-sand-soil base with stone grafting, 8-10 ton roller must be used.

3. For all types of sub-base, the small vibratory roller can be used more efficiently and economically in respect of output, manuevering and surface finishing.

Road Surfacing Trial Project, Rajbari

PROGRAMME OF INVESTIGATION AND TESTING FOR QUALITY CONTROL OF MATERIALS & WORKS

o SAND

1. Purpose of test: To check conformance to specification.

2. Mode of Investigation and Testing:

   a) Collect random samples of sand supplied by contractors at site

   b) Check their conformity in respect of FM and gradation as per specification

   c) In case of unsatisfactory results, collect more samples from new sources and re-test to meet the specification

o BRICKS

1. Purpose of test: To check conformance to specification

2. Mode of Investigation and Testing:

   a) Collect random samples of bricks supplied by the contractors at site

   b) Perform crushing strength, unit wt. and water absorption tests to check conformity as per specification

   c) In case of unsatisfactory results, collect further samples and from new sources and re-test to meet the specification

o SOIL

1. Purpose of test: To classify and determine characteristics

2. Mode of Investigation and Testing:

   a) Collect random samples of mother soil i.e. soil from box-cut and borrow pits

   b) Perform hydrometer analysis test for classification of the soil

   c) Perform atterberg limit tests to determine LL, PL & PI and to select a sample conforming specification for use in sub-base and aggregate stabilised base

   d) Perform proctor test to establish moisture density relationship

o SUB-GRADE

1. Purpose of test: To check preparation of sub-grade inconformity with specification

2. Mode of Investigation & Testing:

a) Collect samples of soil from sub-grade to perform proctor test and establish moisture density relation

b) Check available density of the sub-grade and compare with the MDD

c) If not as per specification, prepare the sub-grade by scarifying, adjusting moisture and compacting to achieve field density as per specification requirement

o SUB-BASE & BASE

1. Purpose of test: To fix proportion of different ingredients and check conformance to specification

2. 2. Mode of Investigation and Testing:

a) Collect samples of different ingredients e.g. sand, soil, brick-aggregates

b) Check if FM, gradation, PI, LAA unit wt., water absorption are as per specification

c) Mix ingredients and check gradation

d) Perform proctor and CBR tests of mixed sample

e) If mixed materials conform to specification, a demonstration on actual method of field mixing is given

f) If mixed materials do not conform to specification proceed through trial and error until proper proportions are established which give mixed materials as per specification

g) Collect random samples from field mix to check their conformity with the design proportion, gradation, MDD and CBR

h) Check field density and in case of unsatisfactory compaction, redo by scarifying, adjusting moisture and compacting to achieve specified degree of compaction.

o <u>SURVEY WORK</u>

1. Purpose: Giving layout and monitoring entire construction process as per design grade, level & camber

2. Mode of Surveying:

   a) Set intermediate BMs and record RL on BMS

   b) Check pre-section of embankment, compare with contract drawings and form the basis of final measurement

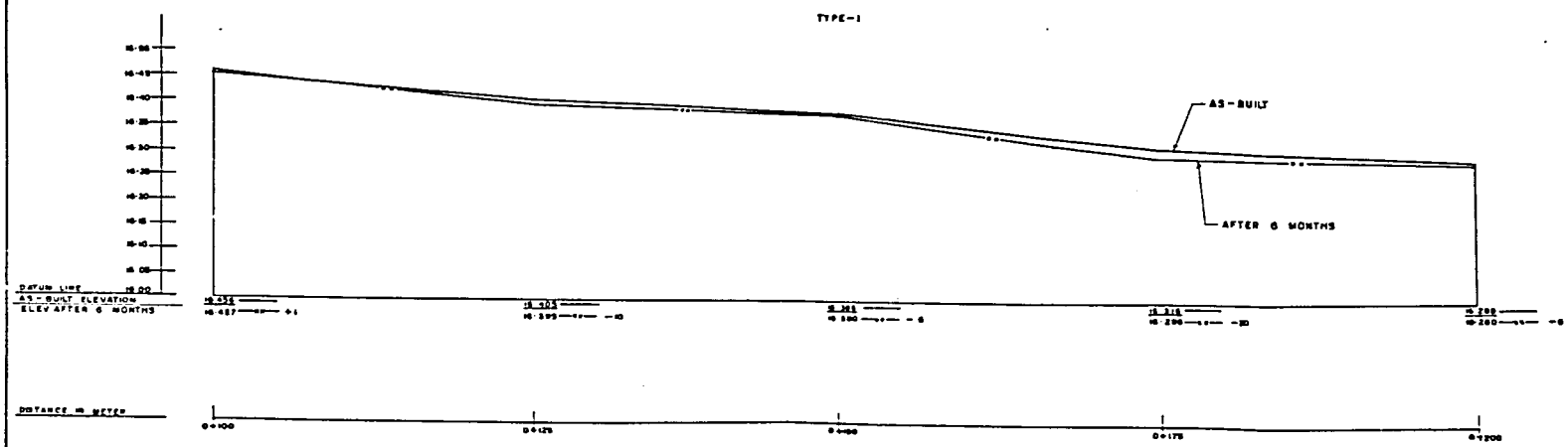
   c) Set control stake points and give layout for stage construction i.e. marking of RL on stakes for SG, SB and base

   d) Check finished RL at every stage of construction i.e. SG, SB and Base, shoulder & embankment slope as per specification

PROJECT : FIRST ROAD SURFACING TRIAL PROJECT
RAJBARI-BALIAKANDI ROAD, RAJBARI

TITLE : VARIATIONS BETWEEN ASBUILT LONGITUDINAL PROFILE ALONG ℄ AND MONITORED PROFILE (AFTER SIX MONTHS)

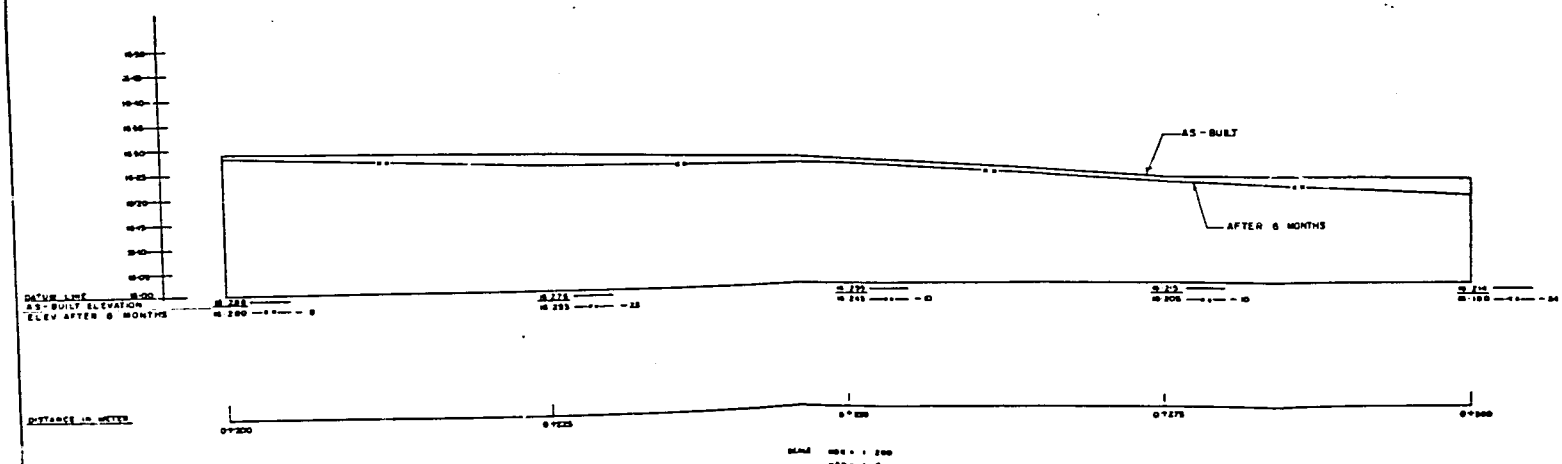
TYPE-I



PROJECT: FIRST ROAD SURFACING TRIAL PROJECT
RAJBARI-BALIAKANDI ROAD, RAJBARI

TITLE : VARIATIONS BETWEEN ABBUILT LONGITUDINAL PROFILE ALONG ℄
AND MONITORED PROFILE (AFTER SIX MONTHS)

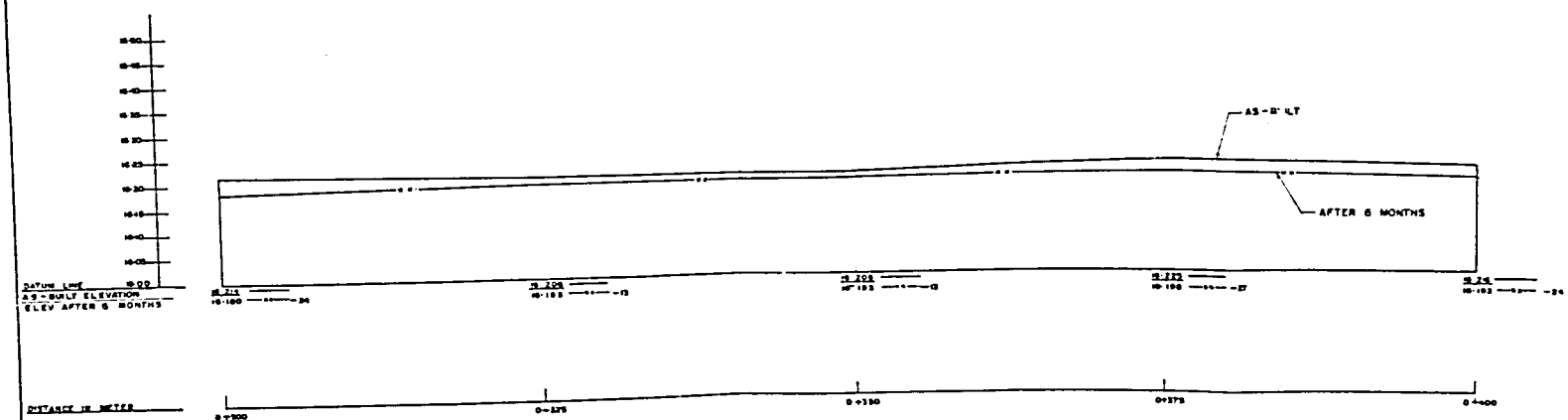
TYPE-2



PROJECT : FIRST ROAD SURFACING TRIAL PROJECT
RAJBARI – BALIAKANDI ROAD, RAJBARI

TITLE : VARIATIONS BETWEEN ASBUILT LONGITUDINAL PROFILE ALONG ℄
AND MONITORED PROFILE (AFTER SIX MONTHS)

TYPE-3

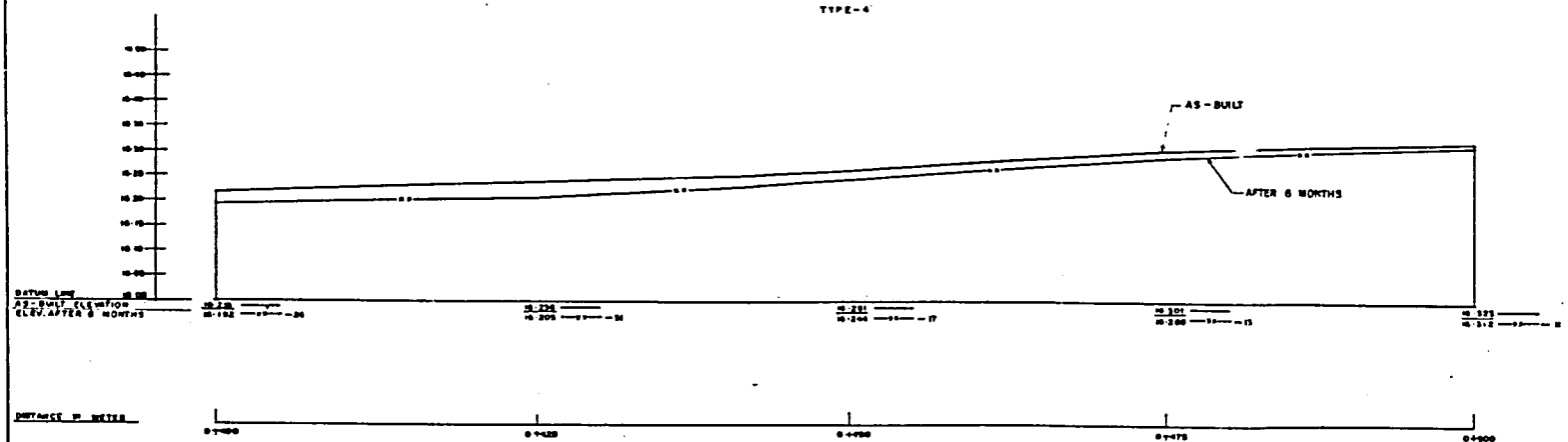


SCALE: HOR = 1:200
VER = 1:5

PROJECT : FIRST ROAD SURFACING TRIAL PROJECT
RAJBARI-BALIAKANDI ROAD, RAJBARI

TITLE : VARIATIONS BETWEEN ASBUILT LONGITUDINAL PROFILE ALONG ℄
AND MONITORED PROFILE (AFTER SIX MONTHS)

TYPE-4

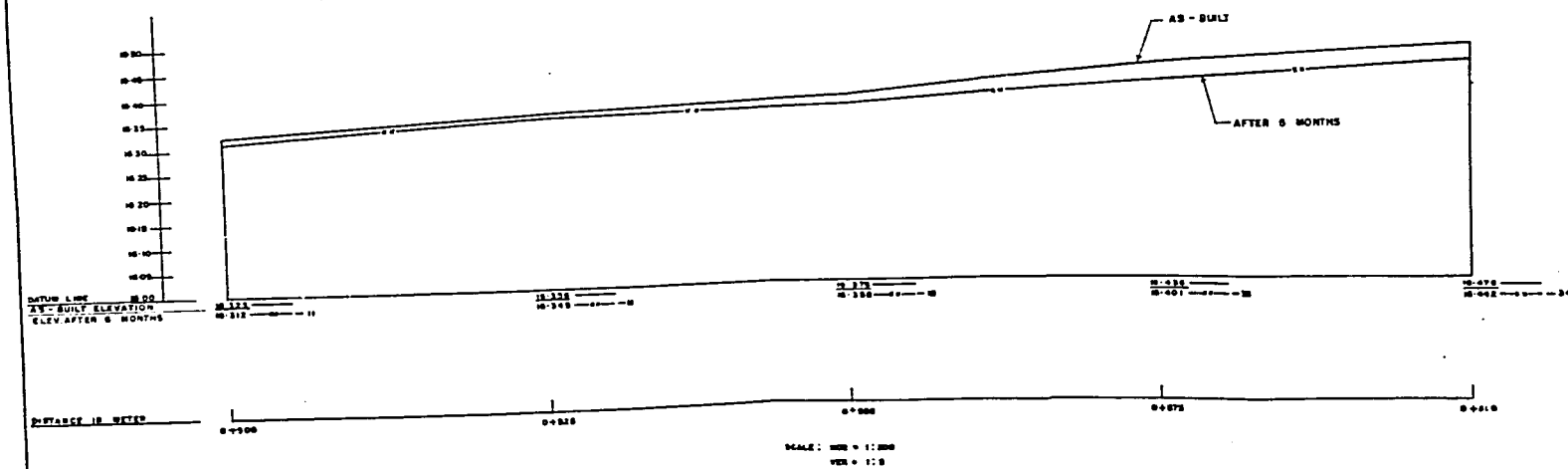


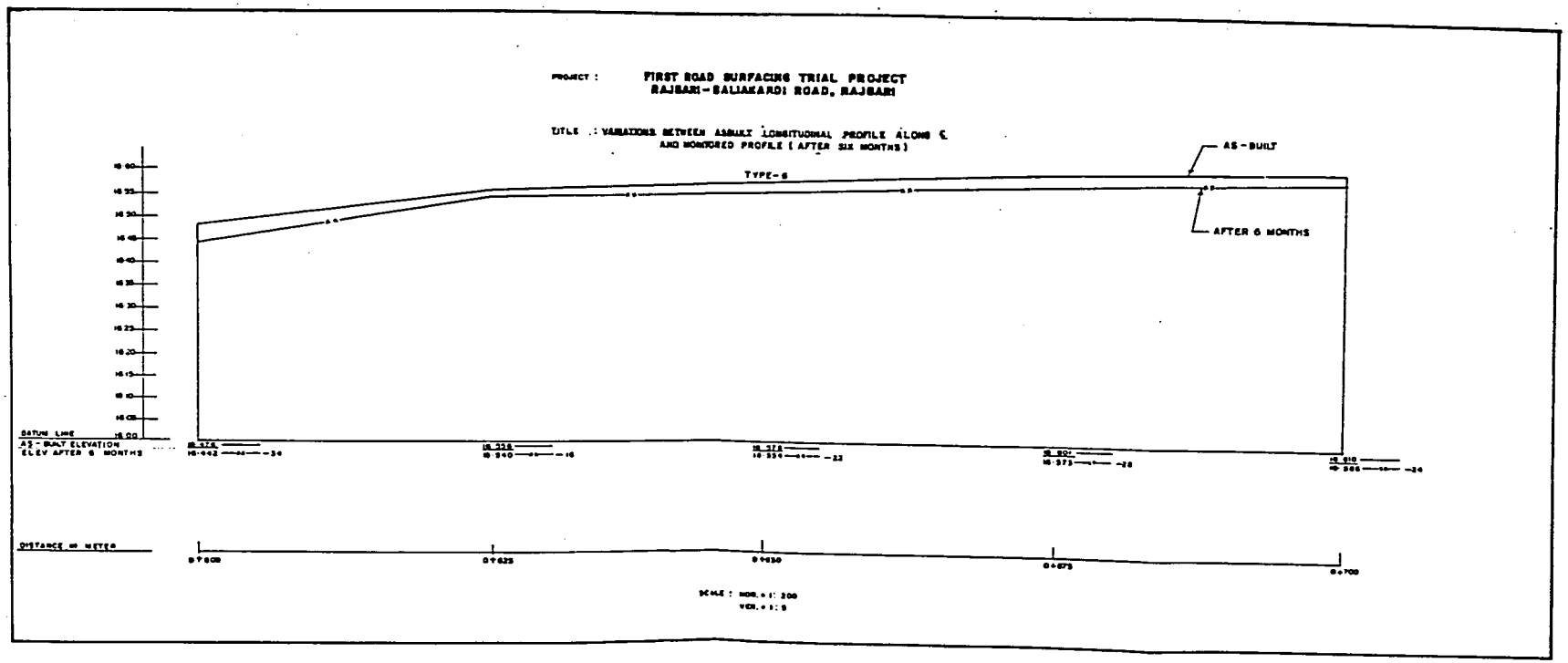
SCALE : HOR = 1:200
VER = 1:5

PROJECT : FIRST ROAD SURFACING TRIAL PROJECT
RAJBARI-BALIAKANDI ROAD, RAJBARI

TITLE : VARIATIONS BETWEEN ASBUILT LONGITUDINAL PROFILE ALONG ℄ AND MONITORED PROFILE (AFTER SIX MONTHS)

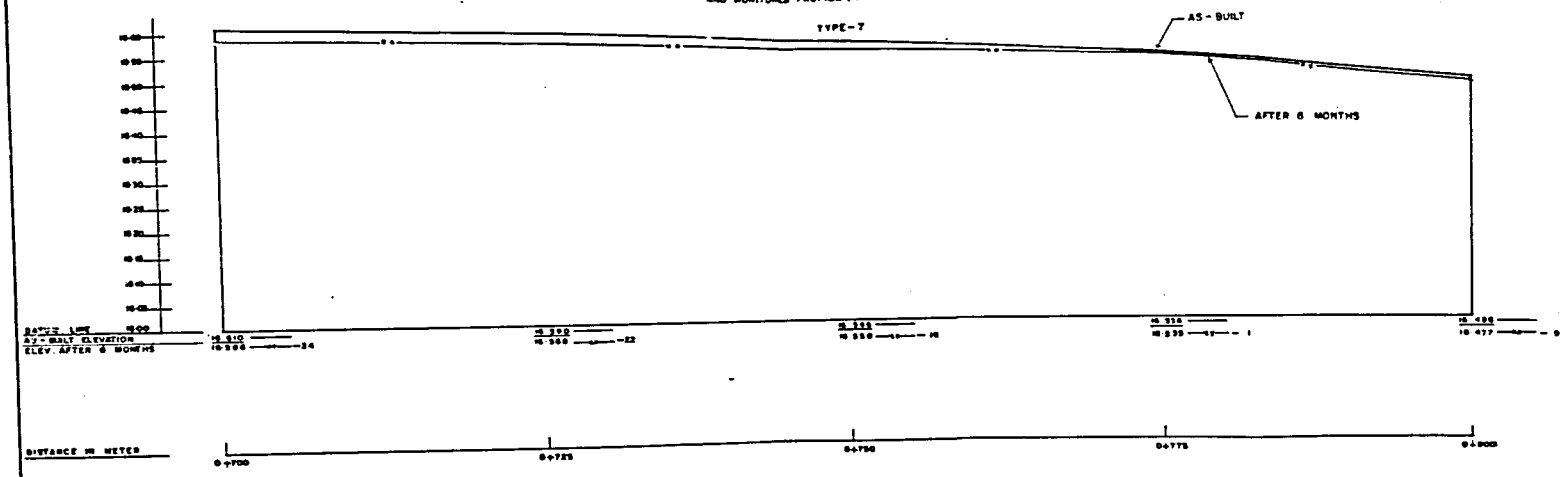
TYPE-5

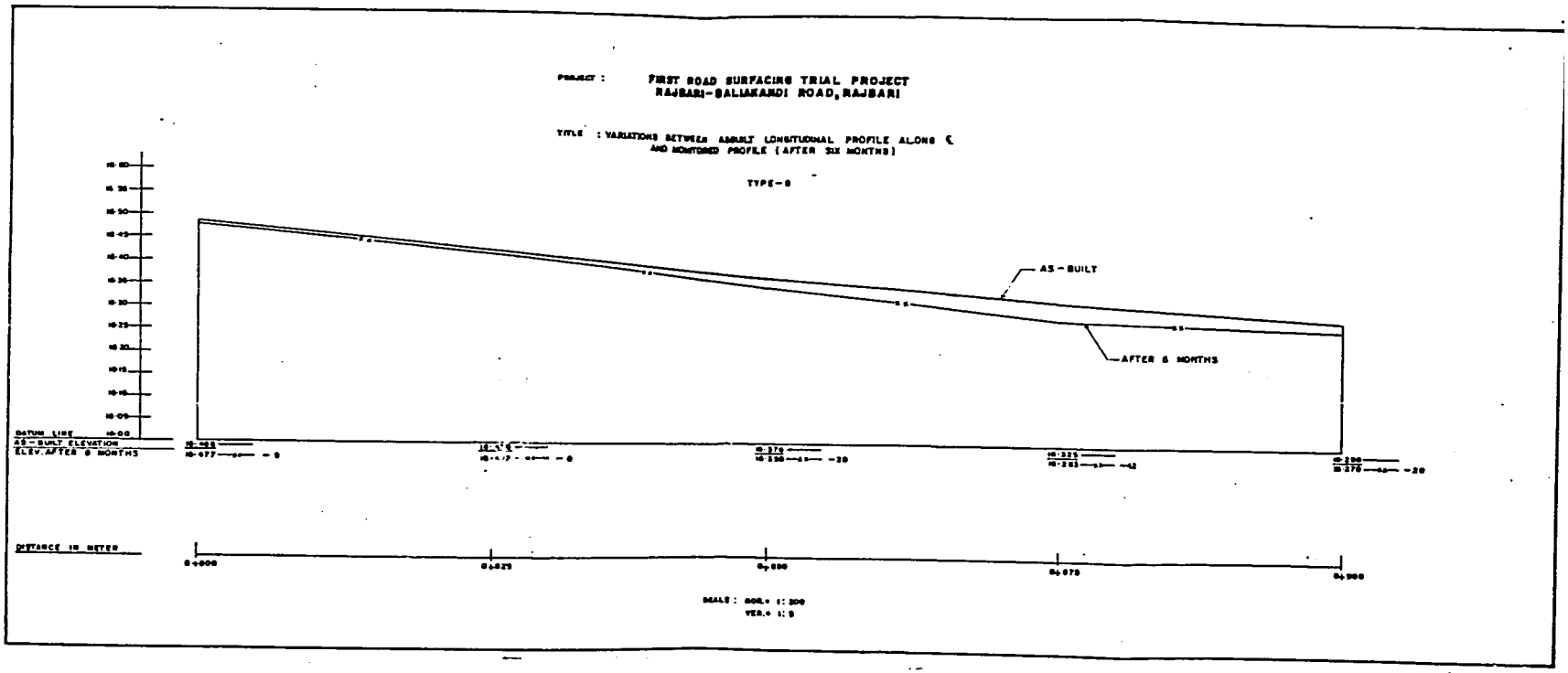



PROJECT :
FIRST ROAD SURFACING TRIAL PROJECT
RAJBARI-BALIAKANDI ROAD, RAJBARI
TITLE : VARIATIONS BETWEEN ASBUILT LONGITUDINAL PROFILE ALONG ℄
AND MONITORED PROFILE (AFTER SIX MONTHS)
TYPE-6
AS-BUILT
AFTER 6 MONTHS
DATUM LINE
AS-BUILT ELEVATION
ELEV AFTER 6 MONTHS
DISTANCE IN METER
SCALE : HOR. = 1: 200
VER. = 1: 5

PROJECT : FIRST ROAD SURFACING TRIAL PROJECT
RAJBARI-PALLIBANDHU ROAD, RAJBARI

TITLE : DEVIATIONS BETWEEN DAILY LONGITUDINAL PROFILE ALONG ℄
AND MONITORED PROFILE (AFTER SIX MONTHS)

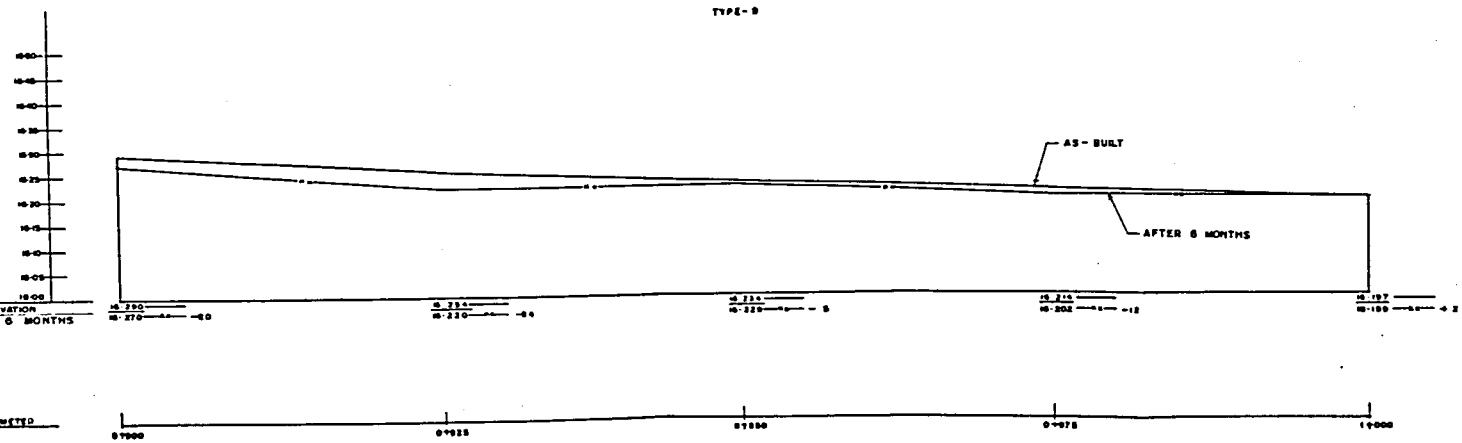



PROJECT : FIRST ROAD SURFACING TRIAL PROJECT
RAJBARI-BALIAKANDI ROAD, RAJBARI
TITLE : VARIATIONS BETWEEN ASBUILT LONGITUDINAL PROFILE ALONG ℄
AND MONITORED PROFILE (AFTER SIX MONTHS)
TYPE-B
AS-BUILT
AFTER 6 MONTHS
DATUM LINE
AS-BUILT ELEVATION
ELEV. AFTER 6 MONTHS
DISTANCE IN METER
0+000
0+025
0+050
0+075
0+100
SCALE : HOR.= 1:200
VER.= 1:5

PROJECT: FIRST ROAD SURFACING TRIAL PROJECT
RAJBARI-BALIAKANDI ROAD, RAJBARI

TITLE : VARIATIONS BETWEEN ASBUILT LONGITUDINAL PROFILE ALONG ℄ AND MONITORED PROFILE (AFTER SIX MONTHS)

TYPE-9

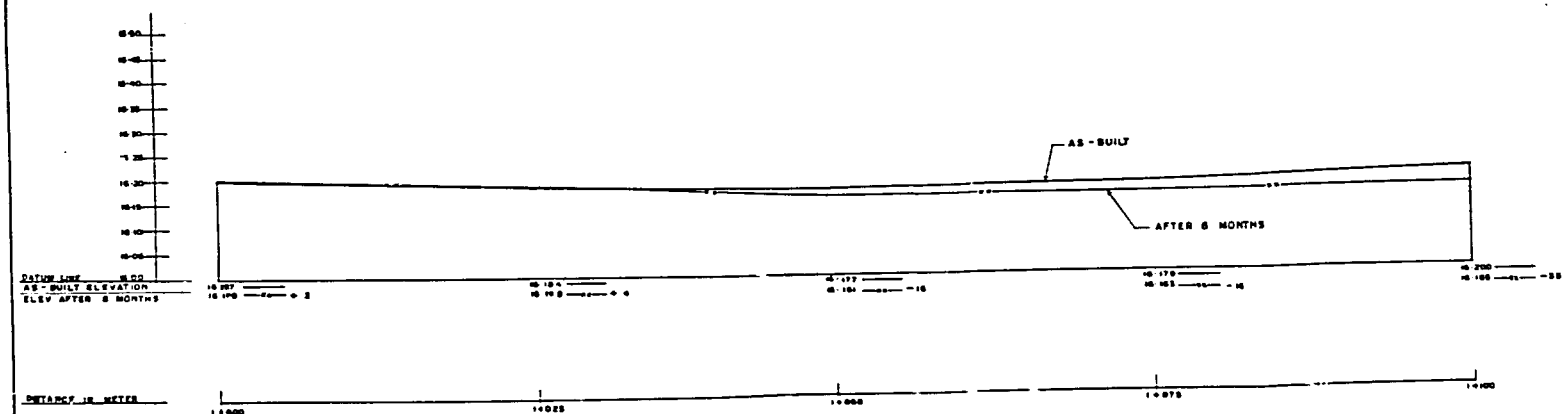


SCALE : HORI. = 1:200
VER. = 1:5

PROJECT : FIRST ROAD SURFACING TRIAL PROJECT
RAJBARI-BALIAKANDI ROAD, RAJBARI

TITLE : VARIATIONS BETWEEN ASBUILT LONGITUDINAL PROFILE ALONG ℄
AND MONITORED PROFILE (AFTER SIX MONTHS)

TYPE-10



SCALE : HOR = 1 : 500
VER = 1 : 5

Annexure-9a

দরালাপনী:

সি, টি, এল-১

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
শিল্প মন্ত্রণালয়
কেন্দ্রীয় পরীক্ষাগার
১১৪-ক তেজগাঁও শিল্প এলাকা
ঢাকা-৮

বিশ্লেষণ/পরীক্ষা বিবরণী

আপনাদের উল্লেখিত নম্বর 255/I/17021.....

তারিখ 24 March 1986

নমুনা প্রেরকের নাম ও ঠিকানা The Senior Engineer Bangladesh consultants Ltd. 4, Dhanmandi R.A. Road 14(New) Dhaka-9

বিবরণী প্রাপকের নাম ও ঠিকানা .....

আমাদের উল্লেখ্য নম্বর CTL/21(24)/85(P) 3628

তারিখ, ঢাকা 13/5/86

পরীক্ষণীয় নমুনার সংখ্যা One

বাদ বিবরণী পত্রের বরাত As per test request

বিষয়:— Testing of an Emulsion sample stated to be of Asphalt Emulsion.

The sample has been tested with the following results.

Sl.No.	Description of tests.	Lab.Regd.No. & test results. 311/314(1)
1.	Viscosity at 20°C in Engler degree	6.61
2.	Residue on B.S. sieve No. 30	Trace
3.	Binder content, % by wt. volume	63
4.	Solubility in Trichloroethylene, % by wt.	99.98

COMPARED BY
12/5/86

(Md. A. Jalil Khan.)

N.B:-1) The results reported above pertain only to the samples supplied to these Labs.
ii) This report or any part thereof, shall not be published without prior permission of the issuing authority.
iii) Erasure, overwriting etc. of any test results should immediately be reported to the issuing authority.

84

Annexure-9b

দরখাস্তনামা: সি, টি, এল-১

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
শিল্প মন্ত্রণালয়
কেন্দ্রীয় পরীক্ষাগার
১১৬-ক তেজগাঁও শিল্প এলাকা
ঢাকা-৮

বিশ্লেষণ/পরীক্ষা বিবরণী

আবেদন উল্লেখিত নম্বর: 255/II/1798 8..

তারিখ: 1.6.86

আবেদন উল্লেখ নম্বর: CTL/21(2+)/85(P)/3870

তারিখ, ঢাকা: 17/6/86

পরীক্ষণীয় নমুনার সংখ্যা: 1(one)

নমুনা প্রেরকের নাম ও ঠিকানা: Senior Engineer. Bangladesh Consultants Ltd., Consulting Engineers & Architects, 4, Dhanmondi R.A., Road-14, Dhaka-8.

বিবরণী প্রদানের নাম ও ঠিকানা:

নমুনার বিবরণী পত্রের বরাত: As per test request.

বিষয়:- Testing of sample on Asphalt Emulsion (Cationic)

The sample has been tested with the following rusults.

Sl.No.	Description of tests.	Lab.Regn.No. & test results with identification mark. CH/255(P) ESN-202
1.	Residue on BS sieve No.30	Trace
2.	Viscosity at 20°C in Engler Degree	15
3.	Binder content, % by volume	67
4.	Solubility in trichloroethylene, % by wt.	99.96

COMPARED BY
16/6/86

(D.A. Nye Elan)

i)The results reported above pertain only to the samples supplied to these Labs.
ii)This report or any part thereof, shall not be published without prior permission of the issuing authority.
iii)Any discrepancy etc. of any test results should immediately be reported to the issuing authority.

85

দুরালাপনী:

বি, টি, এল-১

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
শিল্প মন্ত্রণালয়
কেন্দ্রীয় পরীক্ষাগার
১১৬-ক তেজগাঁও শিল্প এলাকা
ঢাকা-৮

বিশ্লেষণ/পরীক্ষা বিবরণী

আপনাদের উল্লেখিত নম্বর ২৩৩/14/1810B
তারিখ 25.6.86
নমুনা প্রেরকের নাম ও ঠিকানা Project Co-ordinator, Bangladesh Consultants Ltd., 4, Dhanmondi R/A, Road-14(New) Dhaka-9.
বিবরণী প্রাপকের নাম ও ঠিকানা

আমাদের উল্লেখ্য নম্বর CTL/27(24)/87(P)/149
তারিখ, ঢাকা 15/7/86
পরীক্ষণীয় নমুনার সংখ্যা 6(Six)
নাম বিবরণী পত্রের ধরণ As per BDS-867(Part-1) 1978.

বিষয়:— Testing of samples of Asphalt Emulsion(Cattonic).

The samples have been tested with the following results.

S No.	Description of tests.	Lab. Regn. No, & test Results with Identification mark.					
		CH/272(P) BSNGA-1.	CH/273(P) BSNGA -2.	CH/274(P) BSNGB-1.	CH/275(P) BSNGB-2.	CH/276(P) BSNGB-3.	CH/277(P) BSNGB-4.
1.	Viscosity at 20°C in Engler Degree.	12.00	13.73	11.55	8.44	9.86	13.[illegible]5
2.	Water content, % by Vol.	33.00	33.50	34.50	34.50	33.00	34.00
3.	Binder content, % by Vol.	67.00	66.50	65.50	65.50	67.00	66.00

Remark:- Only sample No. CH/275(P) BSNGB-2. conform to the requirement of BDS-867(Part-1)-1978.

COMPARED BY
[illegible]
15/7/86

13926
16-7-86

N.A.
15.7.86.

N.B:-I) The results reported above pertain only to the samples supplied to these Labs.
II) This report or any part thereof, shall not be published without prior permission of the issuing authority. Erasing overtyping etc. of any test results should immediately be reported to the issuing authority.

(M.A.HYE MIAN.)
পরিচালক
কেন্দ্রীয় পরীক্ষাগার

I/86

Road Surfacing Trial Project, Rajbari

MAINTENANCE SCHEDULE FOR EACH KILOMETER OF AGGREGATE STABILISED SOIL ROAD

Maintenance of	Duration of Maintenance of (Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec, Jan)	Labour Requirement
Pavement	2 WKS; 6 WKS; 4 WKS	1 lab/km for total 3 [illegible]
Granular shoulder	4 WKS	2 lab/km for total 2 [illegible]
Earthen shoulder	6 WKS*; 4.5WKS**	Jul-Sep: ½ lab/km for total ¾ [illegible] Nov-Jan: 2 lab/km for total 2¼ [illegible]
Side slopes	2 WKS	5 lab/km for total [illegible]
For all items	8 WKS	1/5 supervisor per km for total 2 [illegible]

* For cutting cross drains in wet weather
** For filling earth in depressions

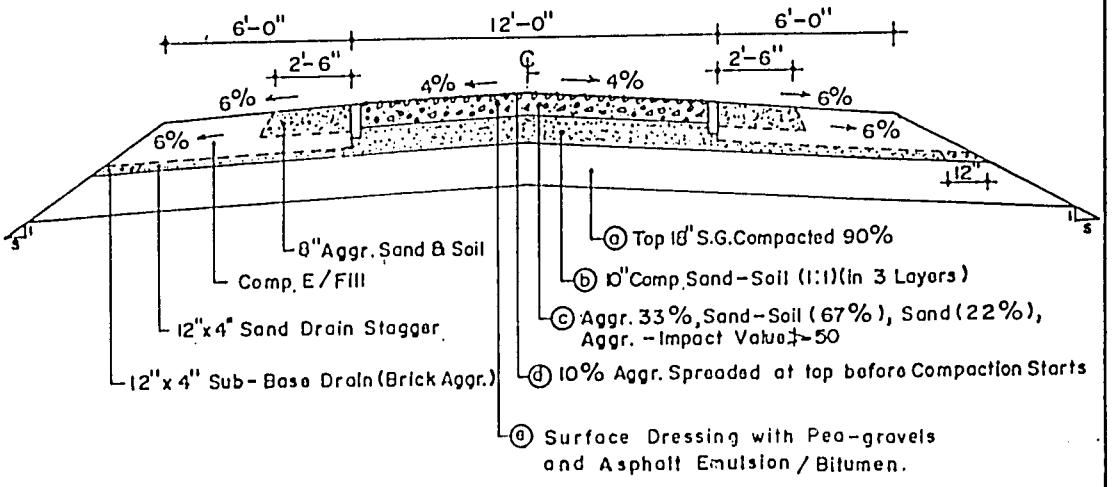
I/87

47

RECOMMENDED PAVEMENT STRUCTURE

Aggregate Stabilised Soil Road With Sand - Soil Sub - Base

Modified Type- 8



S = 2.5 For H = 0 to 8 Feet.

S = 3.00 For H = > 8 Feet < 16 Feet

H = Clear Height of Fill at Shoulder

Compaction Requirements :-

a) Sub - Grade - 90% (Standard)

b) Sub - Base - 95% (Standard)

c) Base - 100 % (Standard)

Project:-	Consultant:-	Drawing No.
ROAD SURFACING TRIAL PROJECT RAJBARI	BANGLADESH CONSULTANTS LTD. House No. 4, Road No. 14 (New) Dhanmondi R.A, Dhaka - 9	Date. 10-1-87

48

Government of the People's Republic of Bangladesh

Rural Employment Sector Programme - Bangladesh

FINAL REPORT
ON
ROAD SURFACING TRIAL, 1986
IN
RAJBARI DISTRICT

PART-II: APPENDICES

BCL
Bangladesh Consultants Ltd
Consulting Engineers & Architects
4 Dhanmondi RA, Road 14
Dhaka-9

For
TECHNICAL ASSISTANCE TEAM
TO THE I D P HQ UNIT

MARCH 1987

DANIDA
NORAD
SIDA

Road Surfacing Trial Project, Rajbari

Sand Sub-base: Type-1

SUB-BASE DESIGN CRITERIA VERSUS ACTUAL FIELD TEST RESULTS DURING CONSTRUCTION

Type.	Local Sand Ramaldia (Rajbari).	Local Sand Alipur (Rajbari).	Combined F.M.	MDD(PCF) / O.M.C %	CBR % Unsoaked.	CBR % Soaked.	Remarks.
(1) Design criteria.	20% FM = 0.32	80% FM = 1.30	1.20 Well graded.	104.97 / 13.75	42.22	24.00	
Lab.No.	19	1	22	25	27	36	
Sample No.	FS-25	FS-1	MS-43	S.SB-64	S.SB-67	S.SB-74	
(1) Field test results.	20% FM = 0.29	80% FM = 1.27	1.20 Well graded.	104.81 / 13.07		23.33	
Lab.No.	90	89	116	111		151	
Sample No.	FS-107	FS-106	S.SB-135	S.SB-130		S.SB-158	

These designs have been adopted in the field for execution through proper monitoring during the whole construction period.

SUB-BASE DESIGN CRITERIA VERSUS ACTUAL FIELD TEST RESULTS DURING CONSTRUCTION

Sand-Soil Sub-base: Type-2

Type.	Local Sand Alipur.	Local Soil.	MDD(PCF). / O.M.C %	CBR % Unsoaked.	CBR % Soaked.	Remarks.
Design criteria.	50% FM=1.30	50% PI= 5%	122 / 11.50	37.22	26.11	
Lab. No. / Sample No.	1 / FS-1	110 / Atter-129	71 / S.S1-95	77 / S.S1-97	84 / S.S1-99	
Field test results.	50% FM=1.30	50% PI= 5%			22.67	
Lab. No. / Sample No.	147 / FS-167	110 / Atter-129			184 / S.S1-173	

These designs have been adopted in the field for execution through proper monitoring during the whole construction period.

SUB-BASE DESIGN CRITERIA VERSUS ACTUAL FIELD TEST RESULTS DURING CONSTRUCTION

Aggregate-Sand-Soil Sub-base: Type-3

Type.	Local Sand Alipur (Rajbari).	Local Soil.	Local brick Aggreagtes (Faridpur).	MDD(PCF). / OMC %	CBR % Unsoaked.	CBR % Soaked.	Remarks.
Design criteria.	30% FM=1.30	50% PI=7%	20% Impact value=27.1%	116.95 / 14.09	46.67	27.70	
Lab. No. / Sample No.	1 / FS-1	123 / Atter-142	183 / B.Agg-128	196 / Agg-S.Sl-203	199 / Agg-S.Sl-206	211 / Agg-S.Sl-207	
Field test results.	30% FM=1.30	50% PI=7%	20% Abrasion=27.10	115.25 / 13.70		25.56	
Lab. No. / Sample No.	147 / FS-167	123 / Atter-142	183 / B.Agg-128	186 / Agg-S.Sl-203		220 / Agg-S.Sl-220	

These designs have been adopted in the field for execution through proper monitoring during the whole construction period.

SUB-BASE DESIGN CRITERIA VERSUS ACTUAL FIELD TEST RESULTS DURING CONSTRUCTION

Sand Sub-base: Type-4

Type.	Local Sand. Kamarkhali.	Local Sand. Faridpur.	Combined F.M.	MDD(Pcf). / O.C %	C.B.R. value %	Remarks.
(4) Design criteria.	75% FM=1.42	25% FM=0.30	1.07 Well graded.	106.50 / 14.42	23.33	Each layer thickness = 4" Total layer thickness, t=11"
Lab. No. / Sample No.	185 / FS-200	247 / FS-258	248 / MS-263	245 / S.SB-261	253 / S.SB-260	
(4) Field test results.	75% FM=1.40	25% FM=0.30		105.02 / 14.55	22,22	t = 4"+4"+3"
Lab. No. / Sample No.	249 / FS-264	250 / FS-265		252 / S.SB-268	258 / S.SB-267	

These designs have been adopted in the field for execution through proper monitoring during the whole construction period.

SUB-BASE DESIGN CRITERIA VERSUS ACTUAL FIELD TEST RESULTS DURING CONSTRUCTION

Sand-Soil Sub-base: Type-5.

Type.	Imported sand (Sylhet).	Local Sand Alipur.	Local Soil.	MDD(Pcf). / OMC %	C.B.R. value %	Remarks.
Design criteria.	5.5% FM=2.82	49.50% FM=1.30	45% PI=9%	121.72 / 12.08	25.33	Each layer thickness = 4" Total layer, t = 11"
Lab. No. / Sample No.	2 / C.S-2	1 / FS-1	30 / Atter-69	40 / S.S1-78	47 / S.S1-82	
Field test results.	5.5% FM=2.86	49.50% FM=1.41		122.00 / 11.80	24.44	t = 4"+4"+3"
Lab. No. / Sample No.	91 / CS-108	92 / FS-109		122 / S.S1-141	150 / S.S1-157	

These designs have been adopted in the field for execution through proper monitoring during the whole construction period.

SUB-BASE DESIGN CRITERIA VERSUS ACTUAL FIELD TEST RESULTS DURING CONSTRUCTION

Sand-Soil Sub-base: Type-6

Type.	Imported Sand (Sylhet)	Local sand Alipur.	Local Soil.	MDD(Pcf). / O.M.C %	C.B.R. value %	Remarks.
Design criteria.	5.5% FM=2.82	49.50% FM=1.30	45% PI=8%	121.72 / 12.08	25.33	Each layer thickness = 4" Total layer, t = 11"
Lab. No. / Sample No.	2 / CS-2	1 / FS-1	131 / Atter-149	40 / S.Sl-78	47 / S.Sl-82	
Field test results.	5.5% FM=2.86	49% FM=1.41			24.44	t = 4"+4"+3"
Lab. No. / Sample No.	91 / CS-108	92 / FS-109			172 / S.Sl-182	

These designs have been adopted in the field for execution through proper monitoring during the whole construction period.

SUB-BASE DESIGN CRITERIA VERSUS ACTUAL FIELD TEST RESULTS DURING CONSTRUCTION

Sand-Soil Sub-base: Type-7

Type.	Local sand Alipur.	Local Soil.	MDD(Pcf). / OMC %	C.B.R.value %.	Remarks.
Design criteria.	55% FM=1.30	45% PI=6%	121.60 / 12.20	24.78	Each layer thickness = 4" Total layer, t = 10"
Lab. No. / Sample No.	1 / FS-1	58 / Atter-83	144 / S.Sl-165	163 / S.Sl-172	
Field test results.	55% FM=1.32	45% PI=6%		24.44	t = 4"+3"+3"
Lab. No. / Sample No.	148 / FS-168	58 / Atter-83		190 / S.Sl-199	

These designs have been adopted in the field for execution through proper monitoring during the whole construction period.

SUB-BASE DESIGN CRITERIA VERSUS ACTUAL FIELD TEST RESULTS DURING CONSTRUCTION

Sand-Soil Sub-base: Type-8

Type.	Local sand Alipur.	Local Soil.	MDD(lcf). / O.M.C %	CBR value %	Remarks.
Design criteria.	55% FM=1.30	45% PI=8%	121.61 / 11.93	25.00	Each layer t [illegible] Total layer, t = 10"
Lab. No. / Sample No.	1 / FS-1	133 / Atter-152	155 / S.S1-176	197 / S.S1-205	
Field test results.	55% FM=1.30	45% PI = 8%		23.11	t = 5" + 5"
Lab. No. / Sample No.	148 / FS-168	133 / Atter-152		205 / S.S1-202	

These designs have been adopted in the field for execution through proper monitoring during the whole construction period.

SUB-BASE DESIGN CRITERIA VERSUS ACTUAL FIELD TEST RESULTS DURING CONSTRUCTION

Sand-Soil Sub-base: Type-9

Type.	Local sand Alipur.	Local Soil.	MDD (Pcf). / O.M.C %	CBR value %	Remarks.
Design criteria.	55% FM= 1.30	45% PI = 8%	121.76 / 12.06	25.00	Each layer thickness = 5" Total layer, t = 10"
Lab. No. / Sample No.	1 / FS-1	138 / Atter-159	189 / S.S1-209	212 / S.S1-217	
Field test results.	55% FM= 1.33	45% PI = 8%	119.67 / 11.25	23.77	t = 5" + 5"
Lab. No. / Sample No.	206 / FS-223	138 / Atter-159	203 / S.S1-221	239 / S.S1-245	

These designs have been adopted in the field for execution through proper monitoring during the whole construction period.

SUB-BASE DESIGN CRITERIA VERSUS ACTUAL FIELD TEST RESULTS DURING CONSTRUCTION

Sand-Soil Sub-base: Type-10

Type.	Local sand Alipur.	Local Soil.	MDD (Pcf). / OMC %	CBR value %	Remarks.
Design criteria.	55% FM=1.30	45% PI = 4%	121.00 / 12.25	24.00	Each layer thickness = 5" Total layer, t = 10"
Lab. No. / Sample No.	1 / FS-1	306 / Atter-291	195 / S.Sl-214	237 / S.Sl-229	
Field test results.	55% FM=1.30	45% PI = 4%	118.87 / 14.51	23.56	t = 5" + 5"
Lab. No. / Sample No.	222 / FS-236	306 / Atter-291	204 / S.Sl-222	240 / S.Sl-246	

These designs have been adopted in the field for execution through proper monitoring during the whole construction period.

BASE COURSE DESIGN CRITERIA FOR CONSTRUCTION: HBB - TYPE 1, 2 & 3

WATER BOUND MACADOM BASE COURSE: TYPE 4, 5 & 6

All bricks from Faridpur & Rajbari	Strength: 1st Class	Strength: Picked Jhama	Unit wt of Aggr	Water absorption	Remarks
Specification requirement	1800 psi	2500 psi	75 pcf	15% max^m	
Qualities of the best locally available bricks and aggregates	1824, 1810, 1734, 1856, etc	2277, 2507, 2592, etc	65.14, 65.46, 65.12, 66.72	7.02, 8.40, 10.29, 7.95	For unit wt, ½" sieve was not available, so the reqd. gradation was affected, thus the lower unit wt. Water absorption indicates a higher unit wt. Aggr. impact value of average 26 shows stronger aggr.
Lab. No. / Sample No.	193/B210, 221/235, 87/PJ101		20/PJ.BAgg-34	20/PJ.BAgg-34	Unit wt determined by CBR mould as ½ cft capacity mould was not available (as per std. test procedure). This may also have an effect on unit wt. (ref. P-103, Test Procedure).
	159/180, 194/211, 156/177, 158/179		66/90, 67/91, 176/194	68/92, 69/93, 177/195	

Construction: 6" Compacted WBM achieved by compacting in two successive layers, using 8-10 ton steel wheeled roller.

BASE COURSE: DESIGN CRITERIA VERSUS ACTUAL FIELD TEST RESULTS DURING CONSTRUCTION

Agg.Sand-Soil Base Course: Type-7.

Type.	Local aggregates (Rajbari brick).	Local sand (Alipur Rajbari).	Local soil (Box-cutting +Borrowpit).	Gradation of mix.	MDD(pcf). / OMC %	CBR Value % (Av).	Remarks
Design criteria.	33% Impact value = 29.40%	27% FM=1.30	40% PI=6%	Well graded.	114.30 / 13.08		
Lab. No. / Sample No.	180 / B.Agg-125	1 / FS-1	58 / Atter-83	228 / B.Agg-252	187 / Agg.S.SB-204		
Field test result.	33% Impact value = 29.40%	27% FM=1.32	40% PI = 6%	Well graded.	114.45 / 13.50	77 * / 82 **	By DCP
Lab. No. / Sample No.	180 / B.Agg-125	148 / FS-168	58 / Atter-83	228 / B.Agg-232	238 / Agg.S.SB-238		

Construction: 6" compacted base course achieved by compacting in two successive layer.

* As-built CBR

** Monitored CBR after six months of construction

BASE COURSE: DESIGN CRITERIA VERSUS ACTUAL FIELD TEST RESULTS DURING CONSTRUCTION

Agg.Sand-Soil Base Course: Type-8

Type.	Local aggregates (Rajbari brick).	Local sand (Alipur Rajbari).	Local soil (Box-cutting +Borrowpit).	Gradation of mix.	MDD (pcf) / OMC %	CBR value %(Av.)	Remarks.
Design criteria.	33% Impact value = 29.40%	27% FM=1.30	40% PI = 8%	Well graded.	113.46 / 13.50		
Lab. No. / Sample No.	180 / B.Agg-125	1 / FS-1	133 / Atter-152	307 / B.Agg-332	254 / Agg.S.SB-269		
Field test result.	33% Impact value = 29.40%	27% FM=1.32	40% PI = 8%	Well graded.	112.84 / 13.75	64 * / 68 **	By Dcp.
Lab. No. / Sample No.	180 / B.Agg-125	148 / FS-168	133 / Atter-152	307 / B.Agg-332	260 / Agg.S.SB-276		

Construction: 6" compacted base course achieved by compacting in two successive layer.

* As-built CBR

** Monitored CBR after six months of construction

BASE COURSE: DESIGN CRITERIA VERSUS ACTUAL FIELD TEST RESULTS DURING CONSTRUCTION

Agg. Sand-Soil Base Course: Type-9

Type.	Local aggregates (Rajbari brick).	Local sand (Alipur Rajbari).	Local Soil (Box-cutting + Borrowpit)	Gradation of mix.	MDD.(pcf) / OMC %	CBR value % (Av.)	Remarks.
Design criteria.	33% Impact value = 29.40%	27% FM=1.30	40% PI = 8%	Well graded.	114.10 / 13.36		
Lab. No. / Sample No.	180 / B.Agg-125	1 / FS-1	138 / Atter-138	308 / B.Agg-333	255 / Agg.S.SB-270		
Field test results.	33% Impact value = 29.40%	27% FM=1.33	40% PI= 8%	Well graded.	113.66 / 13.46	55 * / 50 **	By Dcp.
Lab.No. / Sample No.	180 / B.Agg-125	206 / FS-223	138 / Atter-138	308 / B.Agg-333	261 / Agg.S.SB-277		

Construction: 6" compacted base course achieved by compacting in two successive layer.

* As-built CBR

** Monitored CBR after six months of construction

BASE COURSE: DESIGN CRITERIA VERSUS
ACTUAL FIELD TEST RESULTS DURING CONSTRUCTION

Agg.Sand-Soil Base Course: Type-10

Type	Local aggregates(Rajbari brick).	Local sand (Alipur Rajbari).	Local soil (Box-cutting +Borrowpit).	Gradation of mix.	MDD.(pcf) / OMC %	CBR value % (Av.).	Remarks.
Design criteria.	33% Impact value = 29.40%	27% FM=1.30	40% PI = 4%	Well graded.	114.40 / 13.25		
Lab. No. / Sample No.	180 / B.Agg-125	1 / FS-1	306 / Atter-291	309 / B.Agg-334	259 / Agg.S.SB-274		
Field test results.	33% Impact value = 29.40%	27% FM=1.30	40% PI = 4%	Well graded.	113.92 / 13.46	45 * / 74 **	By Dcp.
Lab. No. / SAmple No..	180 / B.Agg-125	222 / FS-236	306 / Atter-291	309 / B.Agg-334	262 / Agg.S.SB-278		

Construction: 6" compacted base course achieved by compacting in two successive layer.

* As-built CBR

** Monitored CBR after six months of construction

Road Surfacing Trial Project, Rajbari

SUMMARY OF FIELD TEST RESULTS

Items	Type-1			Type-2			Type-3			Type-4		
BRICKS:												
Strength, psi	1734			1856			1845			PJ 2592		
Unit wt. pcf	62.68			62.29			68.30			66.72		
Absorption %	14.22			14.07			10.50			7.95		
SUB-GRADE:	Upper	Middle	Bottom	Upper	Middle	Bottom	Upper	Middle	Bottom	Upper	Middle	Bottom
Lab MDD pcf	105.50	102.50	101.80	105.60	103.50	101.00	108.00	104.54	102.80	107.46	[illegible]	102.25
Opt.moist cont %	16.50	18.65	19.60	17.50	18.40	18.87	17.47	17.93	19.00	17.23	17.23	19.11
% Compaction:												
Upper layer	93, 96, 94, 94			94, 93, 86, 91			91, 93, 95			92, 90, 94		
Middle layer	93, 95, 92, 90			90, 95, 91, 90			90, 97, 98			92, 95, 89		
Bottom layer	91, 89, 92, 92			89, 94, 93, 91			91, 94, 88			87, 95, 90		
SAND SUB-BASE												
Lab MDD. pcf	104.97									106.50		
Opt.Moist.Cont %	13.75									14.40		
Gradation	Nearly well graded									Nearly well graded		
FM	1.20									1.07		
CBR %	24.00									23.33		
% Compaction:												
1st layer	107, 99, 104, 103									100, 103, 102, 100		
2nd layer	102, 103, 103, 106									103, 101, 102, 100		
3rd layer	103, 106, 103, 106									98, 97, 98, 99		
SAND-SOIL SUB-BASE												
Lab MDD. pcf				122.00								
Opt.Moist.Cont %				11.50								
Gradation				Nearly well graded								
FM				1.30								
CBR %				26.11								
PI %				5								
% Compaction:				—								
1st layer				93, 99, 96, 93								
2nd layer				97, 100, 93, 100								
3rd layer				96, 98, 93, 103								
AGG. SAND-SOIL SUB-BASE												
Lab MDD. pcf							116.95					
Opt.Moist.Cont %							14.09					
Gradation							Nearly well graded					
FM							1.30					
CBR %							27.78					
PI %							7.00					
Agg. impact value %							27.10					
% Compaction												
1st layer							96, 101, 93, 97					
2nd layer							100, 93, 100, 97					
3rd layer							101, 97, 95, 101					
BRICK COMBINE												
SUM										PJ	P	
Brick strength, psi										2592	1824	
Unit wt. pcf										66.72	62.29	
Absorption %										7.95	14.07	
Gradation										Nearly well graded	Nearly well graded	
PI %										-	-	
Impact value, %										25.10	27.10	
EARTHWORK												
Lab MDD. pcf	103.86			104.26			102.54			103.90		
Opt.Moist.Cont %	18.13			18.82			19.06			18.70		
% Compaction												
Shoulder	RHS-92 Av. LHS-90 Av.			RHS-94 Av. LHS-94 Av.			RHS-94 Av. LHS-93 Av.			RHS-90 Av. LHS-91 Av.		
Side slope	RHS-75 Av. LHS-75 Av.			RHS-76 Av. LHS-77 Av.			RHS-79 Av. LHS-79 Av.			RHS-76 Av. LHS-74 Av.		
Soil classification %				Sand-[illegible]			[illegible]-clay [illegible]					
GRANULAR SHOULDER												
Lab MDD. pcf	116.95			116.95			116.95			116.95		
Opt.Moist.Cont %	14.09			14.09			14.09			14.09		
Gradation	Nearly well graded			Nearly well graded			Nearly well graded			Nearly well graded		
PI %				5.00			7.00			7.00		
% Compaction	RHS-97, 93, 98 LHS-95, 96, 97			RHS-96, 96, 96 LHS-99, 96, 98			RHS-97, 100, 96 LHS-98, 96, 97			RHS-96, 93, 99 LHS-97, 97, 95		

105

Items	Type-5	Type-6	Type-7	Type-8	Type-9	Type-10
BRICKS:						
Strength, psi	PJ- 2297, 1658	1627	1627	1810	1749	1775
Unit wt. pcf	63.12, 60.50	60.50	63.00	63.00	63.99	63.99
Absorption %	10.29, 17.00	17.00	12.50	12.50	12.48	12.48
SUB-GRADE:	Upper / Middle / Bottom	Upper / Middle / Bottom	Upper / Middle / Bottom	Upper / Middle / Bottom	Upper / Middle / Bottom	Upper / Middle / Bottom
Lab. MDD. pcf	102.23 / 100.40 / 103.37	107.93 / 103.58 / 101.44	107.67 / 104.58 / 102.30	109.70 / 105.00 / 103.[illegible]	108.20 / 105.25 / 103.29	109.36 / 104.63 / 101.75
Opt.Moist.Cont.%	20.00 / 18.50 / 20.00	17.23 / 17.58 / 18.30	17.00 / 17.43 / 19.00	17.00 / 17.50 / 19.00	17.00 / 17.70 / 19.35	17.45 / 17.80 / 18.82
% Compaction:						
Upper layer	93, 90, 95	94, 96, 97	97, 97, 91	90, 98, 85	93, 95, 95	97, 98, 99
Middle layer	90, 91, 93	95, 98, 99	97, 96, 98	93,100, 95	98, 98, 96	95, 97, 96
Bottom layer	95, 90, 91	97, 90, 93	94, 97, 91	88, 91, 95	97, 88, 90	97, 95, 9[illegible]
SAND-SOIL SUB-BASE:						
Lab.MDD. pcf	121.72	121.72	121.60	121.61	121.76	121.00
Opt.Moist.Cont. %	12.08	12.08	12.20	11.93	12.04	12.23
Gradation	Nearly well graded	Nearly well graded	Nearly well graded	Nearly well graded	Nearly well graded	Nearly well graded
FM	1.43	1.43	1.30	1.30	1.30	1.30
CBR %	23.33	23.33	24.78	24.00	24.44	24.00
PI %	-	-	6.00	8.00	8.00	4.00
% Compaction:			-			
1st layer	104, 104, 99, 99	100, 98, 98, 101	96, 97, 99, 100	96, 97, 94, 93	98, 102, 96, 96	93, 96, 97, 103
2nd layer	100, 101, 101, 104	97, 97, 100, 99	101, 99, 98, 97	99, 97, 101	96, 103, 103,101	98, 93, 99, 96
3rd layer	97, 99, 96, 97	99, 100, 99, 98				
BASE COURSE:						
WBM	PJ / B	PJ / B				
Brick strength, psi	2277 / 1658	2277 / 1627				
Unit wt.pcf	63.12 / 60.50	63.12 / 60.50				
Absorption %	10.29 / 17.00	10.29 / 12.50				
Gradation	Well graded / Well graded	Well graded / Well graded				
PI %	-	-				
Impact value, %	24.46 / 29.40	24.46 / 29.40				
AGG. STABILIZED BASE:						
Lab MDD pcf			114.30	113.46	114.10	114.40
Opt.Moist.Cont.%			13.08	13.50	13.36	13.25
Gradation			Nearly well graded	Nearly well graded	Nearly well graded	Nearly well graded
FM			1.30	1.30	1.30	1.30
CBR %			6.00	8.00	8.00	4.00
PI %			29.40	29.40	27.60	27.60
Agg.Impact value, %			100, 100, 102, 100	105, 106, 104, 106	104, 106, 106, 101	110, 105, 100, 105
% Compaction:			101, 100, 100, 100	102, 104, 104 101	101, 103, 102, 104	103, 105, 105, 101
1st layer						
2nd layer						
EARTH WORK:						
Lab MDD pcf	14.33	103.27	105.68	103.69	103.70	103.82
Opt.Moist.Cont. %	18.45	19.27	17.51	18.61	18.60	19.32
% Compaction:						
Shoulder	RHS-91 Av. LHS-90 Av	RHS-93 Av.LHS-92 Av	RHS-90 Av. LHS-94 Av.	RHS-93 Av.LHS-93 Av	RHS-91 Av.LHS-92 Av	RHS-91 Av. LHS-90 Av
Side slope	RHS-76 Av. LHS-76 Av	RHS-75 Av.LHS-75 Av	RHS-77 Av.LHS-75 Av.	RHS-76 Av.LHS-76 Av	RHS-77 Av.LHS-77 Av	RHS-75 Av. LHS-76 Av
Soil classification		Sand-silt-clay=6:91:3	Sand-silt-clay=4:84:12	Sand-silt-clay=5:84:11	Sand-silt-clay=6:90:4	Sand-silt-clay=7:92:1
GRAVELLY SHOULDER:						
Lab.MDD.pcf	116.93	116.93	116.93	116.93	116.93	116.93
Opt.Moist.Cont. %	14.09	14.09	14.09	14.09	14.09	14.09
Gradation	Nearly well graded	Nearly well graded	Nearly well graded	Nearly well graded	Nearly well graded	Nearly well graded
PI %	9.00	8.00	6.00	8.00	8.00	4.00
% Compaction	RHS-95, 97, 93	RHS-98, 96, 96	RHS-95, 96, 97	RHS-96, 96, 98	RHS-99, 95, 98	RHS-97, 96, 93
	LHS-98, 96, 97	LHS-93 99, 96	LHS-98, 97, 93	LHS-93, 96, 93	LHS-97, 95, 96	LHS-96, 97, 93

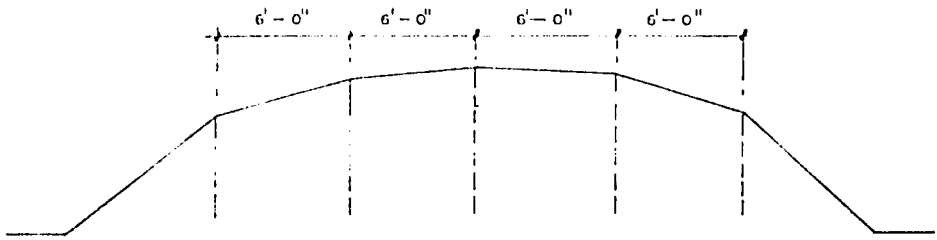
Road Surfacing Trial Project, Rajbari

NUMBER & TYPES OF TESTS PERFORMED DURING CONSTRUCTION PERIOD

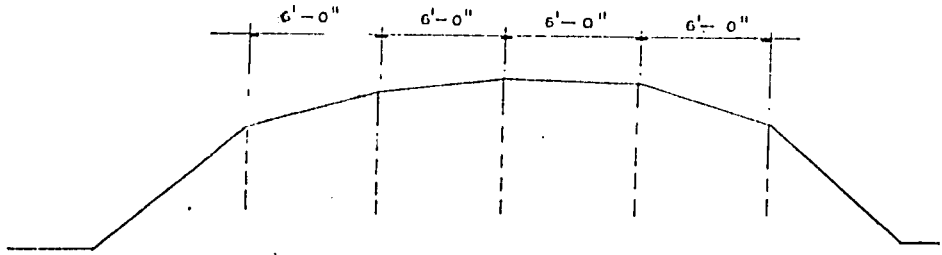
Sl No	Name of test	Materials/layers	Number of test	Remarks
01	Soil classification	Borrowpit soil, sub-grade soil and soil for stabilised sub-base & base	12	
02	Atterberg limit test	Borrowpit soil, sub-grade soil and soil for stabilised sub-base & base	11	
03	Specific gravity test	Sub-grade soil, borrow-pit soil and sand	15	
04	Gradation test (sieve analysis)	Sand, peagravels and brick aggregates	60	
05	F.M	Sand	33	
06	Moisture density relation (standard proctor)	Sub-grade, sub-base and base	73	
07	CBR	Sub-grade, sub-base and base	45	Both unsoaked and soaked
08	Proportioning of ingredients	Sub-grade, sub-base and base	32	From field mix
09	Moisture content	Sub-grade, sub-base and base	182	From field mix
10	Unit weight	Peagravels and brick aggregates	18	
11	Water absorption	Brick aggregates	15	
12	Crushing strength	Bricks	26	
13	Abrasion test	Peagravels and brick aggregates	26	
14	Field density test	Sub-grade, sub-base, base, granular shoulder and embankment side slope	464	
15	Viscosity	Asphalt emulsion	8	
16	Residue	Asphalt emulsion	8	
17	Binder content	Asphalt emulsion	8	
18	Solubility	Asphalt emulsion	8	

Road Surfacing Trial Project, Rajbari

AS-BUILT LEVEL VS LEVEL RECORDED DURING THE SIX-MONTH MONITORING PERIOD

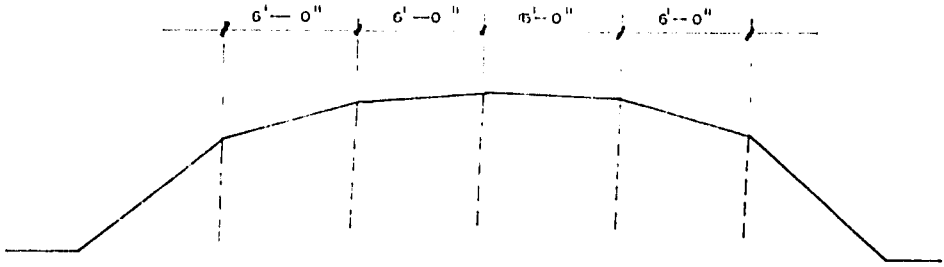


						Date of Observatio
Station 0+100M						
Asbuilt Elvs	16.306	16.406	16.456	16.396	16.316	End of Con
Monitored Elvs.	16.287	16.410	16.462	16.398	16.347	Jul 86
-do-	16.282	16.403	16.458	16.387	16.346	Aug 86
-do-	16.290	16.406	16.458	16.388	16.357	Sep 86
-do-	16.290	16.401	16.456	16.384	16.351	Oct 86
-do-	16.317	16.404	16.459	16.382	16.359	Nov 86
-do-	16.308	16.400	16.457	16.380	16.360	Dec 86
Station 0+125M						
Asbuilt Elvs.	16.251	16.346	16.405	16.346	16.250	
Monitored Elvs.	16.237	16.327	16.397	16.342	16.256	-do-
-do-	16.226	16.321	16.385	16.336	16.251	
-do-	16.226	16.324	16.396	16.346	16.263	
-do-	16.218	16.322	16.393	16.342	16.258	
-do-	16.213	16.321	16.399	16.343	16.267	
-do-	16.215	16.318	16.395	16.340	16.265	
Station 0+150M						
Asbuilt Elvs.	16.226	16.301	16.386	16.306	16.226	
Monitored Elvs.	16.167	16.297	16.387	16.295	16.232	-do-
-do-	16.156	16.296	16.377	16.289	16.239	
-do-	16.159	16.296	16.379	16.292	16.239	
-do-	16.154	16.286	16.378	16.288	16.244	
-do-	16.157	16.293	16.384	16.289	16.247	
-do-	16.156	16.288	16.380	16.285	16.242	
Station 0+175M						
Asbuilt Elvs.	16.186	16.261	16.316	16.271	16.206	
Monitored Elvs.	16.165	16.257	16.307	16.262	16.217	-do-
-do-	16.166	16.250	16.299	16.253	16.216	
-do-	16.166	16.250	16.298	16.253	16.218	
-do-	16.166	16.250	16.298	16.250	16.218	
-do-	16.157	16.252	16.299	16.254	16.220	
-do-	16.158	16.250	16.296	16.253	16.217	
Station 0+200M						
Asbuilt Elvs.	16.176	16.234	16.288	16.236	16.166	
Monitored Elvs.	16.187	16.232	16.292	16.227	16.131	-do-
-do-	16.176	16.224	16.278	16.219	16.111	
-do-	16.178	16.218	16.278	16.219	16.142	
-do-	16.176	16.218	16.279	16.219	16.139	
-do-	16.189	16.220	16.281	16.223	16.134	
-do-	16.185	16.219	16.280	16.221	16.135	

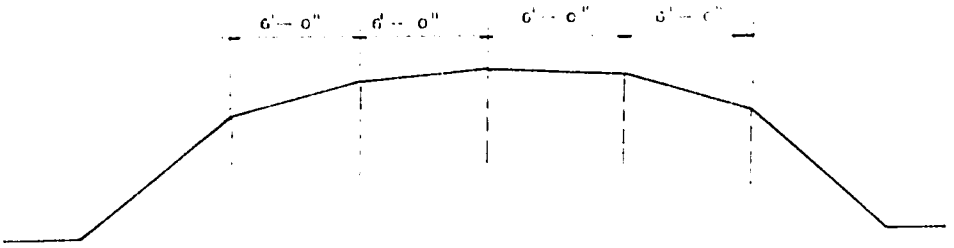


Station 0+225M						
Asbuilt Elvs.	16.146	16.206	16.276	16.216	16.136	
Monitored Elvs.	16.132	16.197	16.267	16.207	16.128	Jul 86
-do-	16.129	16.190	16.256	16.206	16.081	Aug 86
-do-	16.129	16.187	16.253	16.200	16.091	Sep 86
-do-	16.129	16.187	16.252	16.200	16.088	Oct 86
-do-	16.124	16.190	16.255	16.204	16.083	Nov 86
-do-	16.122	16.188	16.253	16.202	16.085	Dec 86
Station 0+250M						
Asbuilt Elvs.	16.115	16.205	16.255	16.195	16.135	
Monitored Elvs.	16.107	16.197	16.252	16.177	16.127	-do-
-do-	16.105	16.195	16.246	16.166	16.116	
-do-	16.106	16.195	16.246	16.166	16.111	
-do-	16.120	16.196	16.244	16.170	16.115	
-do-	16.120	16.200	16.247	16.173	16.120	
-do-	16.115	16.198	16.245	16.168	16.118	
Station 0+275M						
Asbuilt Elvs.	16.105	16.155	16.215	16.153	16.075	
Monitored Elvs.	16.116	16.166	16.231	16.150	16.076	-do-
-do-	16.111	16.150	16.206	16.131	16.066	
-do-	16.106	16.140	16.206	16.121	16.066	
-do-	16.109	16.145	16.209	16.123	16.068	
-do-	16.113	16.149	16.210	16.127	16.074	
-do-	16.110	16.147	16.205	16.124	16.070	
Station 0+300M						
Asbuilt Elvs.	16.065	16.145	16.214	16.140	16.065	
Monitored Elvs.	16.056	16.154	16.197	16.140	16.051	-do-
-do-	16.056	16.131	16.186	16.126	16.036	
-do-	16.056	16.134	16.184	16.126	16.036	
-do-	16.054	16.130	16.179	16.124	16.035	
-do-	16.070	16.137	16.182	16.128	16.042	
-do-	16.065	16.135	16.180	16.125	16.036	
Station 0+325M						
Asbuilt Elvs.	16.046	16.146	16.206	16.146	16.056	
Monitored Elvs.	16.026	16.121	16.196	16.121	16.070	-do-
-do-	16.021	16.122	16.196	16.106	16.068	
-do-	16.010	16.116	16.194	16.108	16.056	
-do-	16.012	16.116	16.191	16.108	16.057	
-do-	15.992	16.117	16.196	16.110	16.054	
-do-	15.994	16.115	16.193	16.107	16.055	

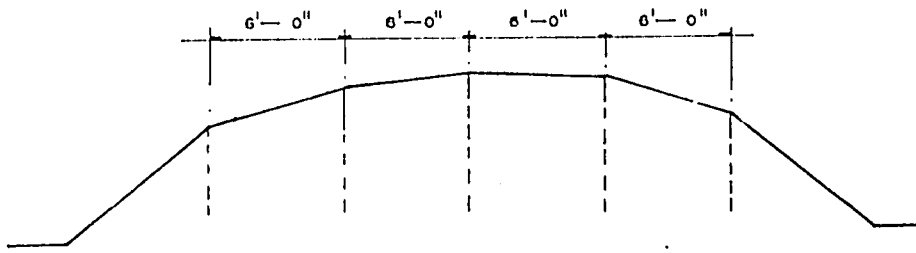
169



Station 0+350M						
Asbuilt Elvs.	16.041	16.136	16.206	16.126	16.076	
Monitored Elvs.	16.036	16.126	16.206	16.126	16.066	Jul 86
-do-	16.026	16.114	16.197	16.116	16.069	Aug 86
-do-	16.003	16.101	16.195	16.116	16.064	Sep 86
-do-	16.005	16.103	16.198	16.116	16.065	Oct 86
-do-	16.016	16.097	16.191	16.116	16.050	Nov 86
-do-	16.011	16.099	16.193	16.114	16.055	Dec 86
Station 0+375M						
Asbuilt Elvs.	16.086	16.146	16.225	16.154	16.060	
Monitored Elvs.	16.066	16.136	16.214	16.146	16.066	-do-
-do-	16.048	16.120	16.206	16.139	16.058	
-do-	16.053	16.113	16.198	16.113	16.053	
-do-	16.055	16.116	16.199	16.115	16.055	
-do-	16.063	16.118	16.201	16.113	16.051	
-do-	16.060	16.116	16.198	16.114	16.048	
Station 0+400M						
Asbuilt Elvs.	16.098	16.151	16.216	16.156	16.076	
Monitored Elvs.	16.051	16.144	16.214	16.146	16.084	-do-
-do-	16.040	16.130	16.207	16.131	16.070	
-do-	16.043	16.113	16.195	16.130	16.051	
-do-	16.043	16.115	16.193	16.130	16.051	
-do-	16.058	16.116	16.195	16.137	16.063	
-do-	16.047	16.114	16.192	16.131	16.056	
Station 0+425M						
Asbuilt Elvs.	16.066	16.181	16.236	16.186	16.111	
-do-	16.066	16.164	16.231	16.171	16.102	-do-
-do-	16.056	16.150	16.216	16.156	16.083	
-do-	16.000	16.147	16.211	16.158	16.077	
-do-	16.005	16.146	16.210	16.160	16.077	
-do-	15.004	16.144	16.206	16.159	16.072	
-do-	16.000	16.145	16.205	16.157	16.073	
Station 0+450M						
Asbuilt Elvs.	16.101	16.206	16.261	16.201	16.131	
Monitored Elvs.	16.131	16.186	16.256	16.196	16.156	-do-
-do-	16.126	16.191	16.246	16.186	16.136	
-do-	16.093	16.183	16.242	16.174	16.131	
-do-	16.096	16.185	16.245	16.175	16.136	
-do-	16.097	16.187	16.246	16.177	16.132	
-do-	16.099	16.186	16.244	16.173	16.135	

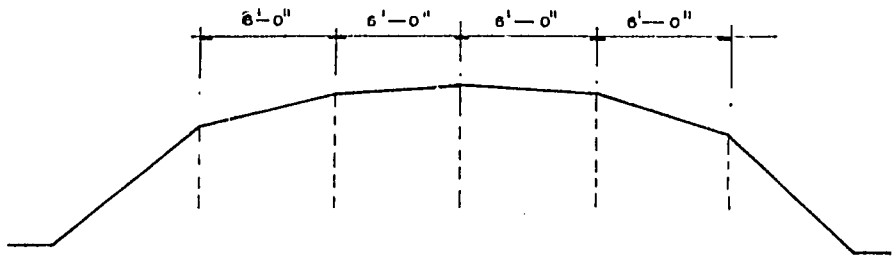


Station 0+475M						
Asbuilt Elvs.	16.151	16.221	16.301	16.221	16.161	
Monitored Elvs.	16.181	16.221	16.306	16.234	16.170	Jul 86
-do-	16.165	16.216	16.296	16.216	16.137	Aug 86
-do-	16.164	16.214	16.290	16.206	16.132	Sep 86
-do-	16.162	16.214	16.291	16.203	16.135	Oct 86
-do-	16.158	16.216	16.286	16.202	16.139	Nov 86
-do-	16.160	16.215	16.288	16.198	16.136	Dec 86
Station 0+500M						
Asbuilt Elvs.	16.181	16.271	16.323	16.251	16.171	
Monitored Elvs.	16.196	16.260	16.324	16.246	16.176	-do-
-do-	16.176	16.256	16.311	16.247	16.140	
-do-	16.175	16.247	16.311	16.232	16.134	
-do-	16.177	16.246	16.310	16.235	16.136	
-do-	16.174	16.246	16.314	16.235	16.136	
-do-	16.170	16.245	16.312	16.231	16.130	
Station 0+525M						
Asbuilt Elvs.	16.231	16.301	16.356	16.306	16.196	
Monitored Elvs.	16.226	16.291	16.356	16.281	16.176	-do-
-do-	16.219	16.276	16.346	16.266	16.136	
-do-	16.214	16.275	16.342	16.264	16.162	
-do-	16.211	16.274	16.346	16.266	16.161	
-do-	16.219	16.276	16.346	16.266	16.169	
-do-	16.212	16.275	16.345	16.265	16.164	
Station 0+550M						
Asbuilt Elvs.	16.221	16.326	16.376	16.326	16.226	
Monitored Elvs.	16.191	16.301	16.361	16.311	16.226	-do-
-do-	16.189	16.296	16.356	16.304	16.199	
-do-	16.181	16.292	16.362	16.302	16.186	
-do-	16.186	16.296	16.361	16.303	16.188	
-do-	16.182	16.293	16.361	16.294	16.179	
-do-	16.180	16.289	16.358	16.295	16.175	
Station 0+575M						
Asbuilt Elvs.	16.286	16.376	16.436	16.376	16.290	
Monitored Elvs.	16.279	16.351	16.411	16.353	16.316	-do-
-do-	16.267	16.346	16.406	16.351	16.266	
-do-	16.282	16.346	16.406	16.351	16.273	
-do-	16.282	16.346	16.407	16.353	16.277	
-do-	16.280	16.340	16.403	16.350	16.277	
-do-	16.275	16.342	16.401	16.351	16.277	

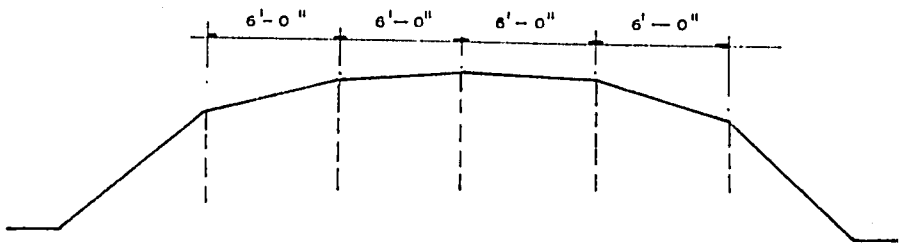


Station 0+600M						
Asbuilt Elvs.	16.306	16.416	16.476	16.411	16.296	
Monitored Elvs.	16.291	16.392	16.456	16.391	16.309	Jul 86
-do-	16.291	16.386	16.447	16.386	16.289	Aug 86
-do-	16.291	16.384	16.443	16.380	16.291	Sep 86
-do-	16.290	16.384	16.446	16.379	16.296	Oct 86
-do-	16.280	16.380	16.444	16.376	16.291	Nov 86
-do-	16.283	16.381	16.442	16.375	16.290	Dec 86.
Station 0+625M						
Asbuilt Elvs.	16.406	16.506	16.556	16.506	16.406	
Monitored Elvs.	16.381	16.476	16.553	16.491	16.356	-do-
-do-	16.387	16.477	16.546	16.496	16.368	
-do-	16.387	16.477	16.545	16.495	16.360	
-do-	16.385	16.475	16.545	16.495	16.365	
-do-	16.376	16.470	16.538	16.489	16.360	
-do-	16.370	16.468	16.540	16.490	16.352	
Station 0+650M						
Asbuilt Elvs.	16.386	16.511	16.576	16.521	16.426	
Monitored Elvs.	16.361	16.491	16.566	16.501	16.386	-do-
-do-	16.366	16.486	16.561	16.487	16.386	
-do-	16.344	16.485	16.561	16.490	16.394	
-do-	16.342	16.485	16.561	16.488	16.390	
-do-	16.338	16.481	16.556	16.483	16.377	
-do-	16.337	16.478	16.554	16.481	16.377	
Station 0+675M						
Asbuilt Elvs.	16.456	16.551	16.601	16.546	16.450	
Monitored Elvs.	16.536	16.536	16.591	16.539	16.476	-do-
-do-	16.436	16.526	16.586	16.529	16.461	
-do-	16.436	16.530	16.586	16.534	16.461	
-do-	16.436	16.528	16.587	16.533	16.460	
-do-	16.436	16.525	16.575	16.529	16.458	
-do-	16.435	16.525	16.573	16.528	16.453	
Station 0+700M						
Asbuilt Elvs.	16.451	16.541	16.610	16.536	16.446	
Monitored Elvs.	16.396	16.511	16.596	16.531	16.421	-do-
-do-	16.386	16.516	16.586	16.516	16.405	
-do-	16.390	16.516	16.590	16.516	16.404	
-do-	16.388	16.514	16.590	16.515	16.398	
-do-	16.392	16.508	16.588	16.515	16.390	
-do-	16.390	16.500	16.586	16.512	16.385	

117

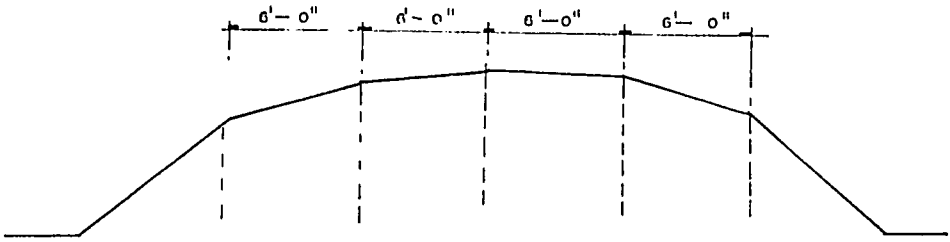


Station 0+725M						
Asbuilt Elvs.	16.431	16.536	16.590	16.526	16.436	
Monitored Elvs.	16.416	16.521	16.586	16.516	16.416	Jul 86
-do-	16.406	16.508	16.574	16.508	16.416	Aug 86
-do-	16.410	16.505	16.578	16.510	16.418	Sep 86
-do-	16.408	16.502	16.573	16.510	16.418	Oct 86
-do-	16.401	16.490	16.570	16.507	16.414	Nov 86
-do-	16.398	16.491	16.568	16.500	16.410	Dec 86
Station 0+750M						
Asbuilt Elvs.	16.430	16.506	16.566	16.536	16.436	
Monitored Elvs.	16.421	16.506	16.562	16.506	16.436	-do-
-do-	16.418	16.488	16.552	16.497	16.426	
-do-	16.420	16.481	16.555	16.497	16.420	
-do-	16.428	16.479	16.553	16.497	16.416	
-do-	16.422	16.470	16.549	16.489	16.410	
-do-	16.417	16.465	16.550	16.490	16.410	
Station 0+775M						
Asbuilt Elvs.	16.384	16.484	16.536	16.541	16.456	
Monitored Elvs.	16.416	16.466	16.540	16.506	16.386	-do-
-do-	16.417	16.461	16.539	16.496	16.366	
-do-	16.419	16.460	16.539	16.490	16.371	
-do-	16.419	16.456	16.539	16.486	16.373	
-do-	16.413	16.444	16.535	16.472	16.362	
-do-	16.409	16.440	16.535	16.469	16.360	
Station 0+800M						
Asbuilt Elvs.	16.326	16.416	16.486	16.506	16.441	
Monitored Elvs.	16.366	16.426	16.488	16.462	16.406	-do-
-do-	16.368	16.406	16.485	16.460	16.398	
-do-	16.365	16.405	16.487	16.460	16.400	
-do-	16.365	16.401	16.487	16.459	16.401	
-do-	16.354	16.398	16.478	16.445	16.382	
-do-	16.355	16.390	16.477	16.447	16.385	
Station 0+825M						
Asbuilt Elvs.	16.275	16.355	16.426	16.460	16.378	
Monitored Elvs.	16.236	16.316	16.426	16.426	16.386	-do-
-do-	16.237	16.316	16.419	16.432	16.386	
-do-	16.222	16.302	16.419	16.422	16.372	
-do-	16.226	16.303	16.416	16.422	16.376	
-do-	16.236	16.306	16.420	16.425	16.369	
-do-	16.230	16.300	16.418	16.423	16.380	



Station 0+850M						
Asbuilt Elvs.	16.225	16.305	16.370	16.370	16.286	
Monitored Elvs.	16.216	16.301	16.361	16.341	16.281	Jul 86
-do-	16.214	16.297	16.364	16.344	16.294	Aug 86
-do-	16.196	16.285	16.352	16.332	16.267	Sep 86
-do-	16.201	16.290	16.352	16.331	16.271	Oct 86
-do-	16.212	16.289	16.354	16.33	16.279	Nov 86
-do-	16.210	16.285	16.350	16.330	16.275	Dec 86
Station 0+875M						
Asbuilt Elvs.	16.178	16.270	16.325	16.265	16.165	
Monitored Elvs.	16.171	16.241	16.301	16.246	16.176	-do-
-do-	16.164	16.244	16.297	16.240	16.164	
-do-	16.151	16.235	16.280	16.232	16.164	
-do-	16.151	16.235	16.284	16.232	16.171	
-do-	16.156	16.232	16.282	16.222	16.171	
-do-	16.153	16.230	16.283	16.220	16.169	
Station 0+900M						
Asbuilt Elvs.	16.225	16.305	16.290	16.225	16.137	
Monitored Elvs.	16.166	16.286	16.286	16.206	16.146	-do-
-do-	16.159	16.298	16.270	16.215	16.127	
-do-	16.152	16.278	16.262	16.196	16.122	
-do-	16.151	16.274	16.265	16.191	16.118	
-do-	16.143	16.266	16.271	16.191	16.119	
-do-	16.145	16.265	16.270	16.188	16.114	
Station 0+925M						
Asbuilt Elvs.	16.206	16.304	16.254	16.186	16.104	
Monitored Elvs.	16.171	16.271	16.241	16.161	16.081	-do-
-do-	16.160	16.275	16.238	16.164	16.074	
-do-	16.134	16.254	16.202	16.149	16.057	
-do-	*	*	*	*	*	
-do-	16.149	16.256	16.223	16.152	16.054	
-do-	16.148	16.255	16.220	16.147	16.050	
Station 0+950M						
Asbuilt Elvs.	16.184	16.264	16.234	16.164	16.079	
Monitored Elvs.	16.151	16.241	16.246	16.151	16.071	-do-
-do-	16.178	16.238	16.236	16.150	16.074	
-do-	16.152	16.242	16.233	16.135	16.066	
-do-	*	*	*	*	*	
-do-	16.171	16.223	16.233	16.149	16.071	
-do-	16.168	16.219	16.229	16.148	16.070	
Station 0+975M						
Asbuilt Elvs.	16.074	16.164	16.214	16.154	16.050	
Monitored Elvs.	16.115	16.143	16.191	16.122	16.056	-do-
-do-	16.119	16.144	16.193	16.121	16.064	
-do-	16.120	16.155	16.218	16.128	16.080	
-do-	*	*	*	*	*	
-do-	16.123	16.130	16.204	16.120	16.063	
-do-	16.120	16.130	16.202	16.121	16.054	

144



Station 1+000M						
Asbuilt Elvs.	16.040	16.140	16.197	16.141	16.047	
Monitored Elvs.	16.061	16.146	16.201	16.111	16.044	Jul 86
-do-	16.065	16.144	16.201	16.116	16.066	Aug 86
-do-	16.055	16.150	16.200	16.118	16.061	Sep 86
-do-	16.055	16.148	16.205	16.123	16.061	Oct 86
-do-	16.052	16.139	16.199	16.113	16.052	Nov 86
-do-	16.048	16.135	16.199	16.111	16.048	Dec 86
Station 1+025M						
Asbuilt Elvs.	16.019	16.109	16.184	16.119	16.029	
Monitored Elvs.	16.013	16.119	16.194	16.128	16.079	-do-
-do-	16.002	16.095	16.190	16.111	16.073	
-do-	16.003	16.102	16.190	16.113	16.072	
-do-	16.007	16.104	16.199	16.117	16.073	
-do-	16.004	16.099	16.192	16.109	16.060	
-do-	16.005	16.097	16.188	16.100	16.062	
Station 1+050M						
Asbuilt Elvs.	16.030	16.129	16.177	16.107	16.049	
Monitored Elvs.	16.079	16.129	16.186	16.109	16.042	-do-
-do-	16.057	16.116	16.171	16.093	16.023	
-do-	16.062	16.108	16.175	16.093	16.028	
-do-	16.060	16.106	16.175	16.089	16.028	
-do-	16.053	16.099	16.165	16.081	16.019	
-do-	16.045	16.094	16.161	16.082	16.015	
Station 1+075M						
Asbuilt Elvs.	16.037	16.119	16.179	16.099	16.000	
Monitored Elvs.	16.029	16.119	16.183	16.099	15.962	-do-
-do-	16.044	16.114	16.178	16.096	15.968	
-do-	16.033	16.114	16.182	16.096	15.964	
-do-	*	*	*	*	*	
-do-	*	*	*	*	*	
-do-	16.030	16.092	16.163	16.079	16.940	
Station 1+100M						
Asbuilt Elvs.	16.049	16.139	16.200	16.126	16.029	
Monitored Elvs.	16.014	16.139	16.204	16.144	16.029	-do-
-do-	16.009	16.110	16.195	16.121	16.020	
-do-	16.973	16.110	16.195	16.109	16.028	
-do-	*	*	*	*	*	
-do-	*	*	*	*	*	
-do-	15.968	16.101	16.165	16.102	16.005	

* Levels could not be taken as the top layer of base course in these areas has been removed for repair.

115

ROAD SURFACING TRIAL PROJECT, RAJBARI

MONITORING PROGRAMME:
RECORD OF OBSERVATIONS IN TYPE -1

	Sl No	Type of deterioration	Date of observation: July 1986			Date of observation: August 1986			Date of observation: September 1986		
			Location	Measurement of deteriorations	Remarks/ possible reasons, etc	Location	Measurement of deteriorations	Remarks/ possible reasons, etc	Location	Measurement of deteriorations	Remarks/ possible reasons, etc
A-PAVEMENT	A.1	Local depression	0+100 to 0+125 LHS	25m×0.5m×15mm	-	0+100 to 0+125 LHS	25m×0.5m×20mm	-	0+100 to 0+125 LHS	25m×0.5m×15m-25mm	
	A.2	Wavy surface	-	-	-	-	-	-	-	-	-
	A.3	Spongy surface	-	-	-	-	-	-	-	-	-
	A.4	Surface cracking	-	-	-	-	-	-	-	-	-
	A.5	Loss of pea gravels from surface	-	-	-	-	-	-	-	-	-
	A.6	Pot holes	-	-	-	-	-	-	-	-	-
	A.7	Water accumulation	-	-	-	-	-	-	-	-	-
	A.8	Others	Scattered	5% of bricks (corners & edges are broken) are damaged	Due to inconsistant quality	Scattered	6% of bricks (corners & edges are broken) are damaged	Due to inconsistant quality	Scattered	6-7% of bricks (corners and edges are broken) are damaged	Due to inconsistant quality
B-SHOULDER	B.1	Local depression	0+115 RHS 0+155 LHS	5m×0.5m×40mm 3m×0.5m×40mm	-	115m RHS 155-165LHS 165-185RHS	5m×0.5m×40mm 10m×0.5m×40mm 15m×0.5m×30mm	-	115m RHS 155-165LHS 165-185RHS	5m×0.5m×40mm 10m×0.5m×40mm 15m×0.5m×30mm	
	B.2	Wavy surface	-	-	-	-	-	-	-	-	-
	B.3	Spongy surface	-	-	-	-	-	-	-	-	-
	B.4	Surface cracking	-	-	-	-	-	-	-	-	-
	B.5	Pot holes	-	-	-	-	-	-	-	-	-
	B.6	Water accumulation	0+115 RHS 0+155 LHS	5m×0.5m×40mm 3m×0.5m×40mm	-	115m RHS 155-165LHS 165-185RHS	5m×0.5m×40mm 3m×0.5m×40mm 15m×0.5m×30mm	-	115m RHS 155-165LHS 165-185RHS	5m×0.5m×40mm 3m×0.5m×40mm 15m×0.5m×30mm	
	B.7	Erosion of edge	-	-	-	-	-	-	-	-	-
	B.8	Others	0+100 to 0+150 LHS	50m×0.75m	Agg. are exposed due to washing away of top soil	100-200LHS 150-200RHS	100×0.75m 0.50×0.5m	Agg. are exposed due to washing away of sand & soil ingredients	100-200LHS 150-200RHS	100×0.75m 50×0.5m	Agg. are exposed due to washing away of sand & ingredients.
C-SLOPE	C.1	Rain cuts	Scattered	Moderate	For less compaction & excessive rain	Scattered	Moderate	For less compaction and excessive rain	Scattered 130-135LHS	Moderate	For less compaction and excessive rain
	C.2	Sliding	-	-	-	-	-	-	130-135LHS	Severe	-
	C.3	Rat holes	Scattered	-	-	Scattered	-	No change from previous observation	Scattered	-	-
	C.4	Fox holes	-	-	-	-	-	-	-	-	-
	C.5	Others	-	-	-	-	-	-	-	-	-

rvation: September 1986		Date of observation: Oct 1986			Date of observation: November, 1986			Date of observation: December 1986		
asurement f deteriora-ions	Remarks/ possible reasons, etc	Location	Measurement of deteriora-tions	Remarks/ possible reasons, etc	Location	Measurement of deteriora-tions	Remarks/ possible reasons, etc	Location	Measurement of deteriora-tions	Remarks/ possible reasons, etc
ex0.5mx15m-25mm		0+100 to 0+125 LHS	25mx0.5mx15cm - 25mm		0+100 to 0+125 LHS	25mx0.5mx15mm-25mm		0+100 to 0+125 LHS	25mx0.5mx15mm-25mm	
-	-	-	-		-	-		-	-	-
-	-	-	-		-	-		-	-	
-	-	-	-		-	-		-	-	
-	-	-	-		-	-		-	-	
-	-	-	-		-	-		-	-	
-7% of bricks corners and ges are bru-n)are damag	Due to incon-sistant quali-ty	Scattered	10% of bricks (corners & edges are bro-ken)are damag	Due to incon-sistant quality.	Scattered	10% to 12% of bricks (corners & edges are broken)are damaged.	Due to incon-sistant quality	Scattered	15% of bricks (corners & edges are bro-ken)are damaged	Due to incon-sistant quali-ty
x0.5mx40mm 5mx0.5mx40mm 5mx0.5mx30mm		110-125LHS 110-130RHS 155-165LHS 165-185RHS	15mx0.5mx30cm 20mx0.5mx40mm 10mx0.5mx40cm 20mx0.5mx30cm		110-125LHS 100-130RHS 155-165LHS 165-185RHS	15mx0.5mx30mm 20mx0.5mx40mm 10mx0.5mx40mm 20mx0.5mx30mm		110-125LHS 100-130RHS 155-165LHS 165-185RHS	15mx0.5mx30mm 20mx0.5mx40mm 10mx0.5mx40mm 20mx0.5mx30mm	
-	-	-	-	-	-	-	-	-	-	
-	-	-	-	-	-	-	-	-	-	
-	-	-	-		-	-		-	-	
-	-	-	-		-	-		-	-	
-	-	-	-	-	-	-	-	-	-	-
mx0.5mx40mm mx0.5mx40mm 5mx0.5mx30mm		110-125LHS 110-130RHS 155-165LHS 165-185RHS	15mx0.5mx30cm 20mx0.5mx40cm 10mx0.5mx40cm 20mx0.5mx30cm	-	-	-	-	-	-	
-	-	-	-	-	-	-	-	-	-	
00x0.75m 50x0.5m	Agg.are exposed due to washing away of sand & ingradients.	100-200LHS 150-200RHS	100mx.75m 50mx0.5m	Aggregates are exposed due to washing away of sand & soil ingredients.	100-200LHS 150-200RHS	100x0.75m 50x0.5m	Agg. are exposed due to washing-away of sand & soil ingredients.	100-200LHS 150-200RHS	100mx0.75m 50mx0.5m	Aggregates are exposed due to washingaway of sand & soil ingredients
Moderate	For less com-paction and excessive rain	Scattered 130-135LHS	Moderate	For less com-paction &exce-ssive rain.	Scattered 130-140LHS	Moderate Severe	For less com-paction & excessive rain.	Scattered 130-135LHS	Moderate Severe	For less com-paction & exce-ssive rain.
Severe	-	130-140LHS	Severe	-do-	130-140LHS	Severe	Excessive rain	130-140LHS	Severe	Excessive rain
-	-	Scattered	-	-	Scattered	-	-	Scattered	-	
-	-				-	-	-	-	-	
-	-				-	-	-	-	-	

ROAD SURFACING TRIAL PROJECT, BAJHANG

MONITORING PROGRAMME:
RECORD OF OBSERVATIONS IN TYPE - 2

	Sl No	Type of deterioration	Date of observation: July 1986			Date of observation: August 1986			Date of observation: September 19		
			Location	Measurement of deteriorations	Remarks/ possible reasons, etc	Location	Measurement of deteriorations	Remarks/ possible reasons, etc	Location	Measurement of deteriorations	Remarks/ possible reasons,
A-PAVEMENT	A.1	Local depression	200-275L 220-270R 285-300L+R	75mx0.5mx20mm 50mx0.5mx15mm 15mx0.5mx15mm	-	200-275L 220-270R 285-300 L+R	75mx0.5mx15-25mm 50mx0.5mx15-20mm 15mx0.5mx15-20mm	-	200-275L 220-270R 285-300 L+R	75mx0.5mx15-25mm 50mx0.5mx15-20mm 15mx0.5mx15-20mm	
	A.2	Wavy surface	-	-	-	-	-	-	-	-	-
	A.3	Spongy surface	-	-	-	-	-	-	-	-	-
	A.4	Surface cracking	All through	70% joint sealing with emulsion has been cracked and opened	Emulsion is not sticky and also there is individual movement of bricks under traffic	All through	80% joint sealing with emulsion has been cracked and opened	Emulsion is not sticky & also there is individual movement of bricks under traffic	All through	100% joint sealing with emulsion has been cracked and opened	Emulsion i sticky and there is i vidual mov of bricks traffic.
	A.5	Loss-of-aggregate from surface	-	-		-	-		-	-	-
	A.6	Pot holes	-	-	-	-	-	-	-	-	-
	A.7	Water accumulation	-	-	-	-	-	-	-	-	-
	A.8	Others	Scattered	3-5% of bricks (corners & edges are broken) are damaged	Due to inconsistant quality	Scattered	3-5% of bricks (corners and edges are broken) are damaged	Due to inconsistant quality. No change from previous observation.	Scattered	5% of bricks (corners and edges are broken) are damaged	Due to inc stant qu
B-SHOULDER	B.1	Local depression	0.225 RHS	4mx0.5mx30mm	-	225-250m LHS 225-275m RHS	25mx0.25mx30mm 50mx0.25mx30mm	Along extreme edge in the form of tyre mark	225-250m LHS 225-275m	25mx0.25mx30mm 50mx0.25mx30mm	Along extr edge in th form of ty
	B.2	Wavy surface	-	-	-	-	-	-	-	-	-
	B.3	Spongy surface	-	-	-	-	-	-	-	-	-
	B.4	Surface cracking	-	-	-	-	-	-	-	-	-
	B.5	Pot holes	-	-	-	-	-	-	-	-	-
	B.6	Water accumulation	0.225 RHS	4mx0.5mx30mm	-	225-250m LHS 225-275m RHS	25mx0.25mx30mm 50mx0.25mx30mm	-	225-250m LHS 225m-275 RHS	25mx0.25mx30mm 50mx0.25mx30mm	
	B.7	Erosion of edge	-	-	-	-	-	-			
	B.8	Others	-	-	-	Scattered and althrough	-	Agg. are exposed due to washing away of sand & soil ingredients	Scattered & although	-	Agg. are e due to was away of sa soil ingre
C-SLOPE	C.1	Rain cuts	Scattered	Moderate	For less compaction & excessive rain	Scattered	Moderate	For less compaction & excessive rain	Scattered	Moderate	For less compaction excessive
	C.2	Sliding	-	-	-	-	-	-	-	-	-
	C.3	Rat holes	-	-	-	-	-	-	-	-	-
	C.4	Fox holes	-	-	-	-	-	-	-	-	-
	C.5	Others	0.287 LHS	Moderate erosion toe of embankment	Due to drain for discharging rain water in the borrow pit.	287 LHS	Moderate erosion at toe of embankment	Due to drain for discharging rain water in the borrow pit.	287 LHS	Moderate erosion of toe of embankment	Due to drai for discher rain water borrow pit

Date of observation: September 1986			Date of observation: Oct 1986			Date of observation: Nov'86			Date of observation: December 1986		
cation	Measurement of deteriorations	Remarks/ possible reasons, etc	Location	Measurement of deteriorations	Remarks/ possible reasons, etc	Location	Measurement of deteriorations	Remarks/ possible reasons, etc	Location	Measurement of deteriorations	Remarks/ possible reasons, etc
-275L -270R -300	75mx0.5mx15-25mm 50mx0.5mx15-20mm 15mx0.5mx15-20mm		200-300 L 215-275 R	100mx0.5mx 15-25mm 60mx0.5mx 15-25mm		200-300 L 215-275 R	100mx0.5mx15-25mm 60mx0.5mx15-25mm		200-300 L 215-275 R	100mx0.5mx15-25mm 60mx0.5mx15-25mm	
-	-	-	-	-	-	-	-	-	-	-	
-	-	-	-	-	-	-	-	-	-	-	
1 rough	100% joint sealing with emulsion has been cracked and opened	Emulsion is not sticky and also there is individual movement of bricks under traffic.	All through	100% joint sealing with emulsion has been cracked & opened	Emulsion is not sticky and also their is individual movement of bricks under traffic.	All through	100% joint/sealing with emulsion has been cracked &opened	Emulsion is not sticky & also there is individual movement of bricks under traffic.	All through	100% joint sealing with emulsion has been cracked & opened.	Emulsion is not sticky and also there is individual movement of bricks under traffic.
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
tered tion.	5% of bricks (corners and edges are broken) are damaged	Due to inconsistant quality	Scattered	7-8% of bricks (corners & edges are broken)are damaged	Due to inconsistant quality.	Scattered	8-9% of bricks (corners A edges are broken)are damaged	Due to inconsistant quality.	Scattered	12% of bricks (corners and edges are broken)are damaged.	Due to inconsistant quality.
250m 275m	25mx0.25mx30mm 50mx0.25mx30mm	Along extreme edge in the form of tyremark	225-250m L 225-290m R 275-285m L	25mx0.25mx30mm 65mx0.25mx30mm 10mx0.40mx30mm	Along extreme edge in the form of tyremark.	225-250LHS 225-290RHS 275-285LHS	25mx0.25mx30mm 65mx0.25mx30mm 10mx0.40mx30mm	Along extreme edge in the form of tyremark.	225-250LHS 225-290RHS 275-285LHS	25mx0.25mx30mm 65mx0.25mx30mm 10mx0.40mx30mm	Along extreme edge in the form of tyremark.
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
250m -275	25mx0.25mx30mm 50mx0.25mx30mm		225-250mLHS 225-290mRHS 275-285mLHS	25mx0.25mx30cm 65mx0.25mx30cm 10mx0.40mx30cm							
tered though	-	AGG. are exposed due to washing away of sand & soil ingredients	Scattered & althrough	-	Agg.are exposed due to washing away of sand& soil ingredients.	Scattered & althrough		AGGR.are exposed due to washing away of sand &soil ingredients.	Scattered & althrough	-	AGGR. are exposed due to washingaway of sand & soil ingredients
tered	Moderate	For less compaction and excessive rain	Scattered	Moderate	For less compaction & excessive rain	Scattered	Moderate	For less compaction & excessive rain.	Scattered	Moderate	For less compaction and excessive rain
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	285-290LHS	-	-	285-290LHS	-	-
-	-	-	-	-	-	-	-	-	-	-	-
LHS	Moderate erosion of toe of embankment	Due to drain for discharging rain water in the borrow pit.	285-290LHS	Moderate erosion at toe of embankment	Due to drain for discharging rainwater in the borrow pit.	285-290LHS	Moderate erosion at toe of embankment	Due to drain for discharging rain water in the borrow pit.	285-290LHS	Moderate erosion at toe of embankment	Due to drain for discharging rain water in the borrow pit.

ROAD SURFACING TRIAL PROJECT, RAJBARI

MONITORING PROGRAMME:
RECORD OF OBSERVATIONS IN TYPE - 3

	Sl No	Type of deterioration	Date of observation: July 1986			Date of observation: August 1986			Date of observa	
			Location	Measurement of deteriorations	Remarks/ possible reasons, etc	Location	Measurement of deteriorations	Remarks/ possible reasons, etc	Location	Measu of de tions
A-PAVEMENT	A.1	Local depression	330-340L 350-400R	10mx0.5mx15mm 50mx0.5mx 15-20mm	-	330-400L 330-400R	10mx0.5mx15mm 50mx0.5mx 15-20mm	Depression has extended in lengthwise	330-400L 330-400R	70mx0 70mx0 15-20
	A.2	Wavy surface	-	-	-	-	-	-	-	
	A.3	Spongy surface	-	-	-	-	-	-	-	
	A.4	Surface cracking	Scattered	50% joint sealing with emulsion has been cracked and opened	Due to individual movement of bricks and emulsion being non-sticky to the bricks	Scattered	60% joint sealing with emulsion has been cracked and opened	Due to individual movement of bricks and emulsion being non-sticky to the bricks	Scattered	75% j sealin emulsi been opened
	A.5	Loss of pea gravels from surface	-	-	-	-	-	-	-	
	A.6	Pot holes	-	-	-	-	-	-	-	
	A.7	Water accumulation	-	-	-	-	-	-	-	
	A.8	Others	Scattered	3-5% of bricks (corners & edges are broken) are damaged	Due to inconsistant quality	Scattered	3-5% of bricks (corners & edges are broken) are damaged	Due to inconsistant quality but no change or increase from previous observation	Scattered	5% of (corne edges are da
B-SHOULDER	B.1	Local depression	-	-	-	350-360 m RHS	10mx0.5mx30mm	Like tyre mark	350-360m RHS.	10mx0.
	B.2	Wavy surface	-	-	-	-	-	-	-	
	B.3	Spongy surface	-	-	-	-	-	-	-	
	B.4	Surface cracking	-	-	-	-	-	-	-	
	B.5	Pot holes	-	-	-	-	-	-	-	
	B.6	Water accumulation	-	-	-	350-360m RHS	10mx0.5mx30mm	-	350-360m RHS	10mx0.
	B.7	Erosion of edge	-	-	-	-	-	Aggr. are exposed due to washing away of sand & soil ingredients	-	
	B.8	Others	-	-	-	300-350m LHS	50mx0.5m		300-350m and scattered on RHS.	50mx0.
C-SLOPE	C.1	Rain cuts	Scattered 300-350LHS	Not harmful Moderate	Less compaction and excessive rain	Scattered 300-350 LHS	Not harmful Moderate & few severe	Less compaction and excessive rain	Scattered 300-350LHS	Not ha Moderat few sev
	C.2	Sliding	-	-	-	-	-	-	-	
	C.3	Rat holes	-	-	-	-	-	-	-	-
	C.4	Fox holes	-	-	-	-	-	-	-	-
	C.5	Others	-	-	-	315m LHS	Moderate exposed at toe of embankment	Due to drain for discharging rain water in the borrow pit.	315m LHS	Moderat sion at of emba

September 1986		Date of observation: Oct 1986			Date of observation: Nov'86			Date of observation: December 1986		
Remarks/ possible reasons, etc	Location	Measurement of deteriora-tions	Remarks/ possible reasons, etc	Location	Measurement of deteriora-tions	Remarks/ possible reasons, etc	Location	Measurement of deteriora-tions	Remarks/ possible reasons, etc
No change	330-400 L 330-400 R	70mx0.5mx15mm 70mx0.5mx 15-20mm	No change from previous observation	330-400 L 330-400 R	70mx0.5mx15mm 70mx0.5mx15-20mm	No change from previous observation.	300-400 L 330-400 R	70mx0.5mx15mm 70mx0.5mx15-20mm	No change from previous observation.
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
Due to individual movement of bricks and emulsion being non-sticky to the bricks.	Scattered	80% joint sealing with emulsion has been cracked & opened	Due to individual movement of bricks & emulsion being non-sticky to the bricks.	Scattered	100% joint sealing with emulsion has been cracked & opened.	Due to individual movement of bricks & emulsion being non-sticky to the bricks.	Scattered	100% joint sealing with emulsion has been cracked and opened.	Due to individual movement of bricks and emulsion being non-sticky to the bricks.
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
Due to inconsistent quality	Scattered	7-8% of bricks (corners & edges are broken)are damaged	Due to inconsistant quality	Scattered	8-9% of bricks (corners and edges are broken)are damaged.	Due to inconsistant quality.	Scattered	12% of bricks (corners & edges are broken) are damaged .	Due to inconsistant quality.
Like tyre mark	350-360m RHS	10mx0.5mx30mm	Like tyremark	350-360RHS	10mx0.5mx30mm	Like tyremark.	350-360RHS	10mx0.5mx30mm	Like tyremark.
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
	350-360m RHS	10mx0.5mx30mm	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
Aggr.are exposed due to washing of sand & soil ingredients.	300-350m LHS and scatteredly	50mx0.5m	Agg.are exposed due to washingaway of sand & soil ingredients.	300-350LHS and scatteredly on RHS.	50mx0.5m	Aggr.are exposed due to washing away of sand & soil ingredients.	300-350LHS and scatteredly on RHS.	50mx0.5m	Aggr. are exposed due to washing away of sand & soil ingredients.
Less compaction and excessive rain.	Scattered	Not harmful	Less compaction and excessive rain.	Scattered 300-350LHS	Not harmful moderate and a few are severe.	Less compaction and excessive rain.	Scattered 300-350LHS	Not harmful Moderate and a few are severe	Less compaction and excessive rain.
-	300-350LHS	Moderate and a few are severe	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
Due to drain for discharging rain water by the borrowpit.	308-318LHS	Severe erosion at toe of embankment	Due to drain for discharging rain water in the borrow pit.	308-318LHS	Severe erosion at toe of embankment.	Due to drain for discharging rain water in the borrowpit.	308-318LHS	Severe erosion at toe of embankment.	Due to drain for discharging rain water in the borrow pit.

ROAD SURFACING TRIAL PROJECT, RAJBARI

MONITORING PROGRAMME:
RECORD OF OBSERVATIONS IN TYPE - 4

	Sl No	Type of deterioration	Date of observation: July 1986			Date of observation: August 1986			Date of observation:	
			Location	Measurement of deteriorations	Remarks/ possible reasons, etc	Location	Measurement of deteriorations	Remarks/ possible reasons, etc	Location	Measurement of deteriorations
A-PAVEMENT	A.1	Local depression								
	A.2	Wavy surfate								
	A.3	Spongy surface								
	A.4	Surface cracking							430-470m	20mx1.5m
	A.5	Loss of peagravels from surface	Track ways	40-60% of the loose pea-gravels are lost	Washed away by rain and also by tyres	Although A complete trackways	More than 80% of the loose pea gravels are lost	Washed away by rain and also removed by tyres	Although A complete	100% of the loose pea gravels are lost.
	A.6	Pot holes								
	A.7	Water accumulation								
	A.8	Others							410-425m 440-450m 450-475m	15mx0.25m 2mx0.5m 4m²
B-SHOULDER	B.1	Local depression				480-495m RHS	15mx0.5mx30mm	Like tyre mark	480-495m RHS	15mx0.5mx30m
	B.2	Wavy surface								
	B.3	Spongy surface								
	B.4	Surface cracking								
	B.5	Pot holes								
	B.6	Water accumulation				480-495m RHS	15mx0.5mx30mm	-	480-495m RHS.	15mx0.5mx30mm
	B.7	Erosion of edge								
	B.8	Others								
C-SLOPE	C.1	Rain cuts	Scattered	Not harmful	For less compaction and excessive rain	Scattered	Not harmful	For less compaction and excessive rains. No change from previous observation.	Scattered	Not harmful
	C.2	Sliding								
	C.3	Rat holes								
	C.4	Fox holes								
	C.5	Others	Right slope	Not covered all areas	Turfing	Right slope	Not covered all areas	Turfing	Right slope	Now covered all areas

...: September 1986		Date of observation: Oct 1986			Date of observation: Nov '86			Date of observation:		
...ment ...riora-	Remarks/ possible reasons, etc	Location	Measurement of deteriorations	Remarks/ possible reasons, etc	Location	Measurement of deterioration	Remarks/ possible reasons, etc	Location	Measurement of deteriorations	Remarks/ possible reasons, etc
		-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-
		475-490 R 450-475LR 410-420RHS	15mx0.50m 25mx0.50m 10mx0.50m	-	475-490 R 450-475LR 410-420RHS	15mx0.50mx 25mx0.50m 10mx0.50m		475-490R 450-475LR 410-420RHS	15mx0.50m 25mx0.50m 10mx0.50m	
...5m ...the ...ed ...are	Washed away by rain & also removed by tyres.	Althrough A complete tracksays	100% of the loose peagravels are lost	Washed away by rain & also removed by tyres.	Althrough A complete	100% of the loose pea gravels are lost.	Washed away by rain &also removed by tyre.	Althrough A complete tracksays	100% of the loose pea-gravels are lost	Washed away by rain and also removed by tyres.
		-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-
...5m ...2 ...	Coated peagravels are lost scatteredly.	410-425 440-450 450-475	15mx0.25m 10mx0.50m 25mx0.20m	Coated peagravels are lost scatteredly.	410-425 440-450 450-475	15mx0.25m 10mx0.20m 25mx0.20m	Coated pea gravels are lost scatteredly.	410-425 440-450 450-475	15mx0.25m 10mx0.20m 25mx0.20m	Coated pea-gravels are lost scatteredly.
...x30m	Like tyre mark.	400-415 R 480-495RHLS	15mx0.40mx30mm 15mx0.5mx30mm	Like tyre mark.	400-415R 480-495m RHS	15mx0.40mx30mm 15mx0.5mx30mm	Like tyre mark.	400-415R 480-495RHS	15mx0.40mx30mm 15mx0.5mx30mm	Like tyremark
		-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-
		400-415RH 480-495RH	15mx0.4mx30mm 15mx0.5mx30mm	-	-	-	-	-	-	-
...30mm		-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-
...ful	For less compaction and excessive rain No change from previous obser	Scattered	Not harmful	For less compaction and excessive rains No change from previous observation	Scattered	Not harmful	For less compaction & excessive rains.No change from previous observation.	Scattered	Not harmful	For less compaction & excessive rains. No change from previous observation.
				-			-			-
				-			-			-
...red ...	Turging is good.	Right slope	Now covered all areas	Turfing is good.	Right slope	Now covered all areas.	Turfing is good.	Right slope	Now covered all areas	Turfing is good.

123

ROAD SURFACING TRIAL PROJECT, RAJBARI

MONITORING PROGRAMME:
RECORD OF OBSERVATIONS IN TYPE - 3

	Sl No	Type of deterioration	Date of observation: July 1986			Date of observation: August 1986			Date of observat	
			Location	Measurement of deteriora-tions	Remarks/ possible reasons, etc	Location	Measurement of deteriora-tions	Remarks/ possible reasons,etc	Location	Measur-tions
A-PAVEMENT	A.1	Local depression								
	A.2	Wavy surface								
	A.3	Spongy surface								
	A.4	Surface cracking				500-550 Scattered			Althrough & scatte-redly	100mx2m
	A.5	Loss of-peagravels from surface								
	A.6	Pot holes								
	A.7	Water accumulation								
	A.8	Others	Scattered	Several spots of very small area	Painting is damaged due to oil droping & also by people	Scattered	Several spots of very small area	Painting is damaged due to oil dropping & also by people. Previously damaged spots have been repaired.	Scatterdly at 500-550, 550-580 LHS 550-600 RHS	Sev and ver ame
B-SHOULDER	B.1	Local depression								
	B.2	Wavy surface	0.500 to 0.550 RHS	50mx0.75m	Due to repair of damaged shoulder by loose materials	520-550 RHS	50mx0.75m	Due to repair of damaged shoulder by loose materials. No change from previous observation.	520-550RHS	50mx0.75m
	B.3	Spongy surface								
	B.4	Surface cracking								
	B.5	Pot holes								
	B.6	Water accumulation								
	B.7	Erosion of edge				575-595m RHS	-	Due to severe rain cut	570-595m RHS	-
	B.8	Others	0.520 to 0.560 LHS	40mx0.75m	Aggregates are exposed due to washing away of top soil	500-600 LHS	40mx0.75m	Agg. are exposed due to washing away of top soil and ingredients.	500-600LHS & RHS	100mx0.75m in each si
C-SLOPE	C.1	Rain cuts	Scattered 570-580RHS	Moderate severe	For less compaction and excessive rain	Scattered 550-595m RHS	Moderate Severe	For less compaction and excessive rains	Scattered Althrough 590-595RHS	Moderate severe
	C.2	Sliding								
	C.3	Rat holes								
	C.4	Fox holes								
	C.5	Others	Scattered	-	Turfing is Not good	Scattered	-	Turfing is not good	Althrough	Turfing has improved

tion: September 1986		Date of observation: Oct 1986			Date of observation: Nov 1986			Date of observation: December 1986		
rement teriora-	Remarks/ possible reasons, etc	Location	Measurement of deteriorations	Remarks/ possible reasons, etc	Location	Measurement of deteriorations	Remarks/ possible reasons, etc	Location	Measurement of deteriorations	Remarks/ possible reasons, etc
		-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-
.2m	Surface painting has been cracked due to settlement in the pavement also due to inconsistent quality of emulsion.	Although and scatteredly	100mx2m	Surface painting has been cracked due to settlement in pavement also due to inconsistant quality of emulsion.	Although and scatteredly.	100mx2mm	Surface painting has been cracked due to settlement in the pavement also due to inconsistant quality of emulsion.	Although scatteredly	100mx0.2m	Surface painting has been cracked due to settlement in the pavement also due/inconsistant quality of emulsion.
		-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-
Several spots of very small area	Painting is damaged due to oil dropping & also by people	Scatteredly at 500-550 550-580LHS 550-600RHS	Several spots of very small area.	Painting is damaged due to oil droping & also by people	Scatteredly at 300-550, 550-580LHS 550-600RHS	Several spots of very small area.	Painting is damaged due to oil dropping & also by people. Patch repair to a few spots has been done.	Scatteredly at 500-550 550-580LHS 550-600RHS	Several spots of very small area.	Painting is damaged due to oil dropping &also by people.Patch repair to a few spots has been done.
		-	-	-	-	-	-	-	-	-
0.75m	Due to repair of damaged shoulder by loose materials. No change from previous observation.	520-550RHS	50mx0.75m	Due to repair of damaged shoulder by loose materials.Appeared to be more loose & dusty.	520-550RHS	50mx0.75m	Due to repair of damaged shoulder by loose materials.Appeared to be more loose & dusty	520-550RHS	50mx0.75m	Due to repair of damaged shoulder by loose materials.Appeared to be more loose & dusty
		-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-
-	Due to sever rain cut	570-595m RHS	-	Due to severe raincuts	570-595RHS	-	Due to severe rain cut.	570-595RHS	-	Due to severe rain cut
mx0.75m each side	Agg. are exposed due to washing away of top soil and sand ingredients.	500-600m LHS+RHS	100mx0.75m in each side	Agg. are exposed due to washing away of top soil and sand ingredients.	500-600 LHS+RHS	100mx0.75m in each side.	Agg. are exposed due to washing away of top soil and sand ingredients.	500-600LHS	100mx0.75m in each side	Agg. are exposed due to washing away of top soil & sand ingredients
derate vere	For less compaction & excessive rains	Although scatteredly 550-595RHS	Moderate severe	For less compaction & excessive rains	Although scatteredly 550-595RHS	Moderate Severe	For less compaction & excessive rains.	Although scatteredly 550-595RHS	Moderate severe	For less compaction and excessive rains
		-	-	-	-	-	-	-	-	-
		530-540LHS	Moderate		530-540LHS	Moderate	-	530-540LHS	Moderate	-
		-	-	-	-	-	-	-	-	-
rfing has proved	Turfing is now almost is good	Although	Turfing has been improved	Turfing is now almost good	Although	Turfing has been improved	Turfing is now almost good.	Although	Turfing has been improved	Turfing is now almost good.

ROAD SURFACING TRIAL PROJECT, RAJBARI

MONITORING PROGRAMME:
RECORD OF OBSERVATIONS IN TYPE - 6

	Sl No	Type of deterioration	Date of observation: July 1986			Date of observation: August 1986			Date of observation: September		
			Location	Measurement of deteriorations	Remarks/ possible reasons, etc	Location	Measurement of deteriorations	Remarks/ possible reasons,etc	Location	Measurement of deteriorations	Remarks/ possible reasons,
A-PAVEMENT	A.1	Local depression									
	A.2	Wavy surface									
	A.3	Spongy surface									
	A.4	Surface cracking							630-650	Scatteredly	
	A.5	Loss of peagravels from surface	Trackways	40-60% of the loose pea-gravels are lost	washed away by rain and also by tyres	Althrough a complete trackways	More than 80% of the loose pea gravels are lost	Washed away by rain and also by tyres	Althrough	100% of the loose pea-gravels are lost	Washed rain an by tyre
	A.6	Pot holes									
	A.7	Water accumulation									
	A.8	Others							Scatteredly at 630-650 680-690	$3m^2$ $3m^2$	Coated gravels surface asing a
B-SHOULDER	B.1	Local depression				600-615LHS 600-615RHS	15mx0.5mx30mm 15mx0.5mx30mm	-	600-615LHS 600-615RHS	15mx0.5mx30mm 15mx0.5mx30mm	
	B.2	Wavy surface									
	B.3	Spongy surface									
	B.4	Surface cracking									
	B.5	Pot holes									
	B.6	Water accumulation				600-615LHS 600-615RHS	15mx0.5mx30mm 15mx0.5mx30mm	-	600-615mLHS 600-615mRHS	15mx0.5x30mm 15mx0.5mx30mm	
	B.7	Erosion of edge	0.660 LHS 0.667 RHS	-	Due to severe rain cuts	660 LHS 640-670RHS	-	Due to sever rain cuts	600 LHS 640-670RHS		Due to rain cu
	B.8	Others				Agg. exposed scatteredly	-	Due to washing away of top sand & soil ingredients	Both shoulder	Scatteredly.	Agg. ar sed due washing sand &
C-SLOPE	C.1	Rain cuts	Scattered 640-650RHS 660-667LHS	Not harmful Moderate and few severe	For less compaction and excessive rain	Scattered 640-670RHS 640-670LHS	Not harmful Moderate and few severe	For less compaction and excessive rains	Scattered 640-670RHS	Not harmful Moderate and few severe	For les nation excessi
	C.2	Sliding									
	C.3	Rat holes									
	C.4	Fox holes									
	C.5	Others	Scattered	-	Turfing is not good	Scattered	-	Turfing is not good	Althrough	Turfing has improved	Almost

ervation: September 1986		Date of observation: Oct 1986			Date of observation: Nov 1986			Date of observation: December 1986		
easurement f deteriora-ions	Remarks/ possible reasons, etc	Location	Measurement of deteriora-tions	Remarks/ possible reasons, etc	Location	Measurement of deteriora-tions	Remarks/ possible reasons, etc	Location	Measurement of deteriora-tions	Remarks/ possible reasons, etc
		-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-
atteredly		500-625HIS 625-650 LH 670-685HIS 685-692LHS	Scatteredly	-	600-625HIS 625-650LH 670-685HIS 685-692LHS	Scatteredly	-	600-625HIS 625-650LH 670-685HIS 685-692LHS	Scatteredly	-
00% of the ose pea-gra-ls are lost.	Washed away by rain and also by tyres.	Althrough	100% of the loose pea-gra-vels are lost.	Washed away by rain and also by tyres.	Althrough	100% of the loose pea-gra-vels are lost.	Washed away by rain and also by tyres.	Althrough	100% of the loose pea-gra-vels are lost.	Washed away by rain and also by tyres.
		-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-
m^2 m^2	Coated pea-gravels from surface dre-sing are lost.	Scatteredly 530-650 580-690	$3m^2$ $3m^2$	Coated peagra-vels from surface dress-ing are lost	Scatteredly at 630-650 680-690	$3m^2$ $3m^2$	Coated pea gravels from surface dres-sing are lost	-	-	-
m x0.5m x30mm m x0.5m x30mm		600-615LHS 600-615HHS	-	15mx0.5mx30mm 15mx0.5mx30mm	600-615LHS 600-615HHS 685-692LHS	15mx0.5mx30mm 15mx0.5mx30mm 7mx0.75mx40mm	-	[illegible] 600-615HHS 685-692LHS	15mx0.5mx30mm 15mx0.5mx30mm 7mx0.75mx40mm	
		-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-
m x0.5x30mm m x0.5mx30mm		600-615LHS 600-615HHS	15mx0.5mx30mm 15mx0.5mx30mm		-	-	-	-	-	-
	Due to severe rain cuts	660 LHS 640-670HHS		Due to severe rain cuts.	0+660LHS 640-670HHS	-	Due to severe rain cuts.	[illegible] 640-670HHS	-	Due to severe rain cuts
atteredly.	Agg. are exposed due to washing away of sand & soil ingr	Both shoulder	Scatteredly	Agg. are exposed due to washing away of top sand & soil ingredients	Both shoulder	Scatteredly	Agg. are exposed due to washing away of top sand & soil ingredients	Both shoulder	Scatteredly	- Exposed agg. are covered with turfing
harmful derate and severe	For less com-paction and excessive rains	Scattered 640-670LHS	Not harmful Moderate and a few severe	For less com-paction and excessive rains	Scattered 640-670HHS	Not harmful Moderate and a few severe	For less compaction & excessive rains	Scattered 640-670HHS	Not harmful Moderate and a few severe	For less com-paction and excessive rains
		-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-
fing has roved	Almost good	Althrough	Turfing has been improved	Almost good	Althrough	Turfing has been improved	Almost good	Althrough	Turfing has been improved	Almost good

ROAD SURFACING TRIAL PROJECT, RAJHARI

MONITORING PROGRAMME:
RECORD OF OBSERVATIONS IN TYPE - 7

	Sl No	Type of deterioration	Date of observation: July 1986			Date of observation: August 1986			Date of observation: Septem		
			Location	Measurement of deteriora-tions	Remarks/ possible reasons, etc	Location	Measurement of deteriora-tions	Remarks/ possible reasons, etc	Location	Measurement of deteriora-tions	Rem pos rea
A-PAVEMENT	A.1	Local depression							710-730LR 750-770LR 780-795LR	20mx0.5m 20mx0.5m 15mx0.5m	Alo way
	A.2	Wavy surface									
	A.3	Spongy surface							Scatteredly	30mx0.5m	Rot
	A.4	Surface cracking				Scattered	-	Hair cracks	Althougha Scatteredly	100mx1.5m	Hai
	A.5	Loss-of pegravels from surface									
	A.6	Pot holes									
	A.7	Water accumulation						Painting is damaged due to oil droping & also by people.			
	A.8	Others	700-720 760-770	Several spots of very small areas	Painting is damaged due to oil droping & also by people	700-720 760-775	Several spots of very small areas	Patch repair has been done but not properly	700-750 750-800	Scatteredly at several spots of approx. 30m²	Pai dam oil nla
B-SHOULDER	B.1	Local depression				785-795RHS 790-800LHS	10mx0.5mx30mm 10mx0.5mx30mm	-	735-770LHS 785-795RHS 790-800LHS	15mx0.5mx40mm 10mx0.5mx30mm 10mx0.5mx30mm	
	B.2	Wavy surface									
	B.3	Spongy surface									
	B.4	Surface cracking									
	B.5	Pot holes									
	B.6	Water accumulation				785-795RHS 790-800LHS	10mx0.5mx30mm 10mx0.5mx30mm	-	-do-	-do-	
	B.7	Erosion of edge							700-750RHS	Scatteredly	Due t rain
	B.8	Others				725-800LHS Scatteredly on RHS	75mx0.5m	Agg. are exposed due to washing away of soil & sand ingredients	725-800LHS Scatteredly on RHS	75mx0.5m 30mx0.5m	Agg. due t away incr
C-SLOPE	C.1	Cuts	Scattered	Moderate and few severe	For less compaction and excessive rain	700-750RHS 750-800LHS	Many scattered moderate rain cuts but few severe. Shoulder edge is being eroded	-	700-750RHS 750-800LHS	Many scattered moderate rain cuts but few severe, shoulder edge is being eroded.	
	C.2	Sliding									
	C.3	Rat holes									
	C.4	Fox holes									
	C.5	Others	Scattered	-	Turfing is not good	Scattered	-	Turfing is not good	Although	Turfing has improved	Now also

ion: September 1986		Date of observation: Oct 1986				Date of observation: November 1986			Date of observation: December 1986		
ement eriora-	Remarks/ possible reasons, etc	Location	Measurement of deteriora-tions	Remarks/ possible reasons, etc	Location	Measurement of deteriora-tions	Remarks/ possible reasons, etc	Location	Measurement of deteriora-tions	Remarks/ possible reasons, etc
	Along track-way	710-730LH 750-770LH 780-795LH	20mx0.5mx15m 20mx0.5mx10m 15mx0.5mx10m	Along track-way			1) Depressions have been repaired by LGEB.			1) Depressions have been repaired by LGEB
	Both trackways						11) Surface has been treated althrough with hot bitumen and peagravels			11) Surface has been treated althrough with hot bitumen and pea-gravels
5m	Hair cracks	Althrough and scatteredly	100mx1.5m	Hair cracks						
edly at spots, 2 x.30m	Painting is damaged due to oil droping & also by people	700-750 750-800	Scatteredly at several spots appox.30m² area	Painting is damaged due to oil droping & also by people						
x40mm x30mm x30mm		755-770LHS 785-795RHS 790-800LHS	15mx0.5mx40mm 10mx0.5mx30mm 10mx0.5mx30mm		755-770LHS 785-795RHS 790-800LHS	15mx0.5mx40mm 10mx0.5mx30mm 10mx0.5mx30mm	-	755-770LHS 785-795RHS 790-800LHS	15mx0.5mx40mm 10mx0.5mx30mm 10mx0.5mx30mm	
dly	Due to severe rain cut	755-770LHS 785-795RHS 790-800LHS 700-750RHS	15mx0.5mx40mm 10mx0.5mx30mm 10mx0.5mx30mm Scatteredly	Due to severe rain cut	700-750RH	Scatteredly	Due to severe rain cut.	700-750RHS	Scatteredly	Due to severe raincut.
	Agg.are exposed due to washing away of soil & sand ingredients.	725-800LHS Scatteredly on RHS	75mx0.5m 50mx0.5m	Agg.are exposed due to washing away of soil & sand ingredients	725-800LHS Scattered-ly on RHS	75mx0.5m 50mx0.5m	Agg.are exposed due to washing away of soil & sand ingredients.	725-800LHS scatteredly on RHS	75mx0.5m 50mx0.5m	Agg.are exposed due to washing away of soil & sand ingredients
ttered rain few houlder being		700-750RHS 725-750LHS 750-800LH	Many scattered moderate rain cuts but few severe,shoulder edge is being eroded.		700-750RHS 725-750LHS 750-800LH	Many scattered moderate rain cuts but few severe,shoulder edge is being eroded.		700-750RHS 725-750LHS 750-800LH	Many scattered moderate rain cuts but few severe,shoulder edge is being eroded.	
has	Now turfing is almost good	Althrough	Turfing has been improved	Now turfing is almost good.	Althrough	Turfing has been improved	Now turfing is almost good.	Althrough	Turfing has been improved	Now turfing is almost good

ROAD SURFACING TRIAL PROJECT, RAJBARI

MONITORING PROGRAMME:
RECORD OF OBSERVATIONS IN TYPE - 8

	Sl No	Type of deterioration	Date of observation: July 1986			Date of observation: August 1986			Date of observation: September 1986		
			Location	Measurement of deteriorations	Remarks/ possible reasons, etc	Location	Measurement of deteriorations	Remarks/ possible reasons, etc	Location	Measurement of deteriorations	Remarks/ possible reasons, etc
A-PAVEMENT	A.1	Local depression	820-840L 897-900R	20mx0.25mx15mm 3mx0.5mx15mm	Along the edging	820-840LHS 895-900RHS	20mx0.25mx15mm 3mx0.5mx15mm-20mm	Along the edging	820-840 L 890-900 R	20mx0.25mx15mm 10mx0.5mx15mm--20mm	Along the edging
	A.2	Wavy surface									
	A.3	Spongy surface									
	A.4	Surface cracking									
	A.5	Loss of peagravels from surface	Track ways	50% of loose pea-gravels are lost	Washed way by rain and also by tyres	Trackway and althrough	80% of loose pea-gravels are lost	Washed way by rain and also by tyres	Althrough	100% of loose pea-gravels are lost.	Washed way by rain and also by tyres.
	A.6	Pot holes									
	A.7	Water accumulation									
	A.8	Others							Scatteredly 840-850 & 850-900	Appox. 5m²	Coated pea-gravels from surface dressi has been lost.
B-SHOULDER	B.1	Local depression				860 LHS 800-805LHS	5mx0.5mx30mm 10mx0.5mx40mm	-	800-810 830-850LHS 855-865LHS	10mx0.5mx30mm 20mx0.5mx40mm 10mx0.5mx40mm	
	B.2	Wavy surface									
	B.3	Spongy surface									
	B.4	Surface cracking									
	B.5	Pot holes									
	B.6	Water accumulation				860 LHS 800-805LHS	5mx0.5mx30mm 10mx0.5mx40mm				
	B.7	Erosion of edge							-do-	-do-	
	B.8	Others									
C-SLOPE	C.1	Rain cuts	Scattered	Moderate and few severe	Due less compaction and excessive rain	Scattered 800-850LHS	Moderate May moderate & few severe	Due to less compaction, excessive rains	Scattered 800-850LHS	Moderate, Many moderate & few severe	Due to less compaction, unevenness & excessive rain
	C.2	Sliding									
	C.3	Rat holes									
	C.4	Fox holes									
	C.5	Others	Scattered	-	Turfing is not good	Scattered	-	Turfing is not good	Althrough	Turfing has improved	Now almost good.

ber 1986	Date of observation: Oct 1986			Date of observation: Nov 1986			Date of observation: December 1986		
arks/ sible sons, etc	Location	Measurement of deteriora-tions	Remarks/ possible reasons, etc	Location	Measurement of deteriora-tions	Remarks/ possible reasons, etc	Location	Measurement of deteriora-tions	Remarks/ possible reasons, etc
ng the ing	820-840 L 890-900 R	20mx0.25mx15mm 10mx0.5mx15mm-20mm	Along the edging.	820-840L 890-900R	20mx0.25mx15mm 10mx0.5mx15mm-20mm	Along the edging.	820-840 L 890-900 R	20mx0.25mx15mm 10mx0.5mx15mm-20mm	Along the edging
	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-
ned way by n and also tyres.	Although	100% of loose pea-gravels are lost.	Washed way by rain and also by tyres.	Although	100% of loose pea gravels are lost.	Washed way by rain and also by tyres.	Although	100% of loose pea-gravels are lost	Washed way by rain and also by tyres.
	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-
ated pea-avels from rface dressi s been lost.	Scatteredly at 840-850 & 850-900	Appox.5m²	Coated pea-gravels from surface dressing has been lost.	Scattere-dly at 840-850 & 850-900	Appox. 5m²	Coated pea-gravels from surface dressing has been lost	-	-	-
	800-810LHS 830-850LHS 855-865LHS	10mx.5mx30mm 20mx.5mx40mm 10mx.5mx40mm		800-810LHS 830-850LHS 855-865LHS 880-900LHS 870-880HHS	10mx0.5mx30mm 20mx0.5mx40mm 10mx0.5mx40mm 20mx0.5mx40mm 10mx0.5mx30mm	-	800-810LHS 830-850LHS 855-865LHS 880-900LHS 870-880HHS	10mx0.5mx30mm 20mx0.5mx40mm 10mx0.5mx40mm 20mx0.5mx40mm 10mx0.5mx30mm	
	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	
	800-810LHS 830-850LHS 855-865LHS	10mx.5mx30mm 20mx.5mx40mm 10mx.5mx40mm		-	-	-	-	-	
	-	-	-	-	-	-	-	-	
e to less mpaction, evenness & cessive rain	Scattered 800-850LHS	Moderate.Many moderate & a few severe	Due to less compaction, unevenness & excessive rain	Scattered 800-850LHS	Moderate Many moderate & a few severe	Due to less compaction unevenness & excessive rain.	Scattered 800-850LHS	Moderate.Many moderate and a few severe	Due to less compaction unevenness and excessive rain
	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-
w almost od.	Although	Turfing has been improved	Now almost good.	Although	Turfing has been improved	Now almost good.	Although	Turfing has been improved	Now almost good.

ROAD SURFACING TRIAL PROJECT, RAJHARI

MONITORING PROGRAMME:
RECORD OF OBSERVATIONS IN TYPE - 9

	Sl No	Type of deterioration	Date of observation: July 1986			Date of observation: August 1986			Date of observation: September		
			Location	Measurement of deteriorations	Remarks/ possible reasons, etc	Location	Measurement of deteriorations	Remarks/ possible reasons,etc	Location	Measurement of deteriorations	Remar possi reaso
A-PAVEMENT	A.1	Local depression	900-940R 965-968R	40mx0.5mx20mm 3mx0.25mx15mm	Along the edging	900-945R 960-970L	45mx0.5mx20mm 10mx0.25mx15mm	Along edging	900-950LR 950-980 R	2x50mx0.5mx10 30mx0.25mx50mm	Along way
	A.2	Wavy surface									
	A.3	Spongy surface									
	A.4	Surface cracking	900-940 965-968	40mx1.5m 3mx0.75m	Several scatt. spots along middle strip Along right track way	900-950 960-970R	50mx1.5m 5mx0.75m	Several scatt. spots althrough Along right trackway	900-950 950-1+000	50mx2m 2x50x0.5	Althr Along ways
	A.5	Loss of peagravels from surface	990-1+000	10mx0.5m	Along both edging	985-1000R 965-1000L	15mx0.5m 35mx0.5m	Along right edging Along left edging			
	A.6	Pot holes									
	A.7	Water accumulation			Painting is damaged at several spots in middle strip			Painting is damaged at several scattered spots.			
	A.8	Others	900-940 965-968	Very small areas 3mx0.5m	along right track way	900-945 960-970	Very small area 4mx0.5m	Along right trackway	900-950 950-970	2x50mx1m 2x30mx0.5m	Paintin along t along h trackwa
B-SHOULDER	B.1	Local depression	950-965L 965-968R	15mx0.4mx30mm 3mx0.5mx30mm		950-965L 965-968R 970-990LMS	15mx0.4mx30mm 3mx0.5mx30mm 20mx0.4mx30mm	-			
	B.2	Wavy surface							940-990L 950-980R	50mx0.4mx40mm 30mx0.5mx40mm	
	B.3	Spongy surface									
	B.4	Surface cracking									
	B.5	Pot holes									
	B.6	Water accumulation	950-965L 965-968R	15mx0.4mx30mm 3mx0.5mx30mm		950-965L 970-990L 965-968R	15mx0.4mx30mm 20mx0.4mx30mm 3mx0.5mx30mm	-	940-995L 950-980R	50mx0.4mx40mm 30mx0.4mx40mm	
	B.7	Erosion of edge									
	B.8	Others				Scattered	-	Aggr. are exposed mostly on right shoulder	Althrough	Scatteredly	Agg. are sed most right sh
C-SLOPE	C.1	Rain cuts	Scattered	Moderate	For less compaction, unevenness & excessive rain	Scattered	Moderate	For less compaction, unevenness and excessive rains	Scattered	Moderate	For less paction, nnes & e. rain
	C.2	Sliding									
	C.3	Rat holes									
	C.4	Fox holes									
	C.5	Others	Scattered	Not good	Turfing	Scattered	Not good	Turfing	Althrough	Turfing has improved	Turfing i almost go

eptember 1986	Date of observations: Oct 1986			Date of observations: November 1986			Date of observations: December 1986		
Remarks/ possible reasons, etc	Location	Measurement of deteriorations	Remarks/ possible reasons, etc	Location	Measurement of deteriorations	Remarks/ possible reasons, etc	Location	Measurement of deteriorations	Remarks/ possible reasons, etc
Along Track-ways Althrough Along track ways Painting is dag along both trac along both trackways			Top layer of base course has been removed for repairing			i) Damaged base course has been repaired by LGEB. ii) Surface has been treated althrough with hot bitumen & peagravels			1) Damaged base course has been repaired by LGEB. 2) Surface has been treated althrough with hot bitumen and peagravels
Agg. are exposed mostly on right shoulder			Could not be ascertained as pick-dup materials are damaged on shoulder			Depressions have been repaired but not satisfactory			Depressions have been repaired but not satisfactory
For less compaction, unevennes & excessi rain	Scattered - - -	Moderate - - -	For less compaction, unevennes & excessive rain - - -	Scattered - - -	Moderate - - -	For less compaction, unevennes & excessive rains - - -	Scattered - - -	Moderate - - -	For less compaction, unevennes & excessive rain. - - -
Turfing is now almost good.	Althrough	Turfing has been improved	Turfing is now almost good.	Althrough	Turfing has been improved	Turfing is now almost good.	Althrough	Turfing has been improved	Turfing is now almost good.

ROAD SURFACING TRIAL PROJECT, RAJBARI

MONITORING PROGRAMME:
RECORD OF OBSERVATIONS IN TYPE -10

	Sl No	Type of deterioration	Date of observation: July 1986			Date of observation: August 1986			[illegible]
			Location	Measurement of deteriorations	Remarks/ possible reasons, etc	Location	Measurement of deteriorations	Remarks/ possible reasons, etc	Location
A-PAVEMENT	A.1	Local depression				1+088 to 1+100 LHS	12mx1.0mx15 to 50mm	-	1+065 to 1+077 LHS 1+085 to 1+100 LHS 1+070 to 1+100 RHS
	A.2	Wavy surface							
	A.3	Spongy surface				1+088 to 1+100 LHS	12mx1.0mx15 to 50mm	-	Althrough/ mostly on trackways
	A.4	Surface cracking							
	A.5	Loss of peagravels from surface	Track ways	60% of loose pea-gravels are lost	washed way by rain and also by tyres	Althrough	100% of loose pea-gravels are lost	Washed way by rain and also by tyres	Althrough
	A.6	Pot holes				1+090 to 1+093LHS	3mx1mx(15-50mm)	On left trackway	
	A.7	Water accumulation							1+065 to 1+077 LHS 1+085 to 1+100
	A.8	Others							1+070 to 1+100 RHS.
B-SHOULDER	B.1	Local depression	1+050 to 1+100 L	50mx0.4mx30mm		1+050 to 1+100L	50mx0.4mx 30-50mm	-	1+000 to 1+020 LHS 1+050 to 1+100 L
	B.2	Wavy surface							
	B.3	Spongy surface							
	B.4	Surface cracking							
	B.5	Pot holes							
	B.6	Water accumulation	1+050 to 1+100 L	50mx0.4mx30mm		1+050 to 1+100L	50mx0.4mx 30-50mm	-	1+000 to 1+020 LHS 1+050 to 1+100 L
	B.7	Erosion of edge							
	B.8	Others							
C-SLOPE	C.1	Rain cuts	Scattered	Moderate	For less compaction, unevenness & excessive rain	Scattered	Moderate	For less compaction, unevenness and excessive rains	
	C.2	Sliding							
	C.3	Rat holes							
	C.4	Fox holes							
	C.5	Others	Scattered	Not good	Turfing	Scattered	Not good	Turfing	Althrough

...ion	...observation: September 1986		Date of observation: Oct 1986			Date ... observation: Nov 1986			Date of observation: December 1986		
	Measurement of deteriorations	Remarks/ possible reasons, etc	Location	Measurement of deteriorations	Remarks/ possible reasons, etc	Location	Measurement of deteriorations	Remarks/ possible reasons, etc	Location	Measurement of deteriorations	Remarks/ possible reasons, etc
te LHS to LHS to RHS	12mx0.5mx30-50mm 15mx1.0mx30-75mm 30mx0.5mx30-50mm	Along trackways	-	-	Top layer of base course has been removed from this area.	-	-	Top layer of base course has been repaired in this area but not satisfactory.	-	-	The repaired portion has been treated with hot bitumen and pea-gravels. But untreated strips of Agg. stabilised base are visible.
			-	-	-	-	-	-	1000-1040L	-	
...ugh & / on ...ays	50mx1.5m		1000-1040L & scatterly on right trackways	40mx1.0m	-	1000-1040L & scatterely on right trackway	40mx1.0m	-	1000-1040L and scatterely on right trackways.	40mx1.0m	
...ugh	100% loose pea-gravels are lost.	Washed way by rain and also by tyres.	Although	100% of loose pea-gravels are lost.	Washed way by rain & also by tyres.	Although	100% of loose pea-gravels are lost.	Washed way by rain and also by tyres.	Although	100% of loose pea-gravels are lost.	Washed away by rain and also by tyres.
			-	-	-	-	-	-	-	-	-
			-	-	-	-	-	-	-	-	-
te LHS to	12mx0.5mx(25-50mm) 15mx0.75mx(50-100mm) 30mx0.5mx25-50mm)		-	-	-	-	-	-	-	-	-
to RHS. to LHS to L	50mx0.4mx30-50mm		1000-1020L 1050-1100L 1040-1050R 1010-1025R	20mx0.5mx30-50mm 50mx0.4mx30-50mm 10mx0.4mx40mm 15mx0.4mx40mm		1000-1020L 1050-1080L 1040-1050R 1010-1025R	20mx0.5mx30-50mm 50mx0.4mx30-50mm 10mx0.4mx40mm 15mx0.4mx40mm	-	1000-1020L 1050-1100L 1040-1050R 1010-1025R	20mx0.5mx30-50mm 10mx0.4mx40mm 15mx0.4mx40mm	
			-	-	-	-	-	-	-	-	
			-	-	-	-	-	-	-	-	
			-	-	-	-	-	-	-	-	
			-	-	-	-	-	-	-	-	
te LHS to L	20mx0.5mx30-50mm 50mx0.4mx30-50mm		1000-1020L 1010-1025R 1040-1050R 1050-1100L	20mx0.5mx30-50mm 15mx0.4mx40mm 10mx0.4mx40mm 50mx0.4mx30-50mm	-	-	-	-	-	-	
			-	-	-	-	-	-	-	-	
			-	-	-	-	-	-	-	-	
-			Scattered	Moderate	For less compaction, unevenness & excessive rain	Scattered	Moderate	For less compaction, unevenness & excessive rain.	Scattered	Moderate	For less compaction, unevenness & excessive rain
			-	-	-	-	-	-	-	-	-
			-	-	-	-	-	-	-	-	-
			-	-	-	-	-	-	-	-	-
...ugh	Turfing has improved	Now almost good	Although	Turfing has been improved	Turfing is now almost good.	Although	Turfing has been improved	Turfing is now almost good.	Although	Turfing has been improved	Turfing is now almost good.

Road Surfacing Trial Project, Rajbari

SUMMARY OF TRAFFIC SURVEY ON RAJBARI-BALIAKANDI ROAD

Point of Count: 9 km from Rajbari towards Baliakandi

Date	Commercial Vehicles					Other than Commercial Vehicles							Remar
	Trucks		Bus		Total Com. Vehicle	Pickup Van	Car Jeep etc	Motor cycle	Bi-cycle	Rick-shaw	Animal cart	Total other than com.vehicle	
	3^T	5^T	Small	Big									
21 08 86	-	7	-	39	46	-	-	50	118	67	43	278	
22 08 86	-	22	-	36	58	-	-	50	105	88	45	288	
23 08 86	-	18	-	33	51	-	-	46	95	74	27	242	
24 08 86	-	6	-	37	43	-	1	51	119	87	32	290	
25 08 86	-	10	-	35	45	-	7	37	115	70	21	250	
Daily Average =					49		2					270	

(3)

Road Surfacing Trial Project, Rajbari

LOCATION AND RL OF FLOOD LEVEL GAUGES AND GI STANDPIPES

Station	Chainage	Distance from CL of Pavement		RL on			
		FL Gauge	GI Standpipe	Base of FL Gauge		Top of GI Standpipe	
				As-built**	Monitored*	As-built**	Monitored*
I	0+196.5m	17.52m left	3.5m left	13.006	13.015	16.411	16.348
II	0+700m	14.65m right	3.45m right	14.143	16.603	16.600	16.600
III	1+039.5m	10.97m left	3.5m right	13.992	13.990	16.200	16.196

* Monitored elevations as on December, 1986

** Period of installations of FL gauges and GWT pipes was June, 1986.

Road Surfacing Trial Project, Rajbari

GENERAL COMMENTS FROM MONTHLY MONITORING REPORTS

1.0 FIRST MONITORING REPORT: MONITORING PERIOD 26/07/1986 TO 31/07/1986

a) The Road Surfacing Trial Project was visited by the Consultants jointly with Mr B Mollar, FO (Engg), IRWP, Faridpur on 27 Jul 1986 and discussed about the different types in details and monitoring works. Also meet Executive Engineer (XEN) (FR), IRWP on 30 Jul 1986 at the office of XEN, LGEB, Rajbari. Discussions have been made regarding maintenance work and monitoring of pavement deteriorations, specially regarding way of measuring depressions.

b) All chainage marker pegs were missing. Small pegs of splitted bamboo have been arranged by the Consultants' staff and fixed at every 25m interval to facilitate in taking levels.

c) No sign of maintenance activities has been noticed during the week the Consultants' staff was at site. Also, Contractor's representatives were not available at site for giving instructions regarding repair and maintenance.

d) Damaged spots of surface painting, depressions on shoulder and rain cuts on slopes need to be repaired immediately because timely repair will prevent the pavement from further deterioration and also reduce maintenance cost.

e) To compare the maintained and non-maintained areas, all kinds of repair work as the situation warrants, must be done and for this it is necessary that the Contractors use emulsion wherever required. It is the contractual obligation for the Contractors to repair, maintain and rectify any/all types of defects in the works upto one year from the date of completion of the works (Ref: Clause 9, Special Terms and Conditions of Tender Document).

2.0 SECOND MONITORING REPORT: MONITORING PERIOD 19/08/1986 TO 28/08/1986

a) The road surfacing trial project was visited jointly with Mr B Moller, FO (Engg), IRWP, Faridpur and XEN, LGER, Rajbari in the forenoon of 24 Aug 1986. It was also visited by XEN, FR, IRWP, Dhaka in the afternoon on the same day accompanied by the Consultants' staff. Discussions were made at site and later in the office of XEN, LGER, Rajbari regarding maintenance work, monitoring of pavement deteriorations and traffic survey.

b) Inspite of repeated requests, Contractors have not fixed the chainage marker pegs.

c) Patch repair of damaged painting in Types 5, 7 and 9 has been done by the Contractors before the visit of the Consultants but the repair works were not satisfactory. Also there were no signs of maintenance and repair activities on shoulders and slopes. Contractor's representatives were not available at site during the monitoring period for receiving instructions regarding repair and maintenance.

d) No record is being maintained for repair and maintenance work for which it will not be possible to work out the maintenance cost. But, for comparison, cost involvement is an important factor.

e) Due to ponding of water in the depressions on shoulders, a spot on the pavement in Type 10 (Ch. 1+090 to 1+093 LHS) has been badly damaged and it may further deteriorate. This depression on the shoulder was observed during the previous monitoring period but it was in the area decided to be left without maintenance. Had it been repaired immediately and maintained in proper condition, this damage of pavement could have been avoided. The repair cost would have been low.

f) To have a better comparison between the maintained and non-maintained areas, damaged spots of surface painting, depressions on shoulder and rain cuts on slopes in the maintained areas need to be repaired timely and properly with record of measurement of work and cost involved.

g) The overall pavement in all types has settled by about 20mm on average from the as-built level, but the condition of the pavement, in general, except in a few weak spots, is good.

h) The joint sealing by asphalt emulsion in HBB pavement seems to have been ineffective.

i) Traffic survey has been conducted in this off-season to have a comparison regarding traffic volume and its growth as the initial traffic survey was also conducted during the same time last year.

3.0 THIRD MONITORING REPORT: MONITORING PERIOD 27/09/1986 TO 08/10/1986

a) The Consultants met Mr P Moller, FO (Engg), IRWP Faridur at his office on 30 Sept 1986 where discussions took place regarding marking the levelling spots and fixing pegs so that the levels will be taken exactly on those defined spots to exhibit the actual picture of variation in levels. Regarding black and white photographs in the monitoring report, the Consultants informed that it has been done as per agreement made at the time of the 1st monitoring period.

b) The road surfacing trial project was visited jointly with the Executive Engineer, LGED, Rajbari on 01 Oct 1986. Discussions were made with him on site and at his office regarding maintenance of RSTP works and about deterioration of the pavement of Types 7, 9 and 10. The Consultants expressed dissatisfaction on the poor maintenance activities and also explained that if the surface cracks, damaged surface painting and depressions are not maintained/repaired immediately and properly, rain water will penetrate into the base and pavement will deteriorate to a great extent. Executive Engineer, LGED, Rajbari informed that the contractors were not responding to his letters about maintenance/repair works. However, Executive Engineer, LGED, Rajbari instructed his SAE to take up the emergent repair work departmentally and accordingly the Consultants outlined the detailed procedures of repair works to the Executive Engineer and his SAE.

c) It should be mentioned here that this monitoring period fell within a period of unusual wet weather where there was continuous heavy rainfall for about a fortnight. During this heavy rainfall water was accumulating in depressions on shoulders and also on many places of pavement, specially on the trackway (Types 9 and 10). Due to lack of maintenance, such accumulating water was penetrating into the base course which increased the moisture content and thus reduced the density and stability. The continued plying of traffic over the same trackways has badly damaged some of the depressed areas in Types 9 and 10 (Ch. 0+900 to 0+975 and 1+085 to 1+100).

d) In this monitoring programme, moisture content has been checked for base and sub-base and granular shoulder of all types of pavement. The water contents of base and sub-base of damaged spots and at the spots where there are surface cracks have been found too high and in some cases near saturation, indicating complete loss of stability. So it is again stressed as

also mentioned earlier that if the maintenance works i.e. sealing of surface cracks and filling depressions on pavement and shoulder to prevent infiltration of rain water are not done timely and properly, the deterioration of pavement will aggravate.

e) During the monitoring period from 27 Sept 08 Oct 1986, no maintenance activities have been noticed by the Consultants although the maintenance works were needed, in general, with special attention to the stretches from Ch. 0+900 to 0+975 and 1+085 to 1+100.

f) Turfing in all the Types 5 to 10 have improved very rapidly during the rains by spreading around and covering the intermittent gaps observed during the last monitoring period.

g) It should be mentioned here that the purpose of monitoring of the project may not be fruitful as maintenance works are not being done properly.

h) Further it may be mentioned that a special joint inspection of the RSTP site was made by members from IRWP (Mr DC Brown), LGEB, Rajbari (XEN and AE) and the HO of the Consultants to assess the extent of deterioration caused by the unusual heavy rainfall from 24 Sept to 08 Oct 1986 and to suggest the remedial measures.

The following were the observations made by the members of the inspection team:

1. About 34m pavement of Type 10 (at its last portion) was damaged and having depressions on shoulder.

2. All the 100m length of Type 9 was damaged, some portions are similar to the damaged portion of Type 10 and others are less severe.

3. Type 7 was found having some local depression but not severe and there were cracks in the emulsion painting on the surface.

4. Types 1 to 8 and 66m length of Type 10 were found in good and trafficable condition.

Regarding the reasons of above damages observed by the inspection team, the Consultants' views are outlined in the following manners:

1. As early as in the month of Aug 1986, some cracks were noticed in the last twelve-meter stretch of Type 10 and which was mentioned in the monitoring report for Aug 1986 (ref P-11 of the Report). This

was jointly inspected by Mr B Moller, FO, Faridpur and the Consultants' Resident Engineer (RE). As this last stretch was in the non-maintained area, they decided to leave it as it was to observe the behavioural pattern of the cracks for a further period.

2. Later on, on 07 Sept 1986, Mr B Moller, FO, Faridur, Mr G Mohiuddin, Project Manager and Mr A Hoque, RE of the Consultants visited the RSTP site and observed that the cracks in this same area aggravated, giving way to water-penetration from rain resulting in further damage, which warranted immediate repair. It was decided on the spot that although this portion was in non-maintained area, this damaged portion should be taken up for immediate repair to arrest further damages. During the same joint visit, it was observed that there were cracks in the surface-paintings and exposed areas of base course due to loss of surface painting in scattered areas in Types 7 and 9. It was stressed that maintenance work should be taken up immediately to seal such cracks in the surface paintings.

3. During this visit, it was unanimously felt that the maintenance activities of the Contractors were not at all satisfactory, which also reflected through the Monitoring Report Nos. 1 and 2, in the letter of FO, Faridpur no. F/IRWP/4.K dt 21 Sept 1986 addressed to Executive Engineer, LGEB, Rajbari and Executive Engineer, LGEB, Rajbari no. 569-70/1/8 dt 01 Oct 1986, 52-53 LGEB dt 14 Jul 1986, 99-100 dt 28 Jul 1986, 120-121 dt 31 Jul 1986 and 532-33 dt 24 Sept 1986 addressed to the Contractors of RSTP, Rajbari.

4. Also, there were localised depressions on shoulder at different locations where water accumulation occured due to non-maintenance or unsatisfactory maintenance which were also pointed out in the monitoring reports. Thus, it can be concluded that the damages to the pavement types, as mentioned above, occured due to the infiltration of rain water to the base course and the sub-base-course through the cracks of surface paintings, exposed bases (due to loss of surface painting) and through the edges of pavement (due to ponding of water on depressed shoulder areas). This infiltration of water has substantially increased the moisture content, reducing the density of base and sub-base courses than the design density and thus inducing the damages.

5. Had the maintenance activities been taken up by the Contractors as per contractual agreements and as directed by Executive Engineer, LGEB, Rajbari, FO, IRWP, Faridpur and RE, BCL (during monitoring period), there would have been no infiltration of water to cause the above damages.

6. It needs to be mentioned that the Types 7, 8, 9 and 10 have similar pavement structures but only with varying surface treatments. Even after the recent heavy rains (for about a fortnight), Type 8 and 66m of Type 10 are in good condition, pavement structure of Type 7 is also unaffected except a few local depressions and cracks and loss of surface paintings. The initial deteriorations in the form of cracking, loss of painting and pea-gravels in the surface painting and surface dressing in the relevant sections started due to the unsatisfactory and inconsistant quality of asphalt emulsion (Ref: test results of asphalt emulsion).

7. Such deteriorations were aggravating with time due to lack of proper maintenance which has greatly induced the damages occured in Type 9 and part of Type 10.

144

4.0 FOURTH MONITORING REPORT: MONITORING PERIOD 25/10/1986 TO 31/10/1986

a) The Consultant met the Executive Engineer (XEN), LGEB, Rajbari on 27 Oct 1986 at his office and discussed about the repair works of damaged portions of pavement in Types 7, 9 and 10. XEN, LGEB, Rajbari informed that the repair works have started from 25 Oct 1986 and after picking up the base course, the underlying sub-base has been found in well compacted condition. The Consultants expressed his opinion that if the underlying sub-base or any layer of base course is found in well compacted condition, the same should not be removed/picked up. Further discussion could not be made as the XEN was in a hurry to attend an important meeting with the Deputy Commissioner, Rajbari. However, the XEN, LGEB, Rajbari requested the Consultants to accord necessary guidance to his Asstt Engineer regarding repair works and the relevant tests.

b) During the monitoring period, the Consultants along with Asstt Engineer, LGEB, Rajbari inspected the ongoing repair works of damaged pavement in Types 9 and 10 on 27 to 29 Oct 1986. While inspecting it was found that, in Type 10, the top layer of base course (3"-5" depth) has been removed where the bottom layer of base was in well compacted condition but that in the last 10m portion had excessive moisture. In Type 9, the top layer of base (3"-4" depth) was removed from all the area and in the portion 0+900 to 0+950 RHS (half width) the bottom layer of base was also removed, where the sand-soil sub-base was found in well compacted condition.

As per suggestion of the Consultant, Asstt Engineer, LGEB, Rajbari did a few field density tests on sub-base and bottom layer of base in Type 9 and the available density and moisture content was found satisfactory. But both sub-base and bottom layer of base course were uneven and over excavated. So Asstt Engineer was suggested to first prepare the top layer (exposed portion) of sub-base in Type 9 to the required level, grade and camber by scarifying, adding materials, if needed, adjusting moisture and compacting to specified density. After preparing the sub-base, the bottom layer of base course should be prepared by scarfying the existing layer, placing materials over the exposed portion of sub-base, adjusting moisture and then compacting to specified density. Similarly the top layer of base course shall be prepared to design grade, level and comber as per specification.

14

For Type 10, it was suggested to remove the base course in full depth from the last 10m portion and to check density and moisture content of sand-soil sub-base in this portion. If the available density is found OK but moisture content too high, the moisture content of sub-base must be brought near to OMC by aerating. Later the bottom layer and top layer of base courses should be prepared as per specification and as detailed in Type 9 above.

The construction procedures, field density test, CBR test and other quality control measures in respect of repair works of damaged pavement in Types 7, 9 and 10 have been detailed by the Consultants to Mr Kazi Iqbal Hossain, Asstt Engineer, LGEB, Rajbari.

c) The sands from the joints of HBB brick pavement in Types 1, 2 and 3 have been washed away during the last unusual heavy rainfall due to which the movement of the bricks has increased to some extent and also the bricks are being damaged rapidly. So to arrest movement of the bricks and to prevent further and rapid deterioration of the bricks of HBB pavement, the joints must be filled with sand immediately.

d) Cracks in surface painting and surface dressing and loss of asphalt emulsion painting and bonded pea-gravels from surface dressing have been observed in Types 4, 5, 6 and 10. These cracks and exposed bases due to loss of painting and dressing must be sealed by asphalt emulsion painting and dressing with pea-gravels and emulsion as applicable to prevent further deterioration.

Even if the Contractors do not do the maintenance works as mentioned in items (c) and (d) above, the works should be done departmentally.

e) Substantial increase of traffic volume over that found during monitoring in the month of Aug has been observed. FO, IRWP, Faridpur may conduct traffic count at least for 4 days including 2 market days as it will be of interest to know the actual traffic in the dry season and growth rate of traffic.

f) The progress of repair work was very slow and normal maintenance work was not at all being done by the Contractors.

5.0 FIFTH MONITORING REPORT: MONITORING PERIOD 22/11/1986 TO 27/11/1986

a) The Consultant met the Executive Engineer (XEN), LGEB, Rajbari on 23 Nov 1986 at his office and discussed about the repair and maintenance works of RSTP. XEN informed that except surface treatment in the last portion of Type 10, other repair works of Types 7, 9 and 10 have been completed. In the last 10m portion of repaired base course of Type 10, there had been excess moisture for which the surface has not been treated.

Regarding maintenance activities of the Contractors, XEN expressed his opinion that the Contractors may take up maintenance works during the month of Dec 1986.

b) The Consultants along with Asstt Engineer, LGEB, Rajbari inspected the RSTP site on 23 Nov 1986 when it was observed that the last 10m portion of the repaired base course in Type 10 having excessive moisture has started to deform along the trackways (see Exhibit 24 in Annex-6b). For rectification of this area, the Consultants suggested to adjust the moisture near to OMC by scarifying and aerating and then compacting to specified density. Asstt Engineer informed that the rectification will be done accordingly.

In the surface treatment of Types 7 and 9 done by LGEB, some fat spots, subjected to bleeding, were observed. Asstt Engineer was suggested to spread some additional pea-gravels or coarse sand over those spots to avoid bleeding.

In Type 7, the surface treatment over the depression areas where patch repair has been done by grouting with brick aggregates and hot bitumen was found unsatisfactory which has been shown to Asstt Engineer. The spots should be rectified by cleaning the surface, applying fresh coating of bitumen and spreading required quantity of pea-gravels to make the surface properly sealed and leveled.

c) In Types 1, 2 and 3, the gaps in the joints of HBB which were observed in the last monitoring period have not been filled by sand blinding as suggested and more nos. of bricks have been found damaged and even a few have been crushed. See Exhibit No. 7 in Annex-6b.

d) Patch repairing of a few spots in surface painting and surface dressing of Types 5 and 6 were done by LGEB but not all the spots.

14

e) No sign of normal maintenance activities by the Contractors have been noticed during the monitoring period.

f) The Consultants also met Mr B Moller, FO (Engg), IRWP, Faridpur on 26 Nov 1986 at his office and discussed about monitoring, repair and maintenance works of RSTP, Rajbari. During the discussion, the Consultants also stressed the need for conducting traffic count to know the present traffic volume and the actual growth of traffic in the Rajbari-Baliakandi Road. Mr B Moller informed that he will try to arrange the same.

148

6.0 SIXTH MONITORING REPORT: MONITORING PERIOD 27/12/1986 TO 01/02/1987

a) The Consultant met Mr B Moller, FO (Engg), IRWP, Faridpur on 28 Dec 1986 at his office and discussed about the last monitoring works. Later on the same day, the Consultant attended the office of Executive Engineer (XEN), LGEB, Rajbari and inspected the RSTP site along with Asstt Engineer (AE), LGEB, Rajbari. It was found that the last portion of the Type 10 has been treated with hot bitumen and pea gravels but untreated (without coating of bitumen) strips of stabilised base were visible.

b) Normal maintenance activities of the Contractors have not been noticed during the monitoring period.

c) The gaps in the joints of HBB brick pavements have not been filled by sand blinding as suggested by the Consultant because of which bricks were found being damaged at an accelerated rate. See Exhibit Nos. 9, 12 and 14 in the Annex-6b.

d) Patch repairing of a few spots in surface dressing of Types 6 and 8 has been done but many spots in Types 4 and 5 where surface dressing and painting have been damaged are yet to be repaired.

e) Repairing of ruttings, local depressions, erosion, raincuts, sliding of earth, rat holes, etc on shoulder and embankment side slope have not been done at all.

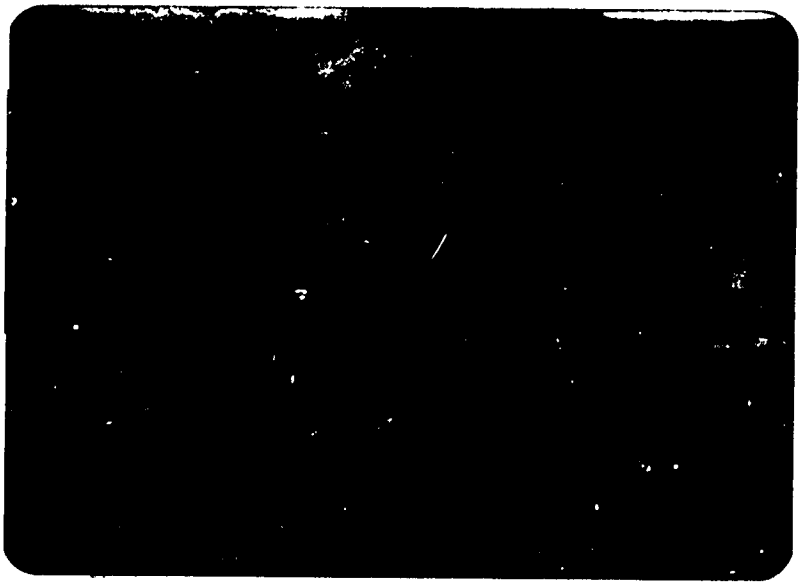
f) Except hair cracks and loss of painting and dressing from few spots, the overall condition of the pavement of Types 4 to 10 have been found to be quite good.

g) The Consultants also met XEN, LGEB, Rajbari on 30 Dec 1986 at his office and discussed about the repair/maintenance cost incurred during the monitoring periods. XEN informed that the Contractors did very negligible maintenance works and also there is no record of the cost incurred thereby; however he agreed that the cost of maintenance work done by LGEB would be communicated by the 1st week of Jan 1987. But, in fact, nothing has been received till by the end of Jan 1987.

149

PHOTOGRAPHS SHOWING
OF THE DIFFERENT TR

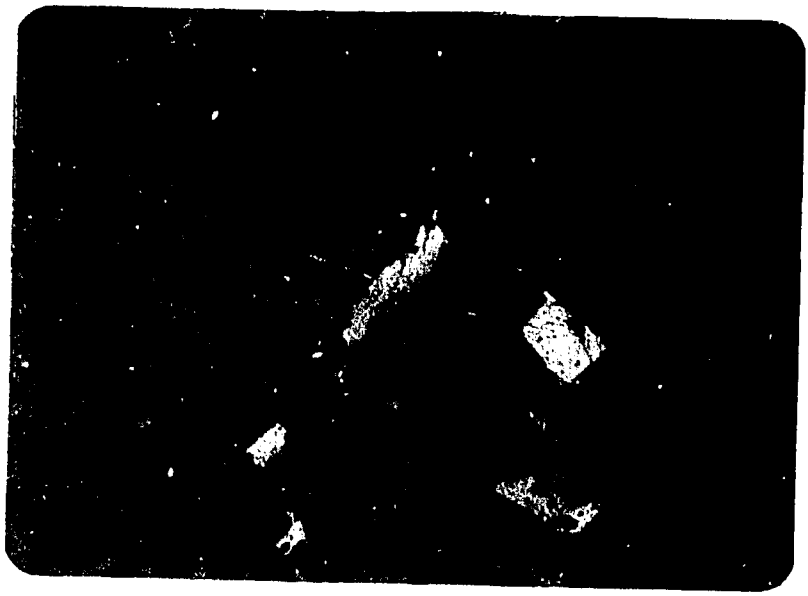
Type-1:



Type-2:

S-BUILT CONDITION
L SECTIONS

Type-3:



Type-1: HBB Brick Road with single brick flat soling over sand sub-base. Note start of breaking of corners of bricks

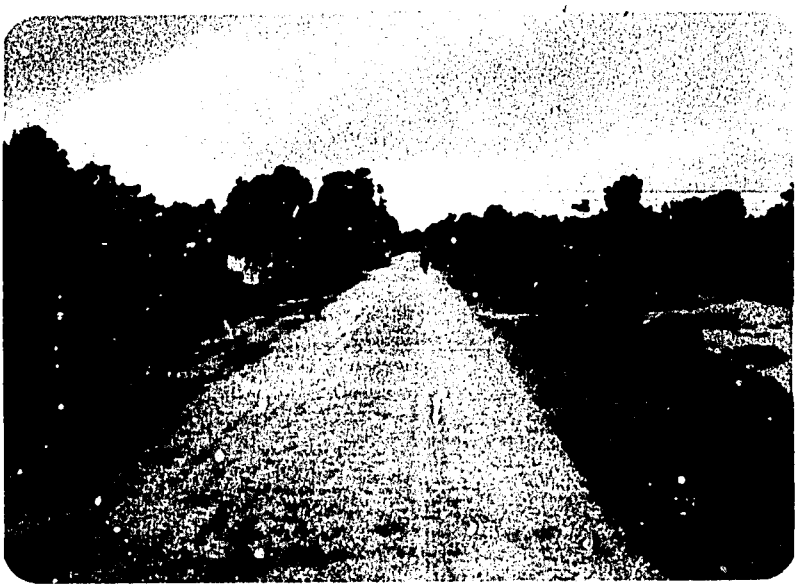
Type-2: HBB Brick Road over sand-soil sub-base but without the brick flat soling. Note appearance of cracks in the joint filler caused by movement of bricks under traffic

Type-3: HBB Brick Road over aggregate-sand-soil sub-base but without the brick flat soling.

Type-4:

Type-5:

Type-6 :



Type-4: WBM Road over sand sub-base and surface dressing with asphalt emulsion and pea-gravels

Type-5: WBM Road over sand-soil sub-base and surface painting with asphalt emulsion. Note loss of painting from the surface.

Type-6: WBM Road over sand-soil sub-base and surface dressing with asphalt emulsion and pea-gravels

Type-7:

ASS Road with aggregate-sand-soil base over sand-soil sub-base and surface painting with asphalt emulsion

Type-8:

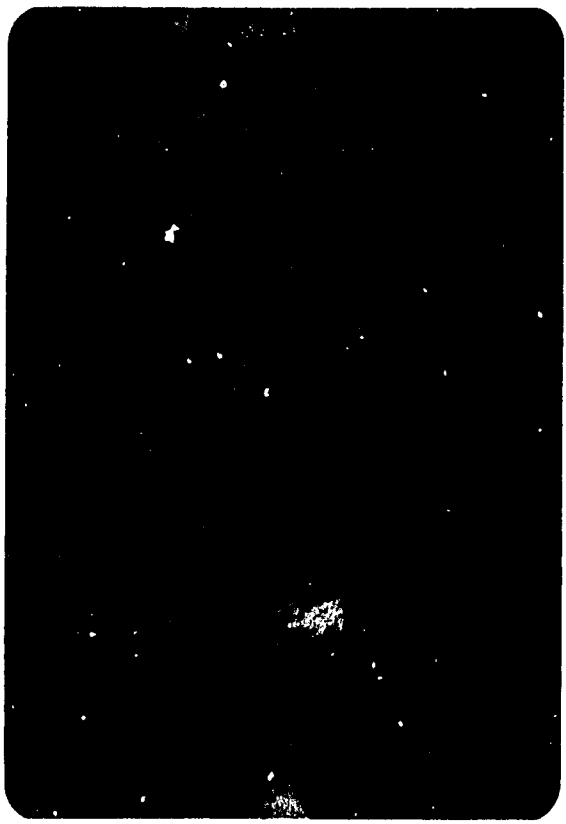
ASS Road. Same as in Type-7 except for surface dressing with asphalt emulsion and pea-gravels

Type-9 (foreground):

ASS Road with aggregate-sand-soil base topped with brick aggregate grafting, sand-soil sub-base and surface painting with asphalt emulsion

Type-10:

ASS Road. Same as in Type-9 except for surface dressing with asphalt emulsion and pea-gravels



Brick-on-end edging and
granular shoulder

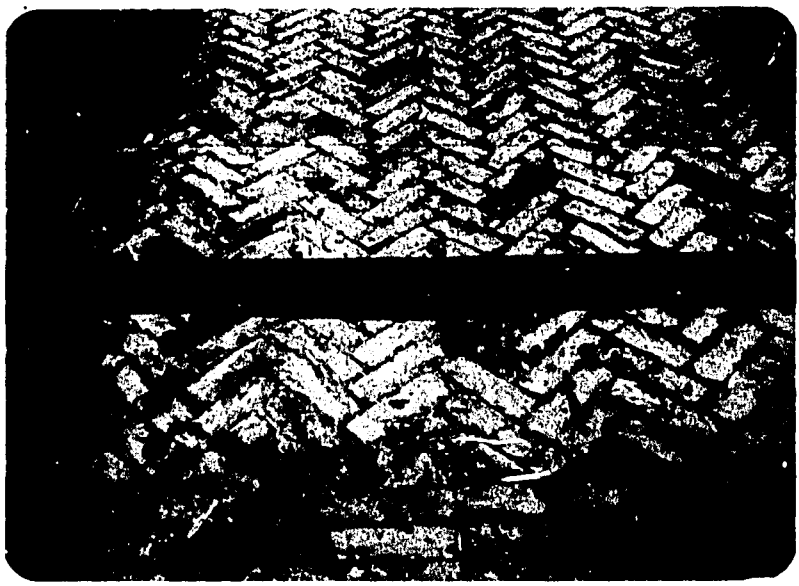
SELECTED PHOTOGRA
SECTIONS TOWARDS

Type-1:

Type-2:

SHOWING STATE OF THE TRIAL
OF THE MONITORING PERIOD

Type-3:

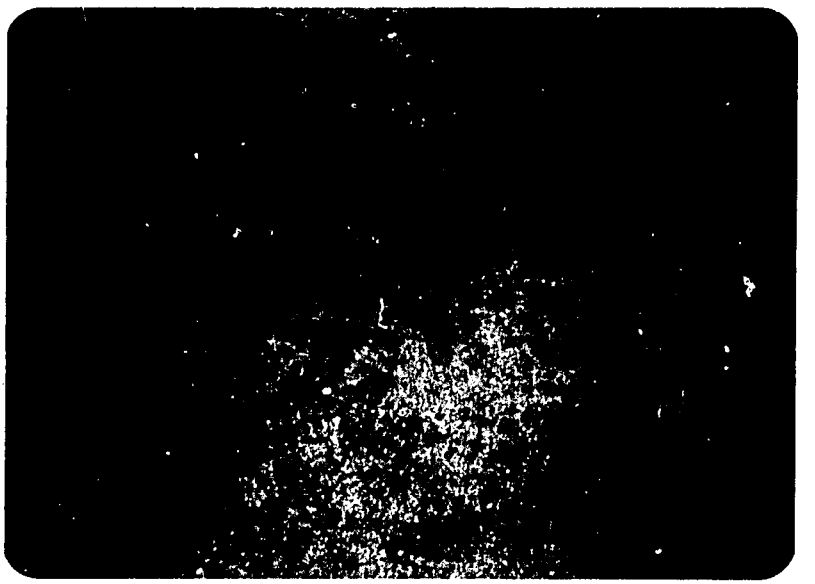


Type-1: HBB brick pavement with soling over sand sub-base -
Note crushing of bricks.

Type-2: HBB brick pavement (without soling) over sand-soil sub-base and joint sealing with asphalt emulsion -
Note crushing of bricks and ineffective sealing of joints with emulsion

Type-3: HBB brick pavement (without soling) over aggr-sand-soil sub-base and joint sealing with asphalt emulsion -
Note crushing of bricks, ineffective joint sealing and depression along trackway

Type-6:



Type 4: WBM road over sand sub-base and with surface dressing with pea gravels and asphalt emulsion - Note satisfactory condition of pavement and its surface

Type 5: WBM road over sand-soil sub-base and with surface painting with asphalt emulsion and sand blindage · Note satisfactory condition of pavement structure but scattered loss of painting from the surface

Type 6: WBM road over sand-soil sub-base and with surface dressing as in Type 4-
Note satisfactory condition of the pavement and its surface

Type-7: Aggr Stabilised Soil Road over sand-soil sub-base and with surface painting with asphalt emulsion and sand blindage

Note severe loss of surface painting (picture taken at end of 4th month of monitoring) which was later repaired by dressing with bitumen and pea-gravel. Picture below, taken at end of the 6th month, shows the condition of the trial section after the repair

141

Type 8: Aggr Stabilised Soil Road over sand-soil sub-base and surface dressing with pea-gravels and asphalt emulsion

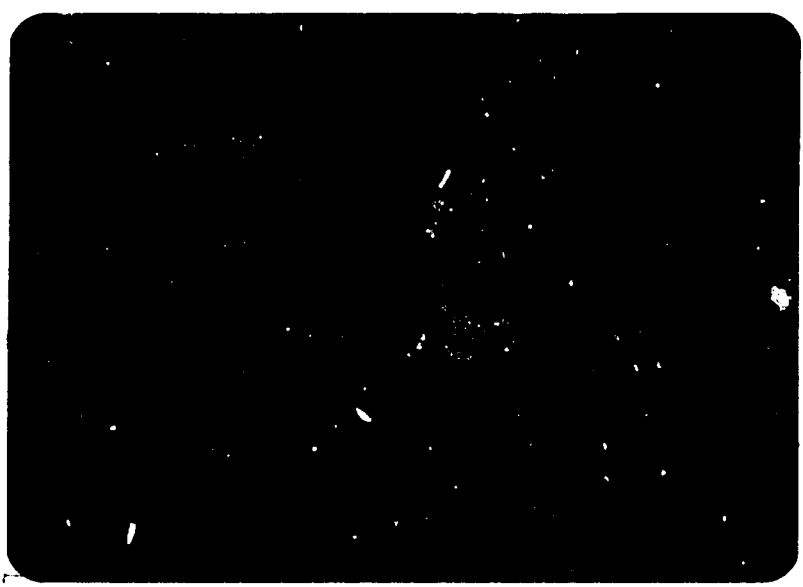
Note satisfactory condition of the surface

General view showing over-all satisfactory condition of the trial section

162

T ype-9: Aggr Stabilised Soil Road over sand-soil sub-base and with brick chip grafting and surface painting

Note, on account of cracks and severe loss of surface painting, ingress of water and lack of timely and adequate maintenance the trial section was severely damaged.

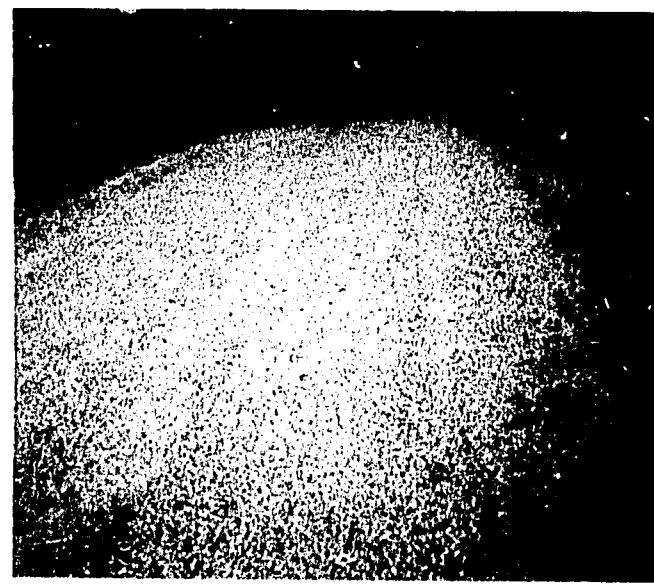


The damage was repaired by scarifying and recompacting the base followed by surface dressing with bitumen and pea-gravels. Picture shows condition after the repair.

163

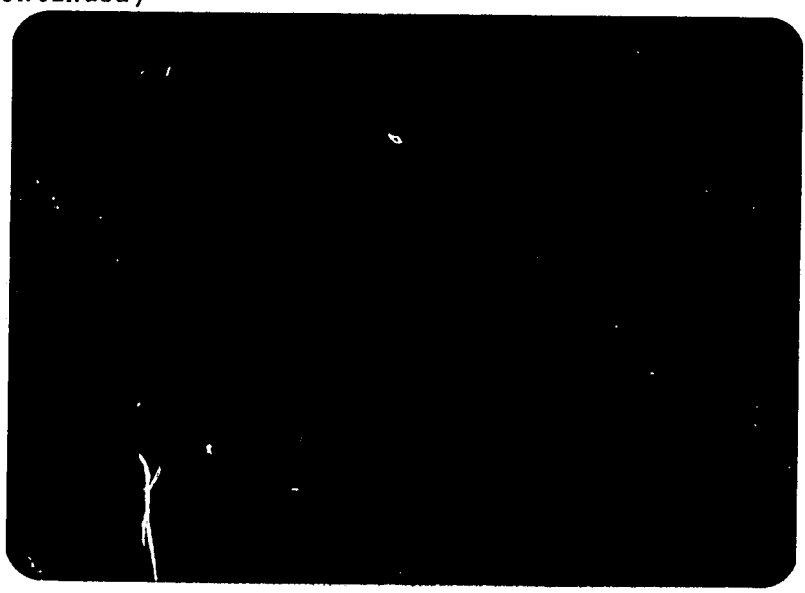
Type 10: Same as Type 9 except that in place of surface painting it had surface dressing with pea-gravels and asphalt emulsion

A small 3 sqm area (shown above) was damaged by end of the 2nd month of monitoring. This was not repaired and, as a result, it spread along a length of 34m to a condition shown below, left. This was repaired in 5th and 6th months by scarifying and recompacting the base followed by surface dressing with bitumen and pea-gravel- see picture below, right.

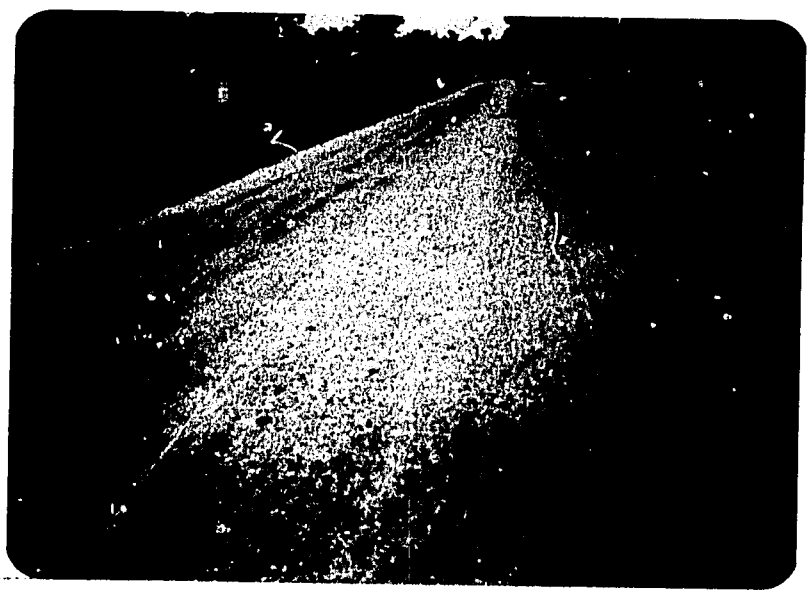


161

Type-10 (continued)

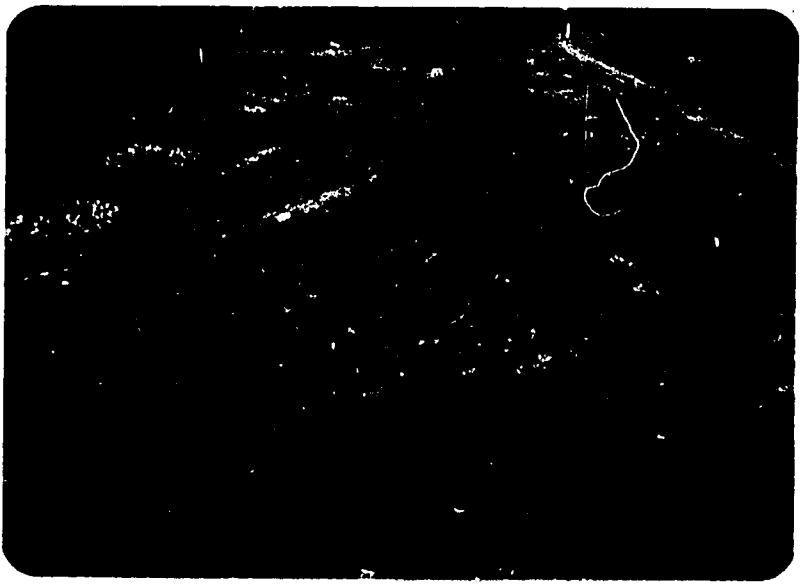


Note condition of pavement in the undamaged 66m portion of the section



General over-all view of the satisfactory condition of the undamaged 66m portion of the trial section

Turfing on Slope and Shoulder



Note well protected slope and shoulder due to satisfactory condition of turfing

Scattered Raincuts on Slope

Note scattered raincuts appeared on account of unsatisfactory compaction of earthwork in slope