Chapter - I

Introduction
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INTRODUCTION

1.1 INTRODUCTION TO THE PROBLEM

Transportation contributes to the economic, industrial, social and cultural development of any country. Among the various modes of transportation, highway transportation gives maximum flexibility and plays an important role in the development as it connects other modes of transport and other points on the land. At the time of achieving independence, the total road length in India was 0.38 million kms, the majority of them being bituminous roads. According to the road development plan, Vision 2021, about 22,000 kilometers of National Highways and 10,000 kilometers expressways are to be constructed by the year 2021. In addition to this, villages with population of above 500 will be connected by the year 2007 and those with population below 500 by the year 2010. The golden quadrilateral underway in India, involves building of nearly 6,000 kms of roads at an estimated cost of 30,000 crores of rupees.

To achieve this target, a huge quantity of road aggregates and other materials are required. Although coarse aggregates are scarce in many areas, sand is plentiful in many areas in India. So if sand could be used as the only aggregate in a bituminous mix, the problem of shortage of road aggregates in road construction would be solved to a great extent. However, a bituminous mix containing only sand as aggregates is not suitable for use as a structural layer in pavements because of its low mechanical stability, high voids content and
requirement of high asphalt content. But it has been found that if sand-bitumen-mix is further mixed with molten elemental sulphur, the properties of the former are improved considerably. Stability increases, voids decrease and asphalt requirement reduces with the addition of sulphur. To minimize the use of bitumen the use of sulphur as an extender and as a substitute for bitumen in the construction of pavement surfaces is studied. Sulphur is the tenth most abundant element and is produced voluntarily and involuntarily. Voluntary source is the internal mining of sulphur, involuntary source is the sulphur obtained as a by-product of industrial processes such as the desulphurising of natural gas and desulphurizing of petroleum crude or coal. Because of the need for improved paving mixtures, the non availability of good quality road aggregates in some places, rapidly increasing cost of bitumen and the accumulation of surplus sulphur, there is growing interest in the use of sulphur in paving mixtures.

1.2 EXISTING SOLUTIONS

Keeping the above in view, some investigations have been carried out in India and other countries using sands of various types, bitumen and sulphur, in the construction of pavements\textsuperscript{12,32,38}, as sulphur is available in large quantities, but not utilized even to the extent of 10 to 15%. The utilization of sulphur is much less in India, when compared to other countries\textsuperscript{31}.

A bitumen mix containing only sand and bitumen is not suitable for use as a structural layer in pavements because of its low mechanical stability, high air voids content and the requirement of high bitumen content. Hence sand-bitumen mix is further mixed with molten elemental sulphur to improve the properties of
the former. The use of sulphur in sand-bitumen mixes resulted in increased stability, though the amount of voids in the mixes is considerable\textsuperscript{11}. However it is proved that the distribution of the voids is such that the permeability of such mixes is less than those of bituminous concrete mixes prepared with coarse and fine aggregates\textsuperscript{11}.

To improve the properties of sand-bitumen-sulphur mixes, investigations have been carried out at Indian Institute of Technology, Kharagpur using byproduct materials like flyash\textsuperscript{32}. These investigations have shown that the use of flyash in the mixes increased the stability and reduced voids. Apart from finding out the Marshall properties for poorly graded river sand, bitumen, sulphur and flyash mixes, tests like indirect tensile test, static flexure test, repeated flexure and fatigue tests have been conducted by the researchers. Among these experimental mixes a number not only satisfied Marshall criteria but also proved to have better indirect tensile strength, modulus of rupture and fatigue values compared to bituminous concrete mixes prepared with coarse and fine aggregates. Thus the research work at Kharagpur has proved that the replacement of sand partly by flyash, results in better mixes. However the utility of flyash was tried only up to 10% of sand content.

In many countries thermal power stations are constructed for the generation of electricity. At the electric static precipitator a fine material called flyash comes out from the plant. This flyash is mixed with water and is disposed off near the plants in the form of pondash. The quantities of these flyash and pondash are so huge that they create environmental problems and occupy large areas at the
plants. Though flyash is utilized as a building construction material, agricultural purposes and for stabilization of soils, the quantity utilized is limited compared to the production. When compared to other countries, India utilizes the least as shown in Table 1.1. India and other countries have appointed commissions for suggesting various ways of utilizing flyash in larger quantities\textsuperscript{16,17}.

To further improve the utilization of flyash, investigations have been carried out by Murali Krishna\textsuperscript{38} at Sri Venkateswara University College of Engineering, Tirupati, by adding flyash and another waste material like pondash in several proportions. In the investigation carried out, beach sand with flyash or pondash are used with 80\%, 82.5\% and 85\% of total mix varying flyash or pondash in different proportions in all the above three compositions. The 80\% mixes are proved better followed by 82.5\% and 85\%. In this investigation only 80/100 grade bitumen was used in about 280 mixes.

1.3 PROPOSED WORK

It is well known that the grade of bitumen affect the aggregate-bitumen mix properties like stability, density, air voids etc. The Ministry of Surface Transport (MOST) specifications (1998)\textsuperscript{21} suggest the use of proper grade of bitumen depending upon traffic intensity, temperature and rainfall etc. in that area. However the earlier investigations, especially by Murali Krishna\textsuperscript{38}, are carried out using only 80/100 grade bitumen. Further the main investigation was carried out using only one type of sand i.e., beach sand. This type of investigation will be more purposeful and useful if the investigations are carried
the required results.

2. If not, replace the bluemen, either partially or fully, by sulphur will give

Government conclusion.

Grades of bluemen will satisfy the Marshall criteria and thus be useful for

Objectives.

Byashpondash, bluemen, sulphur mixes in this investigation with the following
 kicks 80/100, 60/70 and 30/40 is studied in the beach sand / desert sand.

Keeping the above discussion in view, the effect of three grades of bluemen

Arguments.

mixes, prepared with sand, bluemen, sulphur and ash of pondash used for the
more valuable in the near future if the effect of grade of bluemen is studied in the
in the near future. This work, carried out by earlier investigators, will become
mixes with sand, bluemen, sulphur, ash or pondash will be of great importance
for alternative materials for road construction. When this is considered the use of
materials obtained is likely to become scarce in near future, the world has to look very fast
on the problem which from which bluemen of different grades are

quantities in deserts.

Oil using desert sand as coarse aggregate are not available or available in small
3. If the voids in the above mixes are not within the limits, to find out the extent to which the flyash or pondash can be used replacing sand, to satisfy the voids criteria.

4. To find out the effect of the grade of the bitumen on the sand-asphalt-sulphur-flyash or pondash mixes.

5. Finally to decide the extent to which sand can be replaced by flyash or pondash and bitumen can be replaced by sulphur.

In this research work, the Marshall method is adopted for studying the various types of mixes as many researchers in the world have used this method for comparing various types of bitumen aggregate mixes. Further the procedure is simple and straightforward and the results of this test have correlated well with the performance of the pavements in the field. Even though 35, 50 and 75 blows are given to the samples, as per the standard procedure, 10 blows only are given on each side of the samples for the kind of mixes studied in this work, as this compactive effort is proved[12, 31] to be appropriate for these kinds of mixes. This factor attains vital importance in the case of road construction in remote areas, under developed areas, where it is difficult to transport rollers. It has been found that a low compactive effort only is needed to get the best results. The mixes are compared based on important properties like stability, flow, air voids etc. in the mixes. Even though the air voids are high in the specimens studied, the permeability of the specimens prepared is quite low compared to bituminous concrete mix specimens at the corresponding air voids level according to the
Even though bitumen is used in this work, the word “Asphalt” is used in place of bitumen as the word asphalt is generally used in the developed countries and it is felt convenient to use the letter “A” for asphalt in representing various types of mixes. The following abbreviations are used to represent various mixes. Hence from now onwards the word asphalt is used in place of bitumen, even though bitumen is used in this work. B-Beach sand, D-Desert sand, A-Asphalt, S-Sulphur, FA-Flyash and PA-Pondash.

**EX:**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BA</td>
<td>Beach sand - Asphalt mix</td>
</tr>
<tr>
<td>BAS</td>
<td>Beach sand - Asphalt - Sulphur mix</td>
</tr>
<tr>
<td>BFAAS</td>
<td>Beach sand - Flyash - Asphalt - Sulphur mix</td>
</tr>
<tr>
<td>BPAAS</td>
<td>Beach sand - Pondash - Asphalt - Sulphur mix</td>
</tr>
<tr>
<td>DA</td>
<td>Desert Sand - Asphalt mix</td>
</tr>
<tr>
<td>DAS</td>
<td>Desert sand - Asphalt - Sulphur mix</td>
</tr>
<tr>
<td>DFAAS</td>
<td>Desert sand - Flyash - Asphalt - Sulphur mix</td>
</tr>
<tr>
<td>DPAAS</td>
<td>Desert sand - Pondash - Asphalt - Sulphur mix</td>
</tr>
</tbody>
</table>

In the investigation carried out, the beach sand alone and with flyash or pondash are used with 80% of total mix, varying sand and flyash or pondash in the proportions of 100:0, 80:20, 60:40, 50:50, 40:60, 20:80, and 0:100. All the above mixes are tested with three grades (30/40, 60/70, 80/100) of asphalt. In all the above mixes, A/S ratio is changed with asphalt content varying from 5 to
10% and sulphur content varying from 15 to 10%. Selected mixes are also prepared with desert sand to compare with the above mixes having beach sand and to determine the suitability of mixes prepared with desert sand. Asphalt concrete mixes using crushed aggregate are also prepared for comparing the other mixes mentioned earlier. Altogether 462 mixes (for each mix 3 specimens are prepared and the average value is taken) consisting of 15 Asphalt concrete mixes, 18 BA mixes, 18 BAS mixes, 108 BFAAS mixes, 108 BPAAS mixes, 18 DA mixes, 18 DAS mixes, 36 DFAAS mixes, 36 DPAAS mixes, 33 mixes for retained stability and 54 mixes for air voids and permeability are studied in detail. Microsoft Excel software is extensively used in preparing the tables and figures in this work.

In this work the 20 mm asphalt concrete is included to give a comparison of the results of other mixes with that of conventional mixes like asphalt concrete mix. The BAS, BFAAS etc. mixes investigated should not be considered as substitution to conventional asphalt concrete mixes. Where coarse aggregate is not available BAS, BFAAS etc. can be used, even though the asphalt requirement of these mixes is more than those of conventional asphalt mixes.

The thesis is presented in five chapters. Chapter 2 is devoted to the review of literature connected with the use of sulphur, flyash and pondash in pavement construction. Details of experimental work are provided in Chapter 3. In Chapter 4, the test results have been discussed in detail. Important conclusions obtained and scope of future work are included in Chapter 5. Lists of references are provided at the end.
Table: 1.1 Utilization of Flyash - Global Scenario

<table>
<thead>
<tr>
<th>Name of the country</th>
<th>Utilization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>80%</td>
</tr>
<tr>
<td>Holland</td>
<td>70%</td>
</tr>
<tr>
<td>Denmark</td>
<td>65%</td>
</tr>
<tr>
<td>France</td>
<td>65%</td>
</tr>
<tr>
<td>Belgium</td>
<td>65%</td>
</tr>
<tr>
<td>Britain</td>
<td>55%</td>
</tr>
<tr>
<td>Poland</td>
<td>50%</td>
</tr>
<tr>
<td>India</td>
<td>3 to 5%</td>
</tr>
</tbody>
</table>