# EXPERIMENTAL STUDY ON COMPOSITE LAYERS OF GSB-II AND WMM IN FLEXIBLE PAVEMENT

**Vineethraj Math [1], Rajat Vaidya[2], Veeresh Karikatti[3]**

**KLE Institute of technology, Civil Engineering Dept Hubballi.[1, 2&3]**

**vinit555@gmail.com[1], vaidyarajat@gmail.com[2], veeresh.karikatti@gmail.com[3]**

**ABSTRACT :** *Substantial improvement in the technology of traffic and its load carrying capacity to satisfy the current demand, there is need of stable pavement structure but for sustaining the traffic load and to optimum usage for material for economic construction. There is a need of design which (particularly) exhibit optimum thickness of different layer in flexible pavement considering the stability of all the layers separately. In this work an attempt has been made considering the stability in terms of CBR of GSB and WMM layers to design the base and sub base layers of flexible pavement as single composite layer. Gradation of GSB-II and WMM that provides maximum permeability and higher CBR value utilized and design of composite layer thickness is done using AASHTO design specifications. The permeability tests on GSB, WMM, 25%GSB-75%WMM and by the flow obtained the above proportion mentioned showed "Good permeability characteristics" as per AASHTO Manual. The composite layer (25%GSB 75%WMM) pavement design is done by considering the Structural number concept as per AASHTO Manual. CBR of GSB, WMM, 25%GSB-75%WMM and layer coefficients for sub base and base layers and permeability values are considered in the calculation of structural number; it is observed that the pavement which has more value of structural number is stronger. The obtained thickness of the pavement by using the composite layer resulted in much lesser pavement thickness when compared to normal design as per IRC 37-2001. Even comparison is done by using concept of cement treated sub base..The Cost analysis for normal pavements, Composite layer pavements and cement treated sub base pavements resulted that the composite layer pavement resulted in decreased cost with lesser thickness of pavement and cement treated sub base pavement resulted in much lesser cost compared to normal and composite layer pavements with optimum thickness of the pavement.*

*Keywords- Composite layer, GSBII, WMM*

## 1. INTRODUCTION

The surface of the roadway should be stable and non-yielding, to allow the heavy wheel loads of road traffic to move with least possible rolling resistance. The road surface should also be even along the longitudinal profile to enable the fast vehicles to move safely and comfortably at the design speed. A pavement layer is considered more effective or superior, if it is able to distribute the wheel load stress through a larger area per unit depth of the layer. One of the objectives of a well designed and constructed pavement is therefore to keep this elastic deformation of the pavement within the permissible limits, so that the pavement can sustain a large number of repeated load applications during the design life and to keep the sub grade dry.

Base and Sub base layer form two important layers of pavement. Base course is considered as the most important component of flexible pavement layer which sustains wheel load stresses and disperses through layer area onto the GSB layer below. A good base course enhances the load carrying capacity of the flexible pavement structure. Good quality coarse aggregates are generally used in the granular base course of flexible pavement. Sub base layer (GSB) course has to serve an effective drainage layer of pavement and also has to sustain lower magnitude of compressive stresses than the base course. Aggregates of lower strength having good permeability may be used in the GSB layer .Crushed stone aggregates are often used in the GSB layer of important highways as this material has high permeability and serves as an effective drainage layer.

We can go with combining sub base and base layers suitably in the required proportions so that it provides same strength and permeability as that of a four layer pavement. By going with a composite layer of Granular sub base and wet mix macadam material it is found that by AASHTO method of design, overall pavement thickness can be reduced. Hence cost of flexible pavement decreases.

New technology of Cement treated granular sub base/base is used to reduce the overall pavement thickness compared to normal and composite layer pavement design , as strength of the pavement increases considerably, the permeability characteristics are also good with cement treated layers. Hence cost reduction in construction is also another advantage.

# 2. LITERATURE REVIEW

## 2.1 MORTH Manual by Govt Of India (All Clauses are as per MORTH) Specifies that

MORTH states that the work shall consist of laying and compacting well graded materials on prepared sub grade in accordance with the requirements of these specifications. The material shall be laid in one or two layers as lower sub base or upper sub base or simply sub base.

Clause 401.3 Strength of sub base states, it shall be ensured to actual execution that the material to be used in sub base satisfies the requirements of CBR and other physical requirements when compacted and finished.

When directed by the engineer, this shall be verified by performing CBR tests in the laboratory as required on specimens remoulded at field dry density and moisture content and any other tests for the quality of materials, as may be necessary.

Clause 406 Wet mix macadam sub base/base

Clause 406.1 The work shall consist of laying and compacting clean, crushed, graded aggregates and granular material, premixed with water, to a dense mass on a prepared subgade/sub base or existing pavement as in the case may be in accordance with the requirements of these specifications. The material shall be laid in one or more layers as necessary to lines, grades and cross-sections shown on the approved drawings or as directed by the engineer.

The thickness of a single compacted Wet mix macadam layer shall not be less than 75 mm. When vibrating or other approved types of compacting equipment are used, the compacted depth of single layer of the sub base course may be increased to 200 mm upon approval of the engineer.

## 2.2 AASTHO guide for design of pavement structure, (American Association state Highway and transport official Washington DC 1993.) Specifies that

### 2.2.1 Gradation

A wide range of aggregates sizes and gradations are used depending on the pavement type and the condition to which the granular base and sub base stability ,drainage (permeability) and frost susceptibility .Aggregates' for use as granular base tend to be dense graded with a maximum size of 50 mm (2 inch) or less, while granular sub base can have a normal maximum size commonly up to 100 mm (4inch) .The percentage of fine (minus 0.075mm (no 200mm sieve)) in the granular base is limited for drainage and frost susceptibility purposes to a maximum of 8 percent up to 12 percent permitted in a granular sub base.

### 2.2.2 Particle Size

The use of angular, nearly equi-dimensional aggregate with rough surface texture is preferred over rounded, smooth aggregate particles; thin or flat and elongated particles have reduced strength when load is applied to the flat side of the aggregate or across its shortest dimension are also prone to segregation and break down during compaction, creating additional fines.

### 2.2.3 Base Stability

Granular base should have high stability, particularly in a flexible asphalt pavement structure. Large angular aggregate, dense graded and consisting of hard durable particles, is preferred for stability. For maximum base stability, the granular base should have sufficient fineness to just fill the voids and the entire gradation should be close to its maximum density. However, while base density is, maximized at fines content between 6 to 20%, load carrying capacity decreases when fines content exceeds about 9%.Stability also increases with percentage of crushed particles and increases coarse aggregate size.

### 2.2.4 Permeability

Since the granular sub base provides drainage for the pavement structure ,its grading and hydraulic conductivity are important ,the fines content is usually limited to 10 percent for normal pavement construction and 6 percent where free draining sub base is required.

### 2.3 Indian department of transportation manual Aggregates specification and requirements

Specifications are generally clear, concise, quantitative descriptions of the significant characteristics of a construction material. The specifications required by INDOT are documented in the latest edition of the Standard Specifications and the current Supplemental Specifications. . The specifications are to be followed when inspecting aggregates. There are two general types of requirements for aggregate: quality and gradation.

## 2.4 Objectives

- To evaluate the stability and permeability of sub-base layer grade 2.
- To evaluate the combined stability and permeability of sub-base and base layer with different Composition.

- To evaluate the stability and permeability of base layer.

# 3. METHODOLOGY

## 3.1 Proportioning of materials by Rutchforth method for GSB II and WMM

Four groups of Aggregates of nominal size 40 mm, 20 mm, 10 mm and dust are proportioned using Rutchforth method

## 3.2 Preparation of specimens for CBR tests

### 3.2.1 Preparation of specimen for CBR test for GSB II, WMM and proportions of GSB and WMM

Using the volume of CBR mould and knowing the density of coarse aggregates obtain the required mass of coarse aggregate required to be filled in the mould. The materials taken for conducting CBR tests are GSB II, WMM, 25%GSB II-75%WMM, 50%GSB II-50%WMM, 75% GSB II-75%WMM.The CBR tests are conducted separately each time for every material. Take the aggregates in a tray and add known quantity of water (Optimum moisture quantity determined for aggregates) and mix thoroughly and separate this mass into five parts. Fill the first layer of the aggregates in mould and compact them by giving 56 blows using 4.5 kg rammer. Now fill the second layer and give 56 blows to the aggregates by 4.5 kg rammer and repeat the procedure for another three layers, then conduct the CBR test.

### 3.2.2 Preparation of specimen for CBR test for Cement treated sub base (1% and 1.5%cement treated sub base)

Using the volume of CBR mould and knowing the density of coarse aggregate obtain the required mass of coarse aggregate required to be filled in the mould. Take 1% (by mass of aggregates) of cement quantity and add known quantity of water (quantity of water known by conducting standard consistency test on cement) to the cement and mix thoroughly. Add known quantity of water (Optimum moisture quantity determined for aggregates) to the aggregates and mix them properly, then mix cement and aggregates uniformly in the tray and separate them in five parts. Fill the first layer of the aggregates in mould and compact them by giving 56 blows using 4.5 kg rammer. Now fill the second layer and give 56 blows to the aggregates by 4.5 kg rammer and repeat the procedure for another three layers. Then keep them in soaked condition for four days to simulate the field conditions and conduct the CBR test. In the same way the specimen is prepared for conducting CBR test on 1.5% Cement treated sub base.

## 3.3 Preparation of specimens for Permeability of Coarse aggregates

### 3.3.1 Preparation of specimen for permeability test on GSB II, WMM and proportions of GSB II and WMM

The permeability test is conducted on GSB II, WMM, 25% GSB II-75%WMM, 50%GSB-50%WMM, 75%GSB-25%WMM.Using the volume of permeability mould and knowing density of the aggregates calculate the mass of aggregates and fill them in the permeability box in layers. Fill the first layer of aggregates in the box and with the tamping rod compact them by giving suitable number of blows to obtain the required density. Fill the next layer in the box and compact them as in the above step. Repeat the procedure till all the layers are filled in the box and keep the box in the permeability set up and conduct the permeability test.

### 3.3.2 Preparation of specimen for permeability test on Cement treated granular sub base II (1% and 1.5% cement treated sub base)

GSB-II material is taken and suitable quantity of water is added to it (OMC of aggregates).1% of Cement (by weight of aggregates) is taken and required quantity of water (determined by standard consistency test on cement) is added to the cement and is mixed well, then both the aggregates and cement are added and uniformly mixed. Fill this material in the permeability mould in layers. Fill the first layer and compact it by tamping rod to obtain the required density. Similarly fill all the layers and compact them by tamping rod by giving suitable number of blows to obtain the required density and then place the permeability mould in the permeability set up and conduct the permeability test. In the same way Repeat the procedure for conducting permeability test on 1.5% Cement treated Granular sub base II.

## 3.4 Strength and Permeability tests

### 3.4.1 CBR tests

The California Bearing Ratio (CBR) test is a method for evaluating the strength of sub grade soil and other pavement materials for the design and construction flexible pavements. CBR tests are conducted on GSB, WMM and proportions of GSB and WMM materials i.e. 25% GSB-75%WMM,50% GSB-50% WMM,75% GSB-25% WMM in unsoaked or soaked conditions( to Simulate the field conditions). CBR tests on Cement treated sub base with 1% and 1.5% cement content in soaked conditions(to simulate the field conditions) are also conducted. The results of all the CBR tests are mentioned in table no 4.6 and 4.7 in results and discussions chapter.

#### 3.4.2 Permeability tests

Permeability test is used for measuring water draining capacity of aggregates. The material is said to be showing Excellent, Good, fair and poor drainage characteristics depending on the time required to drain the water. Permeability tests on GSB, WMM and 25% GSB-75% WMM materials are conducted as in Fig 1. Permeability tests on Cement treated sub base (1% cement) and cement treated sub base (1.5% cement) have been done and the results have been quoted in Table7.

**Table 1 Drainage coefficients ($m_2$ and $m_3$) of untreated granular layers [2]**

| Drainage quality | Percent time of pavement structure is exposed to saturation moisture levels | | | | |
|---|---|---|---|---|---|
| | | | | | |
| Time required for draining water | Subjective rating | <1% | 1%-5% | 5%-25% | >25% |
| 2 hours | Excellent | 1.40 to 1.35 | 1.35 to 1.30 | 1.30 to 1.20 | 1.20 |
| 1 day | Good | 1.35 to 1.25 | 1.25 to 1.15 | 1.15 to 1.00 | 1.00 |
| 1 week | Fair | 1.25 to 1.15 | 1.15 to 1.05 | 1 to 0.80 | 0.80 |
| 1 month | Poor | 1.15 to 1.05 | 1.05 to 0.80 | 0.80 to 0.60 | 0.60 |
| Never drain | Very poor | 1.05 to 0.95 | 0.95 to 0.75 | 0.75 to 0.40 | 0.40 |

Structural number can be calculated by using the formula below:

Structural number (SN) = $a_1D_1 + a_2D_2m_2 + a_3D_3$

where $a_1, a_2, a_3$ are layer coefficients for asphalt course, granular base course and granular sub base course .$D_1$, $D_2$, $D_3$ are thickness of asphalt course, granular base and sub base layers. $m_2$, $m_3$ are drainage coefficients of granular base and sub base layers as quoted in Table1 .The values of $a_1$, $a_2$, $a_3$, $D_1$, D2, D3, m2, m3 are taken from the above tables mentioned. [2]

Knowing the structural number previously calculated and Using the below formula the composite layer thickness (D) can be found out by the formula below

$SN=a_1D_1+a_xD_xm_x$, where $a_1, a_x$ are layer coefficients for asphalt course, composite layer and $D_1, D_x$ are thickness of asphalt course and composite layer respectively and m is drainage coefficient for composite layer.

Analysis of Cement treated sub base is done according to AASTHO manual and all the procedures done in design of composite layer according to AASTHO mentioned above have to be done to finalize the thickness of pavement.

**Fig1. Permeability apparatus**

## 4. RESULT AND DISCUSSION

### 4.1 Results of Materials Tests

#### 4.1.1 Results of sieve Analysis

The sieve analysis on Granular sub base aggregates have been carried out and the percentage passing of 40 mm, 20 mm, 10mm aggregates and dust are tabulated in the Table2.

**Table 2 Sieve analysis on GSB-II**

| Sieve size (mm) | Percentage of passing of 40 mm | Percentage of passing of 20 mm | Percentage of passing of 10 mm | Percentage of passing of dust |
|---|---|---|---|---|
| 53 | 100 | 100 | 100 | 100 |
| 26.5 | 38.33 | 100 | 100 | 100 |
| 9.5 | 0 | 2.667 | 74 | 100 |
| 4.75 | 0 | 0.334 | 4 | 100 |
| 2.36 | 0 | 0 | 0 | 100 |
| 0.425 | 0 | 0 | 0 | 10 |
| 0.075 | 0 | 0 | 0 | 0 |

The sieve analysis test on Wet mix macadam have been done and the percentage passing of 40 mm.20 mm,10 mm aggregates and dust have been tabulated in the Table3.

**Table 3 Sieve analysis on WMM**

| Sieve size (mm) | Percentage of passing of 40 mm | Percentage of passing of 20 mm | Percentage of passing of 10 mm | Percentage of passing of dust |
|---|---|---|---|---|
| 53 | 100 | 100 | 100 | 100 |
| 45 | 95 | 100 | 100 | 100 |
| 26.5 | 10.667 | 100 | 100 | 100 |
| 22.40 | 1.334 | 88 | 100 | 100 |
| 11.20 | 0 | 0.5 | 88 | 100 |
| 4.75 | 0 | 0 | 4 | 98 |
| 2.36 | 0 | 0 | 2 | 74 |
| 0.6 | 0 | 0 | 0 | 24 |
| 0.075 | 0 | 0 | 0 | 0 |

#### 4.1.2 Physical properties of Aggregates

The physical properties tests on aggregates are conducted and results of tests and specifications laid down by IRC have been quoted in the Table 4.

**Table 4 Basic properties of aggregate**

| Parameters | | Results | Specification as per IRC |
|---|---|---|---|
| Combined Elongation and Flakiness index | | 25% | 30% (max.) |
| Los Angeles Abrasion value | | 20% | 40%(max) |
| Aggregate Impact Value | | 12% | 30% (max) |
| Water absorption | | 1.1% | 2% |
| Specific gravity | | 2.7 | 2.5-2.8 |
| Aggregate crushing value | GSB | 29% | 40% |
| | WMM | 22% | |
| | 25% GSB 75% WMM | 24.6% | |

## 4.2 Proportioning of Aggregate by Rutchforth Method

#### 4.2.1 Proportioning of GSB (grade -II)

The proportioning of Granular sub base aggregates has been done according to Rutchforth method and required gradation and obtained gradation have been laid down in the Table 4.4

### 4.3 CBR tests on different materials

#### 4.3.1 CBR tests on GSB, WMM and proportions of GSB and WMM

The CBR tests on GSB, WMM material and proportions of GSB and WMM are done and following are the results mentioned in the Table 5.

**Table 5 CBR tests on GSB, WMM and proportions of GSB and WMM**

| Specification | GSB | WMM | 25%GSB-75%WMM | 50%GSB-50%WMM | 75%GSB - 25%WMM |
|---|---|---|---|---|---|
| CBR | 55.47% | 92% | 96% | 56.26% | 33.2% |

#### 4.3.2 CBR values of cement treated sub base

The CBR tests on Cement treated sub base with 1% Cement and 1.5% cement have been done and results are given in Table6.

**Table 6 CBR values of cement treated sub base**

| Specification | 1%cement treated sub base | 1.5% cement treated sub base |
|---|---|---|
| CBR | 111% | 128% |

## 4.4 Permeability Tests

The permeability tests on GSB, WMM, and 25% GSB-75% WMM, Cement treated sub base (1% Cement and 1.5% Cement) have been carried out and results are tabulated in the Table7.

**Table 7 Permeability values for different materials**

| Layers | Time taken to collect 100 ml | | Average time in seconds |
|---|---|---|---|
| | Seconds (1) | Seconds (2) | |
| GSB | 3.49 | 3.47 | 3.48 |
| WMM | 4.10 | 4.12 | 4.11 |
| 25%GSB -75%WMM | 5.32 | 5.28 | 5.30 |
| CT GSB (1%) | 5.0 | 6.0 | 5.5 |
| CT GSB (1.5%) | 9.0 | 11.0 | 10 |

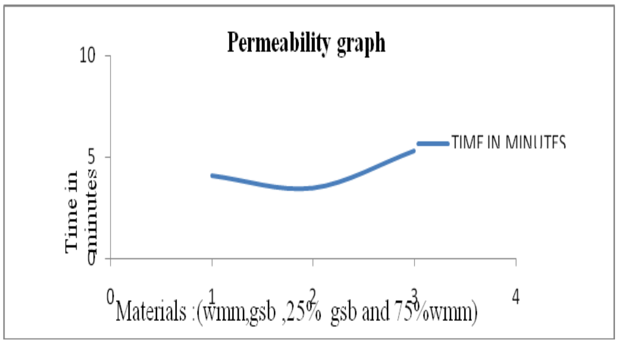


**Fig. 2 Permeability of different materials**

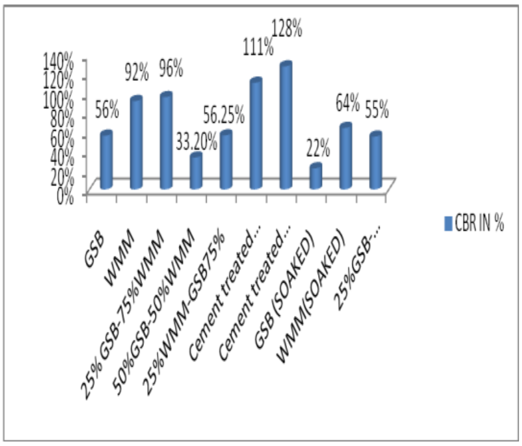


**Fig. 3 CBR tests for different materials**

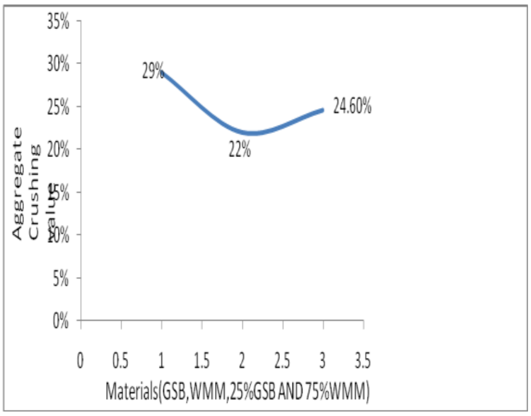


**Fig. 4 Aggregate crushing strength for different materials**

## 4.5 Discussions

- All the basic physical properties of aggregates like have been found within the limits of MORTH manual.
- The aggregate crushing strength tests on GSB-II ,WMM and 25%GSB-75%WMM have been done(test which signifies load carrying capacity until the crushing of aggregates) and it has been found that only WMM layer(with aggregate crushing strength 22%) can carry more load than the other two materials, but composite layer of GSB II and WMM layer can also take up sufficient load(ACV 24.6%).
- The CBR tests on GSB II,WMM,25%GSB-75%WMM,50%GSB-50%WMM,75%WMM-25%GSB revealed highest value of CBR of 96% for 25% GSB-75%WMM and then, only WMM layer gave 92% CBR value , GSB-55.47% ,50% GSB-50% WMM-56.26% ,75% GSB-25% WMM-33.2%.
- The order of decreasing CBR is 25%GSB-75%WMM>WMM>50%GSB-50%WMM>GSB>75%GSB-25%WMM, hence 25%GSB II-75%WMM can be adopted for construction of flexible pavement as it gives maximum strength at optimum thickness of pavement.
- Permeability tests were conducted on GSB,WMM and 25%GSB-75%WMM material and time for collection of water of 100 ml was 3.48,4.11,5.30 seconds respectively which denotes GSB material drains water quickly than the other two materials

Solution:

$$N= [365*A* [ (1+r)^{n} -1)]*LDF*VDF]/(r)$$

$$=[365*500*[(1+0.05)^{15}-1)]*0.75*2.5]/(0.05) \quad =7.3 \quad =8$$ MSA

- The composite layers give the considerable permeability but not to the level of only GSB layer. But it can be used in dry areas as it will give sufficient strength at optimum thickness.
- The Cement treated sub base yielded 111% and 128% CBR values at 1% and 1.5% cement content by weight of aggregates and took 5.5 and 10 seconds for collection of 100 ml water, CTGSB pavement with 1% cement content can be adopted for maximum strength with reduced thickness much lesser than composite layer pavement and for good drainage conditions.

## 5. DESIGN PRINCIPLES

Design procedure as per IRC 37-2001, AASHTO manual for designing flexible pavement using different composition of GSB and WMM layer and cement treated sub base design has been done and presented in Table 8.

### 5.1 Design of flexible pavement as per IRC 37-2001

Number of commercial vehicles after construction A=500 CVPD

Traffic growth rate=5%, Lane distribution factor=0.75, Vehicle damage factor=2.5
Design life =15 years. Design the pavement for the above data.

As per IRC 37-2001, referring the chart for 8 MSA and CBR of sub grade 8% And Pavement design catalogue recommended designs for traffic range 1-10 MSA the thickness of pavement is 510 mm

**Table 8 Pavement design catalogue[3]**

| CBR 8% | | | | | |
|---|---|---|---|---|---|
| Cumulative traffic(msa) | Total pavement thickness (mm) | Pavement composition | | | |
| | | Bituminous surfacing | | Granular base(mm) | Granular sub-base (mm) |
| | | Wearing course(mm) | Binder course(mm) | | |
| 1 | 375 | 20 PC | | 225 | 150 |
| 2 | 425 | 20 PC | 50 BM | 225 | 150 |
| 3 | 450 | 20 PC | 50 BM | 250 | 150 |
| 5 | 475 | 25 SDBC | 50 DBM | 250 | 150 |
| 10 | 550 | 40 BC | 60 DBM | 250 | 200 |

Individual thickness of layers by catalogue for CBR for sub grade =8% and traffic range 1-10 million scale axles are: SDBC=30 mm, DBM=50 mm, WMM=250 mm, GSB=180 mm

## 5.2 Design of pavement as per AASTHO Procedure

We consider layer coefficients of asphalt, base and sub base course. Also thickness of all the three layers is taken into account. Permeability co-efficients are also made use of for granular base and granular sub base layers. The concept of Structural number (SN) is made use of for determining the total pavement thickness in this method instead of Cumulative number of standard axles concept as in IRC 37-2001.

Specification given by AASTHO for the design of flexible pavement and parameters to be considered to calculate structural number are presented in table no from 3.1 - 3.4 from chapter 3 Methodology.

Structural number (SN)= $a_1D_1 + a_2D_2m_2 + a_3D_3m_3$

= (0.363*0.08) + (0.137*0.25*1.15) + (0.127*0.18*1.2) =0.095

Where $a_1, a_2, a_3$ are layer coefficients for asphalt course, granular base course and granular sub base course .

$D_1, D_2, D_3$ are thickness of asphalt course, granular base and sub base layers.

$m_2, m_3$ are drainage coefficients of granular base and sub base layers .

The values of $a_1, a_2, a_3, D_1, D_2, D_3, m_2, m_3$ are taken from the above tables mentioned

SN=0.095=(0.363*0.08)+($a_xD_xm_x$)

=0.095=(0.363*0.08)+(0.140*$D_x$*1.163) (0.08 m is asphalt course thickness)

$D_x$=0.405 m

## 5.3 Design of flexible pavements with cement treated granular sub base/base

Considering cement treated granular sub base with 1.5% by weight of aggregates and standard consistency of 33% (W=6000 gm of aggregates, OMC of aggregates=2.2g/cc, cement=90 gm, water =29 ml).

Structural number SN of flexible pavement obtained was 0.095 .Considering CBR of cement treated granular sub base i.e. 128%

SN=0.095=(0.363*0.08)+(0.1648*$D_x$*1.2) (0.1648 is layer co-efficient for cement treated granular sub base with 128% CBR obtained from table above) therefore $D_x$=0.333 m

# 6. COST ANALYSIS

The cost analysis is done for a typical example considered in our project mentioned in chapter 5 Design principles for a length of one Km and formation width being 10 m ,cross slope being 1:1.5(1 vertical to 1.5 horizontal) and overall pavement thickness being 485 mm with composite layer(25% GSB-75% WMM) thickness of 405 mm .The design life of pavement being 15 years and traffic growth rate 5% and number of commercial vehicles after construction period is 500 CVPD, Lane distribution factor is 0.75, Vehicle damage factor is 2.5

## 6.1 Cost analysis for Normal flexible pavement

The cost of GSB per $m^3$ is 1300 Rs and cost of WMM per $m^3$ is 1400 Rs according to schedule of rates for Dharwad division Karnataka India 2013-2014. Hence for one km length of flexible pavement having 2030 $m^3$ of GSB and 2655 $m^3$ of WMM the cost(excluding bituminous surfacing) incurred is 63,56000 Rs.

## 6.2 Cost analysis for composite layer (25%GSBII-75%WMM) pavement.

The cost of GSB per $m^3$ is 1300 Rs and cost of WMM per $m^3$ is 1400 Rs according to schedule of rates for Dharwad division Karnataka India 2013-2014. Hence for one km length of flexible pavement having 4393 $m^3$ of Aggregates the cost (excluding bituminous surfacing) incurred is Rs 60, 40,375.Hence there is a reduction in percentage cost by 5.23% when compared to normal flexible pavement.

## 6.3 Cost analysis for cement treated sub base road

The cost of GSB per $m^3$ is 1300 Rs and cost of WMM per $m^3$ is 1400 Rs according to schedule of rates for Dharwad division Karnataka India 2013-2014.Hence for one km length of flexible pavement having 2006.5 $m^3$ of normal GSB, 855.2 $m^3$ of Cement treated sub base GSB aggregates and 935.1 $m^3$ of WMM the cost (excluding bituminous surfacing) incurred is Rs 5039850. Hence there is a reduction in percentage cost by 26.11% when compared to normal flexible pavement. Results are quoted in Table 9.

**Table 9 Analysis of cost for different pavements**

| Cost analysis for different type of roads | | |
|---|---|---|
| **Normal conventional flexible pavement** | **Composite layer(25%GSB-75%WMM) pavement** | **Cement treated subbase pavement** |
| 6356000 Rs | 6040375 Rs | 50,39,850 Rs |

# 7. CONCLUSION

- Flexible Pavement consisting of Composite layer of GSB-2 and WMM gives satisfactory permeability and strength.
- It is found that pavement consisting of composite layer of GSB II and WMM with 25% and 75 % respectively has reduced thickness (25 mm thickness reduction) as per AASHTO design procedure compared to Normal Flexible Pavement design as per IRC-37 2001.
- With the use of Cement treated sub base(1.5% cement by weight of aggregates) pavement thickness is reduced by 90 mm.
- The cost of Normal Flexible pavement per Km length designed as per IRC 37-2001 is 63,56,000 Rs(excluding bituminous surfacing),while The cost of Composite layer pavement per Km length (GSB 25%-75% WMM) is Rs 60,40,375 (excluding bituminous surfacing). While the cost of Cement treated sub base pavement per km length is 50, 39,850 Rs(excluding bituminous surfacing).
- We can reduce the cost of the flexible pavement by Rs 3,15,625 adopting composite layer(25%GSB-II and 75%WMM)
- We can reduce the cost of flexible pavement further by adopting cement treated sub base by 13, 16,150 Rs.
- Adopting Composite layer pavement (25%GSB-75%WMM) and Cement treated sub base pavement would give sufficient strength, permeability with overall reduction in pavement thickness and would result in less investment or cost saving for the same strength character as compared to Normal Conventional Flexible pavement and it may be higher fatigue life.

# Reference

1. Ministry of Road transport and Highways, “Specification of road and bridge works” (fourth revision) Indian Roads Congress, New Delhi, India 2001.

2. American association for state Highway and transport officials "AASTHO guide for design of pavement structures", Washington DC 1993.
3. IRC 37-2001 "Guidelines for design of flexible pavement" (second revision) July -2001, New Delhi.
4. Global security org military publications "Sub base and Base materials", June 2000.
5. New Zealand transport agency "specifications for insitu stabilisation of bound sub base layers" edition July 2012.
6. Indian department of transportation manual "Aggregate Specification and requirement" 1999.
7. IS 383-1970 "Indian standard specifications for Coarse and fine aggregates from natural source of concrete" (second revision) 1993.