# NUMERICAL ANALYSIS OF CONCRETE PAVEMENTS & COMPARISON OF ITS SETTLEMENT WITH GEOWEB PAVEMENT BY LVDT & STRAIN GAUGES

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**Abstract** – Western ghat situated in India is considered as one of the most landslide susceptible region which makes it more dangerous to build long lasting road pavements. To overcome this problem we tried to strengthen the base layer of concrete pavement with the help of geoweb, made up of geo polymers. A laboratory based analysis was carried out with the help of various tests. For analysis of vertical stresses on concrete block the strain gauge and LVDT sensor are used in this study.
To validate the results obtained from laboratory based design and analysis the powerful software for finite element design known as ANSYS is used. A 3D model of rigid pavement is created and by keeping all other material properties same the vertical stresses are calculated from ANSYS.
Regarding that finite element analysis, this study gives comparison between the standard concrete pavements having base course, sub base course and concrete block having geoweb included in its base course. The numerical analysis and model analysis by using software provides assurance.

**IndexTerms** - ANSYS, LVDT, Geoweb, CPCD.

## I. INTRODUCTION

There are total 36 biodiversity hotspots in world, out of which Western Ghats is one of them. Situated on the western coast of India, western ghat receives an average rainfall of 3000 – 4000mm. This rainfall leads to rock erosion, landslides, damage to roads etc. This study overviews the effect of rainfall on road pavement, also how we can minimize by changing material properties of road pavement.
Concrete Pavement Contraction Design (CPCD)
CPCD contains transverse joints provided at regular intervals. The transverse joints are used for the purpose of controlling contraction and expansion caused due to temperature in the concrete. Smooth dowel bars are used for load transfer in concrete pavement. Longitudinal joints in this pavement are used to control and prevent longitudinal cracking. Tie bars are used to tie longitudinal joints together.


Fig. 1 : CPCD road construction

Fig. 2 : Geo web pavement construction

There are various factors which are required to consider before construction of rigid pavement. Following are some of the important factors on which the design of rigid pavement is dependent:

- Soil below slab
- Subgrade
- Joints
- Drainage system
- Slope of ground
- Base/ Sub base
- Shoulder/ edge support
- Soil moisture
- Vertical stresses
- Traffic loading

We have witnessed with linear cracking in Western ghat region most often, the reason behind such failure is traffic loads which come at repeated interval and also the curling due to thermal gradient and moisture of soil. Settlement of the pavement is caused due to soft foundation. The pumping or the erosion of material under the pavement leads to formation of voids under pavement slab causes settlement.

In this study the layer below pavement slab are replaced and the fiber based geoweb polymer material is added in base course. Geo web has higher resistance against vertical as well as transverse stresses. As fig. 2 can create a pictionary image the geoweb is mesh like structure which has to be laid in base layer of highway pavement. Due to this, a stronger bond will be developed between soil particles.

For the testing of soil, the location of Posare village situated in Ratnagiri district of Maharashtra, India is selected as it comes in the landslide prone area and recently been witnessed landslide. The site location is shown in fig. 3

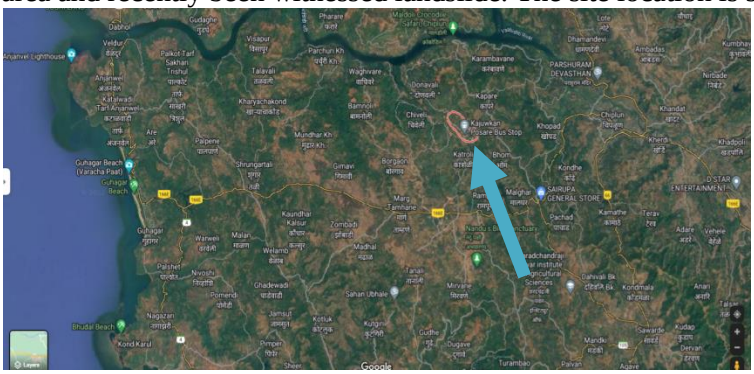


Fig 3 :Posare village map, ratnagiri, western ghat, India.

Total of 500kg soil sample was collected form the site of landslide to perform various laboratory tests on it.

## II. LITERATURE SURVEY

**Otti VI, Nwolun C, Ezechukwu M. DanNwafor K [1]** This study gives the detailed comparison between flexible pavement and rigid pavement. From this study it is observed that in flexible pavement, structure is typically composed of multiple layers. In which the better quality material is placed on the top where intensity of stress from traffic loads is more and low quality material is placed in below layers. The study has shown that, in flexible pavement, base is responsible for structural stiffness and not the top layer.

Also rigid pavement has rich mixture of Portland cement and course aggregate as a single course. From the observations noted by this study, in the comparison of both flexible and rigid pavement, rigid pavement is a preferable choice because it is composed of Portland cement concrete surface course which ultimately stiffer material than flexible pavement due to high modulus of plasticity.

**Gholam Ali Shafabakhsha,*, Afshin Familyb, and Babak Pourzand Hossein Abadc [11]** It is observed in this research that because of time consuming properties and complex intervention of different materials they replaced laboratory based design and analysis of pavements with quick and powerful software including finite element. The finite element software ABAQUS is used for this analysis. The effect of change in concrete thickness according to vertical stresses is pointed out in this paper. Also in this study effect of asphalt concrete thickness change was studied. It has observed that concrete blocks not only act as wearing surface but also act as a single structural element. This means that individual paving blocks interlock more efficiently and they can act to dissipate traffic loads. It is also observed that load transfer will be high in thicker concrete blocks due to higher frictional area that is provided by them. Also in asphalt concrete pavement the use of thicker asphalt layer resulted in reduction in deformations.

**B. C. Panda and A. K. Ghosh [11]** showed that using bedding sand layer in the pavement can improve the efficiency of concrete upon increasing strength versus vertical deflection.

## III. METHODOLOGY

The most important purpose of this research is to identify behavior of concrete pavement in comparison with the pavement with improvised base support. In landslide prone areas of Western ghat the concrete blocks settlement leads to the crack formation and failure of road pavement as vertical stresses are different than normal soil conditions. To ensure the accuracy of FEM analysis, two validations were carried out on is from the theoretical basis and experimental method and another one is from FEM software ANSYS.

For the experimental method to measure the deflection i.e. strains in block, Strain Gauge device is used. To measure the deflection LVDT sensor is used.

I. Strain gauge

A strain gauge is a device used to measure the strain exerted on an object. It is most widely used in experimental stress analysis to state the stress on the material and also to predict its endurance level and safety. The Strain gauge helps to calculate the physical amount of pressure or stress exerted on the material.

When a strain gauge device is placed under a material and force is exerted on the material, the device analyses the amount of stress being put on the material and gives the data on the display monitor.

Fig.4: Strain Gauge

Fig.5: LVDT Sensors.

II. LVDT displacement sensors

"An LVDT measures displacement by associating a specific signal value for any given position of the core. This association of a signal value to a position occurs through electromagnetic coupling of an AC excitation signal on the primary winding to the core and back to the secondary windings. As the loading is applied on the concrete block it gets deflected and the length of deflection can be measured by LVDT displacement sensor."

III. Tests on soil sample collected.

As a part of experiment the soil sample was collected from Western ghat. There is village named 'Posare' in Ratnagiri district which encountered landslide in year 2021, from this location a sample of 500kg of soil is collected for testing purpose. After various soil tests on multiple samples the most of the test results are showing a declination towards the clayey soil.

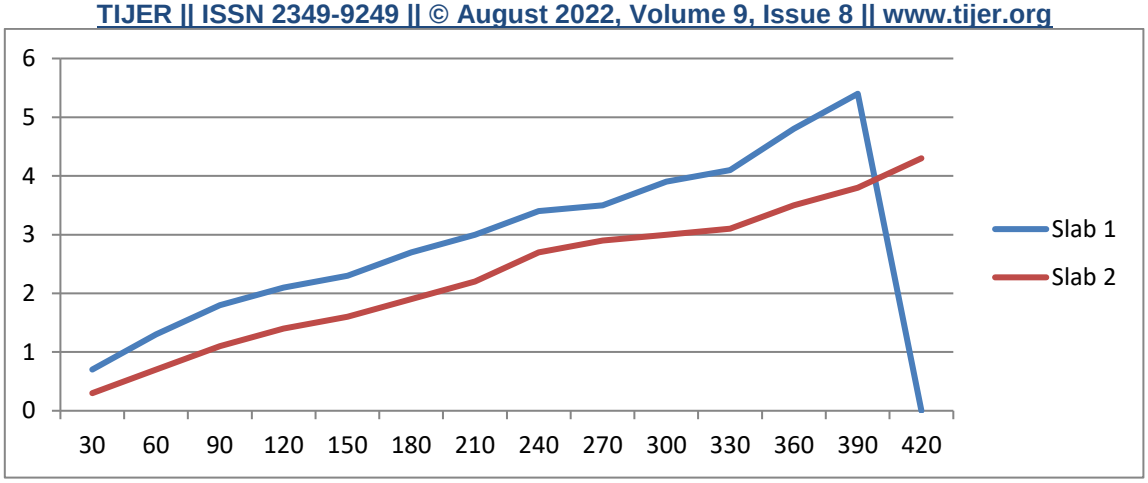
Followings are the test results observed by Strain Gauge and LVDT:

Slab 1 = Slab with standard pavement base

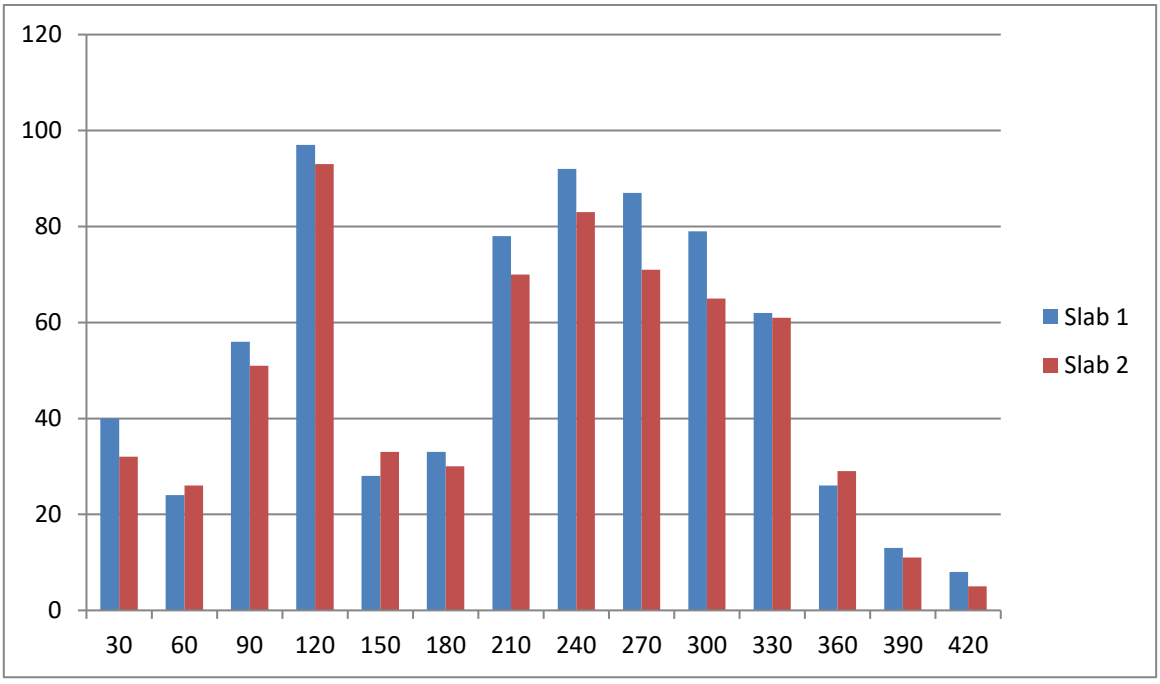
Slab 2 = Slab with geoweb supported pavement base

| **Load ( KN )** | **LVDT Readings** | | **Strain Gauge Readings** | |
|---|---|---|---|---|
| | **Slab 1** | **Slab 2** | **Slab 1** | **Slab 2** |
| 0 | 0.7 | 0.3 | 40 | 32 |
| 30 | 1.3 | 0.7 | 24 | 26 |
| 60 | 1.8 | 1.1 | 56 | 51 |
| 90 | 2.1 | 1.4 | 97 | 93 |
| 120 | 2.3 | 1.6 | 28 | 33 |
| 150 | 2.7 | 1.9 | 33 | 30 |
| 180 | 3 | 2.2 | 78 | 70 |
| 210 | 3.4 | 2.7 | 92 | 83 |
| 240 | 3.5 | 2.9 | 87 | 71 |
| 270 | 3.9 | 3 | 79 | 65 |
| 300 | 4.1 | 3.1 | 62 | 61 |
| 330 | 4.8 | 3.5 | 26 | 29 |
| 360 | 5.4 | 3.8 | 13 | 11 |
| 390 | 6.2 | 4.3 | 8 | 5 |
| 420 | 6.9 | 4.5 | 81 | 77 |

Table 1




Graph 1: loading on X-axis Vs. Deflection in mm on Y-axis




Graph 2: Loading in KN on X-axis Vs. Strain on Y-axis

The above experimental values are validated by the FEM software 'ANSYS'. A 3D Pavement model was analyzed in which subgrade, sub base layers kept same. Only the material properties of Geo web was added in Base course during analysis. Vertical stress resulted in experimental and ANSYS software for concrete block pavement are given in table 2 below.

| Position | Experimental Result ( KPa ) | ANSYS Result( KPa ) |
|---|---|---|
| At the Corner | 450 | 445 |
| At the Mid-section | 250 | 250 |
| ½ Distance from Corner to Middle | 375 | 376 |
| Below Opposite corner | 420 | 420 |

Table 2

## I. Conclusions

The results obtained from model analysis of two cases of rigid pavement by experimental method and ANSYS software, numerical results of this comparison are presented in Table 2. It is observed that there is a good agreement between the results calculated with FE models on ANSYS and the measured results. From the results, it can be concluded that the vertical stresses induced on rigid pavement can be minimized significantly if the geowebs are added in the base layers of pavement and can increase the durability of concrete pavement by minimum 15%.

## II. References

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