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# Strengthening of Rigid Pavement by use of GEO-GRID

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## ABSTRACT

Geo-grid is a new geo-synthetic material that is utilized as structural reinforcement. “The benefits and viability of using geo-grids in concrete must be determined. The flexural and deflection behavior of PCC beams strengthened with biaxial and uniaxial geo-grid in single and double layer for two distinct concrete mix designs is the subject of this research. Geo-synthetic reinforcement has been shown to increase pavement performance in the field. The number of geo-grid layers in concrete beams is being monitored in order to improve flexural strength and deflection. Because PQC lacks reinforcing, it is more likely to fail under tensile strains caused by temperature differences and severe wheel load stresses. Geo-grid materials have demonstrated their capacity to replace stainless steel reinforcement. The experiment included two-point loading of 48 geo-grid concrete beams and the preparation of 18 cubes for compression testing. The test results are broken down into four categories: ultimate load carrying capability, flexural force behavior, load deflection behavior, and crack patterns. The two-point loading test on geo-grid beams reveals that the geo-strength grid's and the number of layers play an essential role in increasing load carrying efficiency and strength.

**KEYWORDS:** Uniaxial Geo-grid, Biaxial geo-grid, PQC, concrete payments, flexural strength, crack pattern andload deflection behavior”.

## INTRODUCTION

For millennia, “reinforced concrete has been employed in the construction of various constructions. Reinforced concrete is defined as a mixture of sand, gravel, cement, water, and a variety of other admixtures coupled with a reinforcement system, which is typically steel. Concrete has a high compressive strength but low tension strength. As a result, cracking and failure can occur under high tensile pressures. Steel has a high friction potential and can be used to compensate for its poor tensile strength in places with high friction stresses..

Beams must be examined from all angles, including strength, stability, and serviceability. Engineers are continuously confronted with the need to maintain and enhance pavement infrastructure while working with limited financial resources. To achieve building criteria, traditional paving and construction activities demand high-quality materials.

Materials are unavailable or out of supply in more parts of the world. Because of the limits imposed by the use of poor materials, engineers are constantly obliged to seek for alternate designs. Innovative architectural methods and commercial construction assistance One sort of industrial building help is geo-synthetics. Geo-synthetics is a term that refers to a group of polymer products that are used to improve geotechnical and transportation projects. A geo-grid is a geo-synthetic material that consists of a connected network of parallel tensile strips with large enough

grids, “welded geo-grids, and composite geo-grids are examples of industrial geo-grids for stone or

Geo-grid can be made from steel, glass fiber, polyester or polypropylene, as well as organic natural products such as bamboo. Pavement distress can occur either because of traffic or environmental loads. Repeated wheel loads result in traffic loads that are cause structural or functional failures.

Temperature fluctuations or sub grade dampness are examples of climate conditions. It can generate surface disturbances as well as structural and environmental loads. The base course material can be broken down by wetting and drying cycles (or freezing and thawing). Pavement efficiency is also influenced by construction procedures. The use of too finer aggregates, for example, will cause pavement to degrade quickly.

Finally, pavement distress is a result of improper maintenance or a lack of upkeep. Ceiling cracks and joints at appropriate intervals, for example,

apertures or holes to allow striking through the surrounding soil. Extruded geo-grids”, knitted geo-aggregate.

and shoulder holding improve pavement efficiency.

New pavement design and maintenance procedures rely heavily on geo-grid. Their global use, particularly for transportation applications, has grown at an incredible rate. Bridges, harbors, and a variety of other infrastructure projects can benefit from geo textiles.

Several studies on the use of geo-grid in flexible pavement have been conducted. The utilization of geo-grid material in concrete pavement will now be discussed. The research focuses on the use of geo-grid in concrete pavements without compromising load carrying capacity or pavement efficiency.

Anyhow geo-grid reinforcement construction shows Significant economic and ecological advantages compared to classical concrete structures.

## 2. OBJECTIVE

The primary goal of this experiment is to investigate the strength and durability of geo-grid reinforced concrete, as well as cost-effective structural component construction to improve plain cement concrete's flexural load carrying capacity.

Structural behavior will be tested for future implementation in construction industry which creates another option in purpose of structural construction using geo-grid material. The high demand for geo-grids and their use in construction is due to good tension and greater capacity for load distribution over a wide area.

1) To study the flexural strength of concrete beam reinforced with geo-grid.

2) Determination of the governing mechanism and relevant geo-grid properties which contribute to enhancedrigid pavement performance.

3) Developing appropriate laboratory methods capable of measuring the properties mentioned above for geo-gridand concrete.

4) Allowing pavement efficiency prediction based on geo-grid.

5) Compare geo-grid reinforced concrete with PQC.

## 3. SIGNIFICANCE OF THE WORK

**Information of Geo-grid**

Information of Geo-grids are polymeric material made by intersecting ribs joining together. These also have wide open spaces known as 'apertures'. The lines of the ribs are called the direction of the machine (md), Throughout the manufacturing process, or perpendicular to the ribs of the unit.. Geo-grids are made mostly of polymeric materials typically polypropylene (PP), high-density polyethylene (HDPE) and polyester. Geo-grids are manufactured as a biaxial or uniaxial.

Biaxial Geo-grids are those with the same force in both directions of the machine and the cross-machine while uniaxial geo-grids exhibit the primary force in the one direction of the machine with limited strength, which is sufficient to preserve the aperture structure in the direction of the cross-machine".

**Methodology**

**Steps for geo-grid used rigid pavement design**

"Steps for geo-grid used rigid pavement design

(1) Preliminary test on materials

(2) Mix design for M25, M40 grade PQC

(3) Casting of control specimens and geo-grid beams using 1, 3 & 5 layers.

(4) Conducting two-point loading test using 30t loading frame for flexural strength and compressive strength ofconcrete.

(5) Study on the obtained results

**Stress analysis**

Stress analysis Stress analysis

a) Temperature Stresses- Because of the temperature difference between top and bottom of the dice, cure stresses (similar to bending stresses) are induced at the bottom or top of the slab. Differential temperature between top and bottom of the slab induces heat curling (warping) in pavement.

b) Frictional Stresses- Due to contraction of the slab due to shrinking or dropping temperature, tensile stresses are induced at the middle portion of the slab. The tensile stresses are causes due to friction between concrete slab and its foundation.

c) Wheel Load Stresses-Cement concrete slab is subjected to flexural stresses due to the wheel loads.

**Design of pavement**

Design data

1) Two lanes two-way National Highway

2) Location - Maharashtra state

3) Total two-way traffic ?3000 commercial vehicles/day at the end of construction period".

4) Flexural strength of cement concrete = 45 kg/cm²

5) Effective modulus sub grade reaction = 8 kg/cm² of the DLC sub base

6) Elastic modulus of concrete = 3 x 105 kg/cm²

7) Poisson's ratio = 0.15

8) Coefficient of thermal coefficient of concrete = 10 x 10-6/

9) Tyre pressure - 0.8 MPA= 8kg/cm²"

10) D

esign

life -

20

years

R -

0.07

5

Cumulative repetition in 20 years = 3000x365 = 47,418,626 commercial vehicles.

Trial thickness
=33 cm
Sub grade modulus = 5kg/ cm3
Design period = 20 years This design is safe against corner stress and temperature stress for single axle dual
wheel.= 3000x365 $\left[\frac{1.075^{20}-1}{0.075}\right]$
= 47,418,626 commercial vehicles.

- Design traffic= 25% of total repetitions of commercial vehicles = 11,854,657
- Trial thickness =33 cm

## 4. EXPERIMENTAL INVESTIGATION

**Specifications of Uniaxial geo-grid:** "Specifications of Uniaxial geo-grid: the Geo-grid be made from high tenacity polyester filament yarns of high tenacity with molecular weight? When measured in accordance to GRI-GG8 / ASTM D4603 and carboxyl end groups, 25000 g / mol? Measured according to GRI GG7 / ASTM D2455, 30 mmol / Kg.

**Table-1:** The Mechanical properties for knitted and PVC coated uniaxial geo-grids”

| Property | Test Method | Unit | Type-I | Type-II | Type-III | Type-IV | Type-V | Type-VI | Type-VII | Type-VIII |
|---|---|---|---|---|---|---|---|---|---|---|
| **Peak tensile strength**[1] | | | | | | | | | | |
| Machine Direction | ASTM D-6637 | kN/m | 60 | 80 | 100 | 120 | 150 | 200 | 250 | 300 |
| Cross-machine Direction | | | 20 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| **Reduction factors (RF) and Machine Direction long term design strength (LTDS)** | | | | | | | | | | |
| Creep ($RF_{CR}$) | 120 years life, 30° | | 1.57 | 1.57 | 1.57 | 1.57 | 1.57 | 1.57 | 1.57 | 1.57 |
| Installation damage ($RF_{ID}$) | Sand/silt/clay | | 1.05 | 1.05 | 1.05 | 1.05 | 1.05 | 1.05 | 1.05 | 1.05 |
| | <37.5 mm gravel | | 1.15 | 1.15 | 1.15 | 1.15 | 1.15 | 1.15 | 1.15 | 1.15 |
| Durability ($RF_D$) | pH = 4 to 9 | | 1.15 | 1.15 | 1.15 | 1.15 | 1.15 | 1.15 | 1.15 | 1.15 |
| LTDS – 120 years; sand/silt/clay; pH = 4 – 9 | | kN/m | 31.65 | 42.2 | 52.75 | 63.30 | 79.12 | 105.5 | 131.87 | 158.25 |
| LTDS – 120 years; Gravel < 37.5; pH = 4 – 9 | | kN/m | 28.89 | 38.53 | 48.16 | 57.80 | 72.24 | 96.32 | 120.40 | 144.4[illegible] |

**Table-2:** The physical properties for knitted and PVC coated uniaxial geo-grids

| **Physical Properties**[2] | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Aperture size (± 3 mm) | | mm | 30 x 25 | 30 x 25 | 30 x 23 | 30 x 23 | 30 x 23 | 30 x 22 | 30 x 20 | 30 x 20 |
| Roll Width | | Mtr | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| Roll Length | | Mtr | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

MD – Machine Direction, CD-Cross Direction, Minimum average rolls value.

**“Specifications of biaxialgeo-grid :** Qualifications of biaxialgeo-grid :The Geo-grid be duty-bound towards being thru of polyester monofilament fish story of high tenacity without molecular weight? When calculated in conjunction with the end groups GRI-GG8 / ASTM D4603 and Carboxyl, 25000 g / mol? Stately as each GRI GG7 / ASTM D2455, 30 mmol / Kg.

**Table-3:** The Mechanical properties for knitted and PVC coated biaxial geo-grids”

| **PROPERTIES** | | **TEST METHOD** | **TYPE-I** | **TYPE-II** | **TYPE-III** |
|---|---|---|---|---|---|
| Ultimate tensile strength -(1) (kN/m | MD | ASTM D 6637 | 30 | 40 | 60 |
| | CD | | 30 | 40 | 60 |
| Elongation at Nominal Strength % | MD | | 14 | 15 | 15 |
| | CD | | 14 | 15 | 15 |
| Tensile strength at 2% strain (kN/m) | MD | | 6 | 7.5 | 9 |
| | CD | | 6 | 7.5 | 8 |
| Tensile strength at 5% strain (kN/m) | MD | | 10.5 | 14 | 16 |

**Table-4:** The Physical properties for knitted and PVC coated biaxial geo-grids

| | CD | | 10.5 | 14 | 16 |
|---|---|---|---|---|---|
| Aperture size in mm (± 2 mm) | MD x CD | | 25 x 25 | 25 x 25 | 25 x 25 |
| Roll Width (Mtr.) | | | 5.00 | 5.00 | 5.00 |
| Roll Length (Mtr.) | | | 100.00 | 100.00 | 100.00 |

MD – Machine Direction, CD-Cross Direction, Minimum average rolls value.

**Concrete Mix Design**

**Design for M 25 Grade**

**Table-5:** Concrete Mix design M25

| **"Mix Proportion for Trials** | | | **Final Content**(Kg/m3) |
|---|---|---|---|
| **Cement** | 390.0 | Kg/m3 | 390.0 |
| **Water** | 149.0 | Kg/m3 | 149 |
| **Fine Aggregate (Crushed Sand)(Sp.gr.-2.78)** | 1010.53 | Kg/m3 | 1011 |
| **Coarse Aggregate** | 1034.16 | Kg/m3 | 1034 |
| **25mm(Sp.gr.-2.81)** | 523.44 | Kg/m3 | 523 |
| **12.5mm(Sp.gr.-2.88)** | 511 | Kg/m3 | 511 |
| **Chemical Admixture** | 1.19 | Kg/m3 | 1.19 |
| **Water-cement ratio** | 0.4 | | 0.4 |
| **Total** | | | 2585.19" |

### 1.2.2. Design for M 40 Grade

**Table-6:** Concrete Mix design M40

| **"Mix Proportion for Trials** | | | **Final Content** (Kg/m3) |
|---|---|---|---|
| **Cement** | 400 | Kg/m3 | 400 |
| **Water** | 149.0 | Kg/m3 | 149 |
| **Fine Aggregate (Crushed Sand)(Sp.gr.-2.78)** | 1004.97 | Kg/m3 | 1005 |
| **Coarse Aggregate** | 1068.46 | Kg/m3 | 1069 |
| **25mm(Sp.gr.-2.81)** | 507.90 | Kg/m3 | 508 |
| **12.5mm(Sp.gr.-2.88)** | 560.56 | Kg/m3 | 561 |
| **Chemical Admixture** | 1.19 | Kg/m3 | 1.19 |
| **Water-cement ratio** | 0.4 | | 0.4 |
| **Total** | | | 2624.19" |

**"Experimental Procedure:**

a) Size of beam specimen for Flexural Strength of specimen(Two point loading test) size of specimen-150x150x700 mm

b) For Compressive Strength Size of cube specimen is specimen(CTM) size of cube -150x150x150 mm"

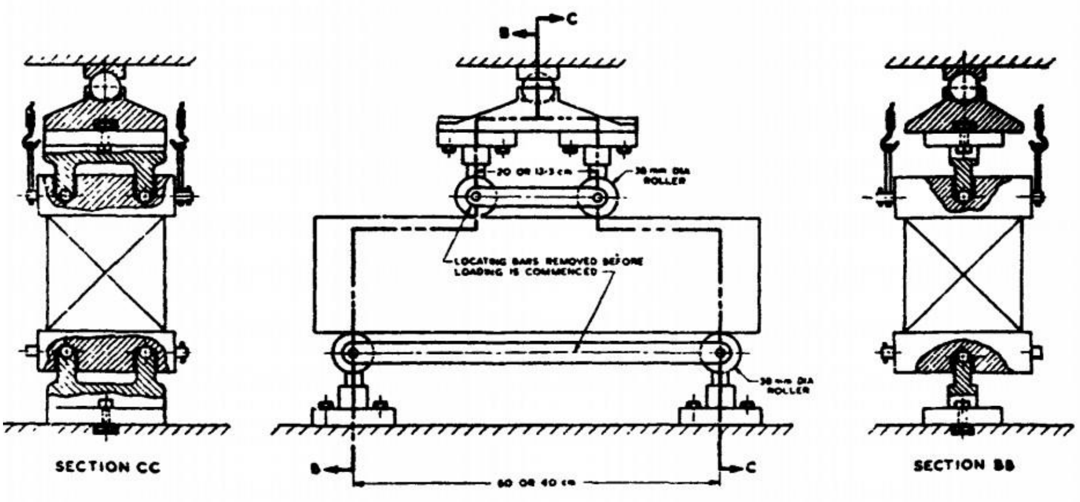



FIG. 3 ARRANGEMENT FOR LOADING OF FLEXURE TEST SPECIMEN

**Fig-1**

**Test matrix -**

| "Mix | Plain concrete beams | Type of Geo-grid | Geo-grid beams | | |
|---|---|---|---|---|---|
| Layer | No geo-grid layer | | Single layer | Double layer At distance 25 mm and 50 mm from bottom | Double layer At distance 50 mm and 100 mm from bottom |
| M25 | 6 | Uniaxial | 6 | 6 | 6 |
| | | Biaxial | 6 | 6 | 6 |
| M40 | 6 | Uniaxial | 6 | 6 | 6 |
| | | Biaxial | 6 | 6 | 6" |
| Total beams casted | 84 Beams | | | | |

**Calculation – "**The flexural strength of the specimen is expressed as the modulus of rupture $f$b. which, Where 'a' is the distance between the fracture line and the nearer support line. Measured in the center line of the specimen 's tensile side in cm, the nearest 0.5kg/sqcm as follows:

$$f_{b} = \frac{pl}{2}$$

when 'a' is greater than 20cm for 15 cm specimen, or greater than 13.3 cm for a 10 cm specimen, or

$$f_{b} = \frac{3pa}{bd^2}$$

when 'a' is greater than 20cm for 15 cm specimen,
or greater than 13.3 cm for a 10 cm specimen, or

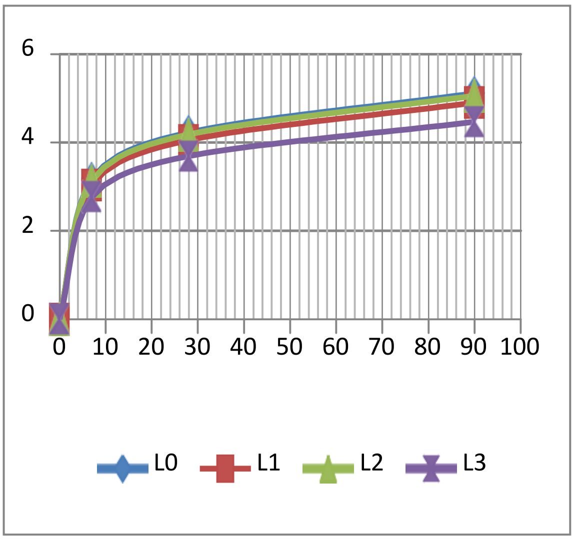
*f*b= when 'a' is less than 20 cm but greater than 17 cm for 15 cm specimen, or less than 13·3 cm but greater than 11 cm for a 10cm specimen.
where b = measured width in cm of the specimen,
d = measured depth in cm of the specimen at the point of failure,
l = length in cm of the span on which the specimen was supported, and
p = maximum load In kg applied to the specimen If a is less than 17cm for a 15cm specimen, or less than 11 cm for a 10 cm specimen, the results of the test shall be discarded".

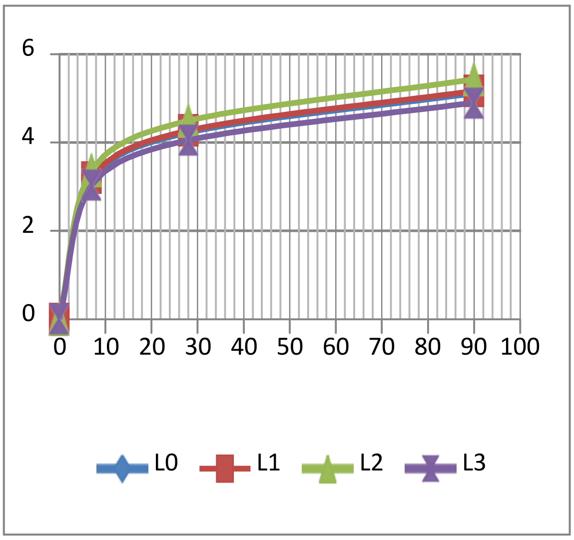
## 5. RESULTS AND DISCUSSION

**Flexural strength And Compressive strength of M25.**

**Selection of geo-grid**

| Specification | Name | Distance from bottom | Flexural Strength in(N/mm$^2$) at | | Compressive Strengthin (N/mm2) at | |
|---|---|---|---|---|---|---|
| | | mm | 7 day | 28 day | 7 day | 28 day |
| Without Geo-grid | $L_0$ | | 3.17 | 4.23 | 26.54 | 35.24 |
| Uniaxial Geo-grid Layer 1 | $L_1$ | 50 | 3.04 | 5.05 | 25.30 | 33.84 |
| Uniaxial Geo-grid Layer 2 | $L_2$ | 50 & 100 | 3.14 | 4.18 | 26.15 | 34.86 |
| Uniaxial Geo-grid Layer 2 | $L_3$ | 25 & 50 | 2.77 | 3.70 | 23.16 | 30.18 |
| Biaxial Geo-grid Layer 1 | $L_1$ | 50 | 3.20 | 4.27 | 26.81 | 35.39 |




**Graph-1:** (Daysof testing vrs.F.S)For Uni. **Graph-2:** (Daysof testing vrs.F.S)For Bia.

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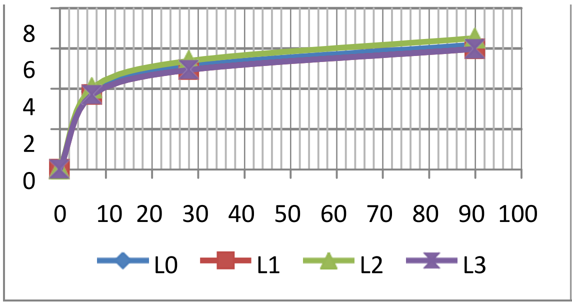
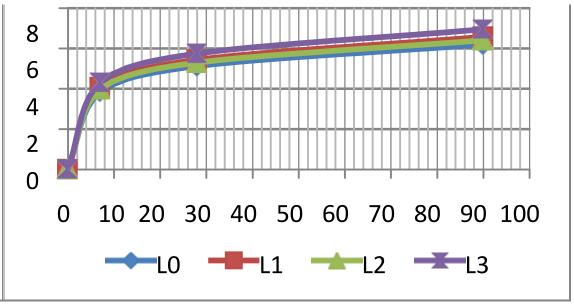
**Flexural strength And Compressive strength of M40.**

| "Specification | Name | Distance from bottom | Flexural Strength in (N/mm$^2$) at | | Compressive Strength in (N/mm2) at | |
|---|---|---|---|---|---|---|
| | | mm | 7 day | 28 day | 7 day | 28 day |
| Without Geo-grid | $L_0$ | | 3.85 | 5.11 | 39.71 | 52.97 |
| Uniaxial Geo-grid Layer 1 | $L_1$ | 50 | 3.71 | 4.94 | 39.17 | 52.25 |
| Uniaxial Geo-grid Layer 2 | $L_2$ | 50 & 100 | 4.04 | 5.38 | 39.46 | 52.58 |
| Uniaxial Geo-grid Layer 2 | $L_3$ | 25 & 50 | 3.70 | 4.94 | 39.94 | 53.02 |
| Biaxial Geo-grid Layer 1 | $L_1$ | 50 | 4.07 | 5.43 | 40.0 | 53.32 |
| Biaxial Geo-grid Layer 2 | $L_2$ | 50 & 100 | 3.97 | 5.30 | 40.95 | 54.37 |
| Biaxial Geo-grid Layer 2 | $L_3$ | 25 & 50 | 4.30 | 5.74 | 40.01 | 53.38" |




**Graph-3:** (Daysof testing vrs.F.S)For Uni. **Graph-4**: (Daysof testing vrs.F.S)For Bia.

**Crack pattern observed**

a) "Normal PQC control specimen (without geo-grid) Normal PQC beam will fails into two parts under the sameloading condition.

b) Uniaxial

Failure of beam is mainly based on layers specified for each beam. In uniaxial geo-grid beam $L_3$specimen failed first with geo-grid layer of spacing 25 & 50 mm. After that beam $L_1$ with single layer having 50 mm distance from bottom failed. $L_2$ beam with spacing 50 & 100 mm from bottom will take more load as compare to previous both $L_{3,}$ $L_1$ and $L_0$

c) Biaxial

Failure of beam is mainly based on layers specified for each beam. In biaxial geo-grid beam $L_2$specimen failed first with geo-grid layer of spacing 50 and 100mm.

After that beam $L_1$ with single layer having 50 mm distance from bottom failed. At last L3 with double layer having 25 and 50 mm spacing were failed".

**Fig-3:** Crack Pattern For Usual PQC Beam

**Fig-4:** Crack Pattern Aimed at Uniaxial Geo-grid Sunbeam

**Fig-5:** Crack Pattern For Biaxial Geo-grid Beam

## 6. CONCLUSION

A. Results obtained from beam specimen with biaxial "geo-grid reinforcement in double layer below neutral axis will give satisfactory result than normal PQC and other layer configurations of geo-grid.

B. Flexural strength by Biaxial geo-grid is increased by 12.17% than normal PQC on 90 days testing.

C. Results obtained from uniaxial geo-grid beam were lower than biaxial geo-grid and increase in strength is about 5% than normal PQC at 90 days testing.

D. From above results it shows that there is increase in 2.7% of compressive strength than conventional cube specimen.

E. On the basis of design pavement, we reduced the thickness of pavement whatever required for given loading conditions and imply the new geo-synthetic material for reducing pavement thickness and increasing strength by providing geo-grid in different layers.

F. Geo-grid can take tensile forces and distribute over larger areas without failing under severe loadingconditions.

G. Cracks appeared in the middle section of the beam i.e. only flexural cracks were formed for all beams reinforced with geo-grid.

H. With the implementation of geo-grid, temperature differentials and wheel load stresses are reduced at considerable depth and pavement will achieve desired strength by reducing pavement thickness".

I. Deflection can be reduced by the use of geo-grid in pavement.

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