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"FLEXIBLE PAVEMENT DESIGN USING GEO-SYNTHETIC MATERIAL"

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Abstract - *Civil Engineering Most of the highways in India are constructed with flexible pavements. Flexible pavement suffers a numbers of distresses like pothole, rutting, cracks, moisture damage, stripping, raveling, reinforcement, drainage, separation, filtration, lake of ground water problem etc. Using geo synthetic in secondary roads to stabilize weak sub grades has been a well accepted practice over the past thirty years. To study in types of geo synthetic material woven and non woven applications. In this study a comprehensive life cycle cost analysis framework was developed and used to quantify the initial and the future cost of 25 representative low volume road design alternatives. All four of these geo textiles functions are in effect to varying degrees when a geo synthetic is used in the paved and unpaved roads. The all test of geo synthetic material in laboratory evaluation. The study also shows when user costs are considered, the greater Traffic Benefit Ratio value may not result in the most effective life-cycle cost. Use of geo synthetic in sub grade reinforcement and soil structure protection are found to be very effective in soft soils. The cost of the installed separation geo synthetic is typically less than the cost of 1 inch of base course aggregate. Studies have demonstrated the benefits of using geo synthetics to improve the performance of pavements.*

Key Words: **Geo synthetic, Flexible pavement, CBR, Geo grid, Design, Surface course, Base course, Sub base course, Sub grade.**

1. INTRODUCTION

A highway pavement is a structure consisting of superimposed layers of processed materials above the natural soil sub-grade, whose primary function is to distribute the applied vehicle loads to the sub-grade. The pavement structure should be able to provide a surface of acceptable riding quality, adequate skid resistance, favorable light reflecting characteristics, and low noise pollution. The ultimate aim is to ensure that the transmitted stresses due to wheel load are sufficiently reduced, so that they will not exceed bearing capacity of the sub-grade. Two types of pavements are generally recognized as serving this purpose, namely flexible pavements and rigid pavements.

1.1 Flexible Pavements

Flexible pavements will transmit wheel load stresses to the lower layers by grain-to-grain transfer through the points of contact in the granular structure. The wheel load acting on the pavement will be distributed to a wider area, and the stress decreases with the depth. Taking advantage of these stress distribution characteristic, flexible pavements normally has many layers. Hence, the design of flexible pavement uses the concept of layered system. Based on this, flexible pavement may be constructed in a number of layers and the top layer has to be of best quality to sustain maximum compressive stress, in addition to wear and tear. The lower layers will experience lesser magnitude of stress and low quality material can be used. Flexible pavements are constructed using bituminous materials. These can be either in the form of surface treatments (such as bituminous surface treatments generally found on low volume roads) or, asphalt concrete surface courses (generally used on high volume roads such as national highways). Flexible pavement layers reflect the deformation of the lower layers on to the surface layer (e.g., if there is any undulation in sub-grade then it will be transferred to the surface layer). In the case of flexible pavement, the design is based on overall performance of flexible pavement, and the stresses produced should be kept well below the allowable stresses of each pavement layer.

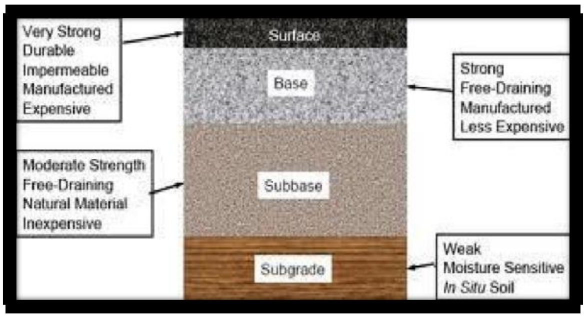


Fig 1 Typical cross section of a flexible pavement

The fibers are drawn into very fine filaments with diameters ranging from 2 to 13 X 10^{-6} m. The glass fiber strength and modulus can degrade with increasing temperature. Although the glass material creeps under a sustained load, it can be designed to perform satisfactorily. The fiber itself is regarded as an isotropic material and has a lower thermal expansion coefficient than that of steel.

1.2 Typical Layers Of A Flexible Pavement

Typical layers of a conventional flexible pavement includes seal coat, surface course, tack coat, binder course, prime coat, base course, sub-base course, compacted sub-grade, and natural sub-grade.

Surface course

Surface course is the layer directly in contact with traffic loads and generally contains superior quality materials. They are usually constructed with dense graded asphalt concrete (AC). The functions and requirements of this layer are:

1. It provides characteristics such as friction, smoothness, drainage, etc. Also it will
2. Prevent the entrance of water.
3. Excessive quantities of surface water into the underlying base, sub-base and sub-grade.
4. It must be tough to resist the distortion under traffic and provide a smooth and skid
5. resistant riding surface.
6. It must be water proof to protect the entire base and sub-grade from the weakening
7. Effect of water.

Base course

The base course is the layer of material immediately beneath the surface of binder course and it provides additional load distribution and contributes to the sub-surface drainage. It may be composed of crushed stone, crushed slag, and other untreated or stabilized materials.

Sub-Base course

The sub-base course is the layer of material beneath the base course and the primary functions are to provide structural support, improve drainage, and reduce the intrusion of fines from the sub-grade in the pavement structure If the base course is open graded, then the sub-base course with more fines can serve as a filler between sub-grade and the base course A sub-base course is not always needed or used. For example, a pavement constructed over a high quality, stiff sub-grade may not need the additional features offered by a sub- base course. In such situations, sub-base course may not be provided.

Sub-grade

The top soil or sub-grade is a layer of natural soil prepared to receive the stresses from the layers above. It is essential that at no time soil sub-grade is overstressed. It should be compacted to the desirable density, near the optimum moisture content.

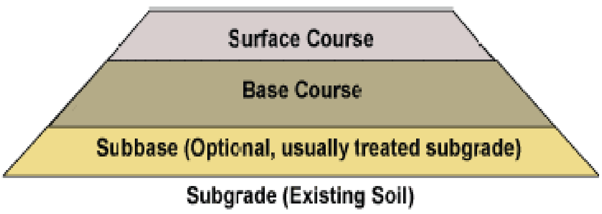


Fig. 2 Typical layers of Flexible pavement

2. GEO-SYNTHETIC

"Geo-synthetics" are defined herein as fabrics, grids, composites, or membranes. Grids and composites are newer generation materials developed for specific purposes by manufacturers. Fabrics or geo-textiles may be woven or nonwoven and are typically composed of thermoplastics such as polypropylene or polyester but may also contain nylon, other polymers, natural organic materials, or fiberglass. Filaments in nonwoven fabrics are typically bonded together mechanically (needle -punched) or by adhesion (spun -bonded, using heat or chemicals). Grids may be woven or knitted from glass fibers or polymeric filaments, or they may be cut or pressed from plastic sheets and then post tensioned to maximize strength and stiffness.

Composites generally consist of a laminate of fabric onto a grid. For the composite, the fabric provides absorbency (primarily to hold asphalt) and a continuous sheet to permit adequate adhesion of the composite onto a pavement surface; whereas, the grid provides high strength and stiffness. A heavy -duty membrane is a composite system, usually consisting of a fabric mesh laminated on one or both sides with an impermeable rubber -asphalt membrane. They are typically placed in strips over joints in concrete pavements or used for repair of localized pavement failures.

2.1 Advantages

Geo-synthetics, including geo-textiles, geo membranes, geo nets, geo grids, geo composites and geo-synthetic clay liners, often used in combination with conventional materials, offer the following advantages over traditional materials:

1. Space Savings - Sheet-like, geo-synthetics take up much less space in a landfill than do comparable soil and aggregate layers.

2. Material Quality Control - Soil and aggregate are generally heterogeneous materials that may vary significantly across a site or borrow area. Geo-synthetics on the other hand are relatively homogeneous because they are manufactured under tightly controlled conditions in a factory. They undergo rigorous quality control to minimize material variation.

3. Construction Quality Control - Geo-synthetics are manufactured and often factory "prefabricated" into large sheets. This minimizes the required number of field connections, or seams. Both factory and field seams are made and tested by trained technicians. Conversely, soil and aggregate layers are constructed in place and are subject to variations caused by weather, handling and placement.

4. Cost Savings - Geo-synthetic materials are generally less costly to purchase.

5. Construction Timing - Geo-synthetics can be installed quickly, providing the flexibility to construct during short construction seasons, breaks in inclement weather, or without the need to demobilize and remobilize the earth work contractor.

6. Material Deployment - Layers of geo-synthetics are deployed sequentially, but with a minimum of stagger between layers, allowing a single crew to efficiently deploy multiple geo-synthetic layers.

7. Material Availability - Numerous suppliers of most geo-synthetics and ease of shipping insure competitive pricing and ready availability of materials.

8. Environmental Sensitivity – Geo-synthetic systems reduce the use of natural resources and the environmental damage associated quarrying, trucking, and other material handling activities.

9. Technical Superiority - Geo-synthetics have been engineered for optimal performance in the desired application.

2.2 Grids

A geo grid is a regular open network (called apertures) of integrally connected tensile elements which is used to reinforce base or sub base materials, earth retailing wall, embankment etc. It is manufactured from high-density polyethylene (HOPE), polypropylene, or high tenacity polyester. Biaxial geo grids are used for base reinforcement applications.

Grids typically exhibit much higher module than fabrics and logically should take on more stress at low strain levels. Grid systems serve primarily as a reinforcing interlayer. To act as overlay reinforcement, a grid must be tightly stretched, or slightly pre tensioned, and it must have sufficient stiffness. Typical grids used as overlay reinforcement exhibit stiffness's varying from 80 to >1000 lb/inch. However, only the stiffest grids (>1000 lb/inch) can act as overlay reinforcement (Bark s dale, 1991). Some grids contain a thin, continuous sheet, designed to assist in installation (i.e., adhere to the tack coat) that melts when the hot overlay is applied. Neither of these products forms a waterproof barrier. These products should be considered as grids and not composites.

2.3 Origin of Geo Grids and its Manufacture

The geo synthetic material, geo grids, is polymeric products which are formed by means of intersecting grids. The polymeric materials like polyester, high-density polyethylene and polypropylene are the main composition of geo grids.

These grids are formed by material ribs that are intersected by their manufacture in two directions: one in the machine direction (md), which is conducted in the direction of the manufacturing process. The other direction will be perpendicular to the machine direction ribs, which are called as the cross-machine direction (CMD).

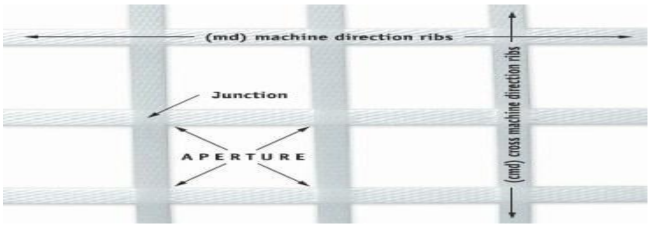


Fig.3 Geo grid's rib formation in machine and cross machine directions of manufacturing process

These materials form matrix structured materials. The open spaces, as shown in the above figure, due to the intersection of perpendicular ribs are called as the apertures. This aperture varies from 2.5 to 15cm based on the longitudinal and transverse arrangement of the ribs.

Among different types of geo textiles, geo grids are considered stiffer. In the case of geo grids, the strength at the junction is considered more important because the loads are transmitted from adjacent ribs through these junctions. Many manufacturing choices are available for ribs. Here we are going to discuss three most used method of manufacturing of geo grids:

1) By Extruding

This manufacturing method of geo grids involves extrusion of a flat sheet of plastic into the desired configuration. The plastic material used may be high-density polypropylene or high-density polyethylene. Already set punching pattern is placed over the sheet to make holes for the formation of desired grids.

The punching of a pattern of holes would result in the formation of so-called apertures. Next step involves the development of tensile strength, by stretching the material to both longitudinal and transverse direction. A figure representing an extruded Geogrid is shown below.

Fig.4 Geogrid manufactured from the method of extrusion

2) By Knitting or Weaving

In this method of Geogrid manufacture, single yarns of polyester or polypropylene material undergo either knitting or weaving to form flexible junctions forming apertures. These materials are recommended to have high tenacity, to give the Geogrid the final desired property.

The product is bought into the market by giving them an additional coating of either bituminous material or a polyvinyl chloride or a latex. This choice varies with the manufacturer of geo grids.

Fig.5 Geogrid sample manufactured by knitting

3) Welding and Extrusion

This is recently developed a method by Secugrid manufactures. The method involves the extrusion of flat polyester or polypropylene ribs by passing them through rollers as shown in the figure below. These are done in automated machines that run at different speeds, enabling stretching of ribs and increasing their tenacity.

Fig. 6 The stretching of ribs through extrusion process

2.4 Geo Grids Physical Properties

The following properties are those that the majority of the geo grids can be tested for and will provide a means to compare the various geo grids against each other. The test methods to determine these properties are nearly all standardized by ISO, CEN, ASTM, Geo-synthetic Research Institute (GRI) or national standards.

The properties typically listed are as follows:

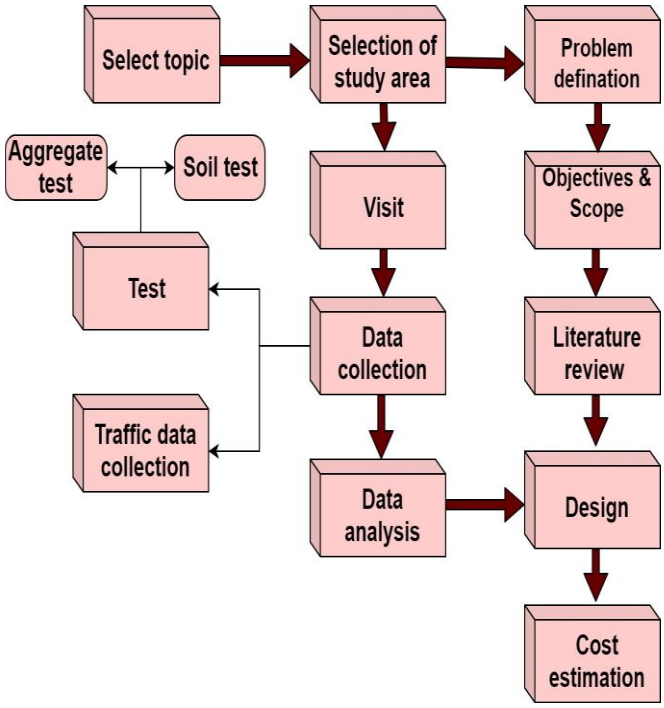
- Tensile strength
- Elongation @ultimate
- Tensile or true tensile strength
- Elongation
- Initial or true initial modulus
- Aperture size or dimensions
- Junction strength
- Junction efficiency
- Flexural rigidity or stiffness
- Apertures ability
- UV Resistance
- Rib thickness and width
- Resistance to installation damage
- Resistance to long term degradation
- Creep behavior

2.5 Functions Of Geo Grids In Roadways And Pavements

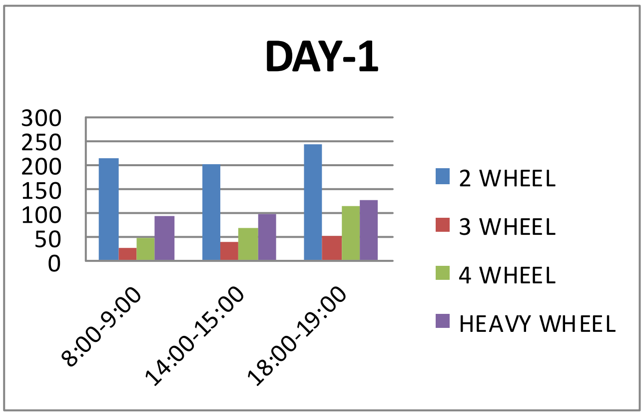
The geo grid improves the pavement system performance through reinforcement, which may be provided through three possible mechanisms.

- ➢ Lateral restraint of the base and sub grade through friction (geo textiles) and interlock (geo grids) between the aggregate, soil and the geo synthetic.
- ➢ Increase in the system bearing capacity by forcing the potential bearing capacity failure surface to develop along alternate, higher shear strength surfaces.
- ➢ Membrane support of the wheel loads.

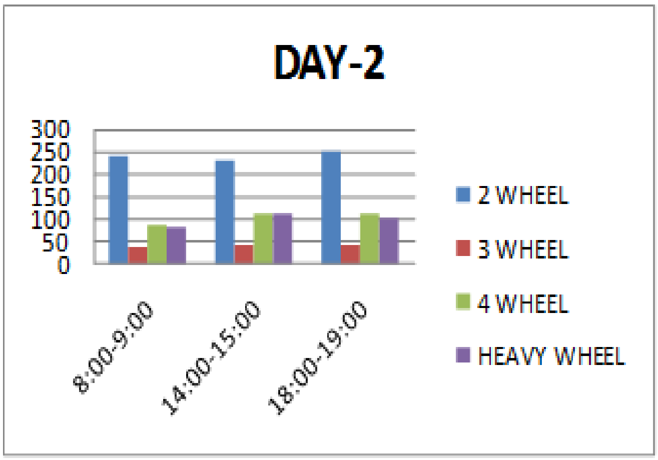
3. METHODOLOGY



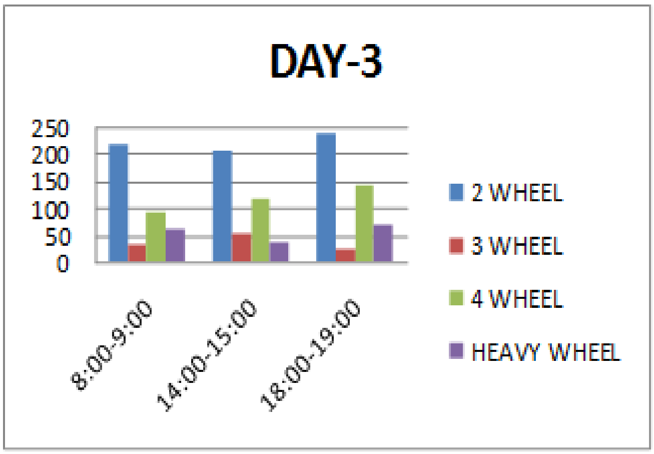
3.1 Traffic Data



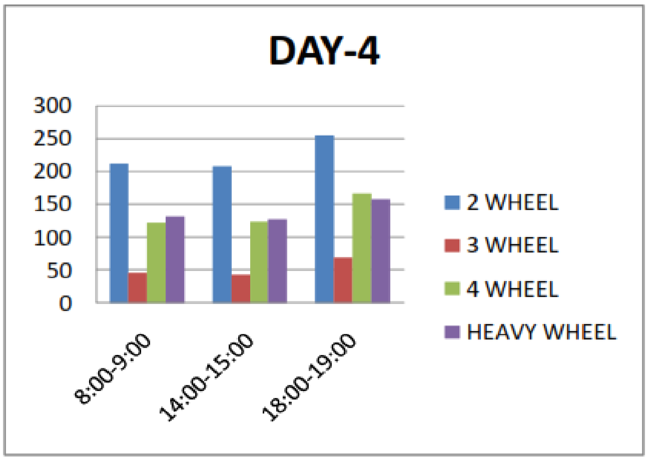
Graph 1:- Traffic collection data W.R.T time 22 February



Graph 2:- Traffic collection data W.R.T time 23 February



Graph 3:- Traffic collection data W.R.T time 24 February



Graph 4:- Traffic collection data W.R.T time 25 February

3.2 Soil Sample Data Report

Sr.No.	Test		Results
1	Modified proctor-MDD(g/cc)		1.82
	Modified proctor-OMC		13.9
2	Atterberg limits (%)	Liquid limit (%)	43
		Plastic limit (%)	23
		Plastic index (%)	20
3	Grain size analysis (%)		
	Large particles		0.0
	Gravels		2
	Sand		7
	Silt + clay		91
4	Soil classification		CI
5	Specific gravity		2.541
6	Volumetric free swell index (%)		17
7	Soaked california bearing ratio (%)		3.8

3.3 CBR Test With Geo-Grid Material

Sr. No.	Sample ID	CBR soaked(%) (A)	CBR soaked(%) (B)	CBR soaked(%) (C)
1	Soil	2.1	2.8	4.0
Test Method Specification		IS:2720 P-16 1987	IS:2720 P-16 1987	IS:2720 P-16 1987

A= Distance of Geo-grid at H/4 from Bottom

B= Distance of Geo-grid at H/2 from Bottom

C= Distance of Geo-grid at 3H/4 from Bottom

4. DESIGN

4.1 Flexible Pavement Design Without Geo-Grid

4.1.1 Calculation of Cumulative Standard Axles

$$csa = \frac{365\{NFD[1+r]^n - 1\}}{r}$$

Where,

r = Growth rate of vehicle = 15%

n = Life of periods = 15 year

N = number of vehicle = 1600 per day

F = VDF value = 2.5

D = Lane distribution factor = 0.75

$$csa = \frac{365\{1600 * 2.5 * 0.75[1+0.15]^{15} - 1\}}{0.15}$$

=52msa

≈50 msa

4.2 Design of Flexible Pavement Without Geo Grid

Using CBR chart take value of CBR = 2

CSA = 50 msa

Total thicness of pavement = 900 mm

Granular sub base = 380 mm

Granular base = 250 mm

Dense bituminious macadam binder course = 220 mm

Bituminious concrete surface course = 50 mm

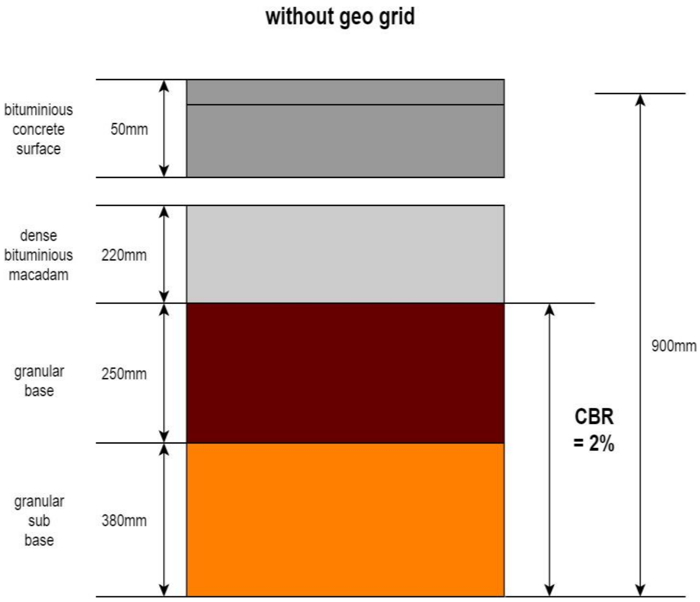


Fig.7 flexible pavement without geo grid

4.3 Design of flexible pavement with geo gried at 3H/4 height from bottom

Using CBR chart take value of CBR = 4

CSA = 50 msa

Total thicness of pavement = 780 mm

Granular sub base = 330 mm

Granular base = 250 mm

Dense bituminious macadam binder course = 60 mm

Bituminious concrete surface course = 40 mm

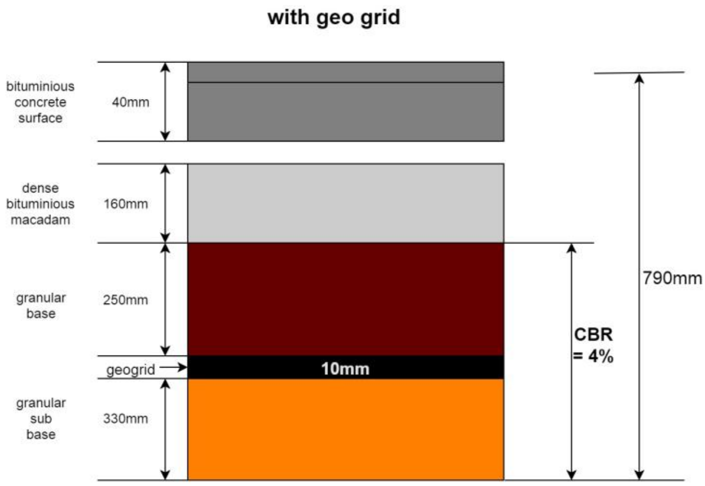


Fig.8 flexible pavement with geo grid

5 CONCLUSIONS

After providing geo grid material we reduce following problems:-

1. Reduce cracking problems.
2. Improve strength of pavement.
3. Provide protection against separation of materials.
4. Increase life of pavements as well as provide comfort and safety to road users.
5. By reducing thickness, it also reduces the cost of pavement.
6. It decrease almost 20% cost compare to flexible pavement without geo grid.
7. It reduces the problems like cracking, separation, drainage system so it has decrease the maintenance cost.

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