International journal of basic and applied research
www.pragatipublication.com
ISSN 2249-3352 (P) 2278-0505 (E)
Cosmos Impact Factor-5.86

Modeling and Designing Analysis of Composite Leaf Spring Accordance with the Applied Loads

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Abstract:
A fundamental type of spring that is frequently used for the suspension in wheeled cars is the leaf spring. Leaf Springs are thin, long plates that are affixed to a trailer's frame and rest above or below the axle of the trailer. There are springs with only one leaf, sometimes known as mono leaf springs or single-leaf springs. These normally lack significant durability and suspension for towed vehicles because they are thick in the middle and taper out toward the end. Chauffeurs that need to carry heavier loads typically utilize multi leaf springs, which are madeup of numerous leaf springs stacked on top of one another. The closer to the bottom it is, the shorter the fallen leaf springtime will be, giving it the same semielliptical shape as a single fallen leaf springtime that is formed by being thicker in the centre. Springs will undoubtedly break from wear and tear brought on by continuous flexing of the spring. The project's objectives to model and design a leaf spring in accordance with the applied loads. Steel that has been developed is currently used as a material for springtime leaf fall. By varying the support angle, we will produce fallen leaf springs for the items made of mild steel and glass carbon composite in this work. As the reinforcing angle varies, the toughness variations will be examined. We are employing two different products, Mild Steel and Glass Carbon, to do FEA Structural Evaluation on the fallen leaf spring to corroborate this architecture. Additionally, modal and fatigue analysis is performed. Modeling is done using the CREO software, while analysis is done using ANSYS.

Key words: Leaf Spring, Ansys, CREO, Mild Steel, glass carbon & etc

I. INTRODUCTION

Fallen leaf springs are mostly used in rail system sand suspension systems in heavy-duty trucks, light- duty trucks, and automobiles to absorb shock loads. It carries shock absorption, lateral loads, brake torque, and driving torque. A leaf spring is a simple type of spring that was on cena medal aminated or carriage spring and is frequently used for the suspension in wheeled autos. It is also one of the earliest springing forms, dating to the middle centuries. The term "cart spring" or "semi-elliptical spring" is sometimes used to describe a thin, arc-shaped length of spring steel with a rectangular cross section.

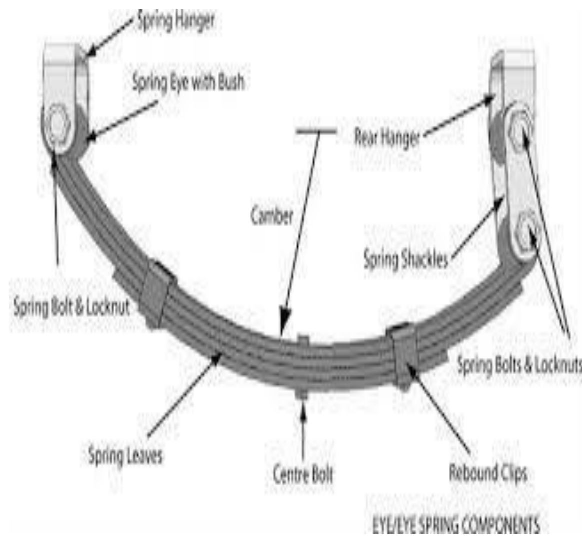

Figure1:Leaf Spring

The axle can be placed in the arc's centre, and at either end are provided connection holes called eyes for attaching to the car's body. A leaf spring can be created from multiple fallen leaves stacked on top of each other in several layers, usually with much shorter leaves, for extremely heavy autos. Fallen leaf springs can be used for springing, finding, and, to some extent, dampening. A leaf spring can be fastened to the framework directly at both ends or it can be fastened straight at one end, usually the front, and the other end is connected through a shackle, a short movable arm. The irons use up the leaf spring's tendency to extend when squeezed, resulting in softer springiness. In order to reduce weight without sacrificing car quality or dependability, the automotive industry is investigating composite materials for use in the creation of architectural features. Today's automotive manufacturers have placed a strong emphasis on weight reduction in order to protect natural resources and save energy. In fact, especially while driving in cities, there is nearly a straight symmetry between the weight of the car and its gas usage. Due to their high specific strength (strength/density) and high specific modulus (modulus/density), the revolutionary composite goods made of graphite, carbon, kevlar, and glass with suitable materials are widely employed. Modern composite products appear to be the perfect choice for leaf spring suspension applications. Their elastic characteristics can be altered to boost strength while also lowering tensions created during application.

II. LITERATUREREVIEW

Composite materials are those materials having higher stress to weight ratio and good corrosion resistance capacity. D.N Dubey et al. [5] stated that composite materials have the more elastic capacity and higher strength to weight ratio as compare to conventional steel. The composite materials used for the manufacturing of leaf springs are made of HM and HS carbon polymers. A composed material of two or more constituents combined on a microscopic scale by mechanical and chemical bonds to form a composite material. Due to the better composition of material strength and modulus of composite materials are better than the traditional metallic material. Several factors (poor design, low quality material and defected fabrication) have combined to facilitate failure. Preventive measures to lengthen the service life of leaf springs are suggested. Anand Kumaretal.
[6] reported that the very first issue in every automobiles is weight reduction with maintenance of strength. The paper here comprises of use of 55SI2MN90 for steel leaf and Glass-fiber 7781 for composite leaf spring as a material. The work comprises of hand layup method and mathematical calculation the paper also discusses about the fabrication of leaf spring and for this a wooden made pattern is used. Anil kumar et al. [7] comprised the work done on the conventional steel leaf spring with variable composite materials like Graphite, Carbon, and EGlass/Epoxy etc. The experiment is performed with the help of 10leaf springs, 2 full length and 8in graduated. Stress based analysis and modal analysis is performed with the help of ANSYS software shown in the figure given below.

The results concluded that the static analysis of steel leaf spring displacement is 92.59mm which is below the chamber length of leaf spring and stiffness noted as 35.60mm. The result of such disturbance will cause some energy lost which will be dissipated in the tires and the shock absorber while the remainder of the energy is stored in the coil spring. In this paper, Finite element models were developed to optimize the material and geometry of the composite elliptical spring based on the spring rate, log life and shear stress. The influence of ellipticity ratio on performance of woven roving wrapped composite elliptical springs was investigated both experimentally and numerically, the study demonstrated that composites elliptical spring can be used for light and heavy trucks with substantial weight saving. The results showed that the ellipticity ratio significantly influenced the design parameters. Composite elliptic spring with ellipticity ratios ofa/b= 2 displayed the optimum spring model. Analytical and experimental studies on Fatigue Life Prediction of steel and composite Multi leaf Spring for Light Passenger Vehicles Using Life Data Analysis is carried by Mouleeswaran Senthil Kumar, Sabapathy This paper describes static and fatigue analysis of steel leaf spring and composite multi leaf spring made up of glass fiber reinforced polymer using life data analysis. The dimensions of an existing conventional steel leaf spring of a light commercial vehicle are taken and are verified by design calculations. Static analysis of 2-D model of conventional leaf spring is also performed using ANSYS 7.1 and compared with experimental results. Same dimensions of conventional leaf spring are used to fabricate a composite multi leaf spring using E glass/Epoxy unidirectional laminates. The load carrying capacity, stiffness and weight of composite leaf spring are compared with that of steel leaf spring analytical land experimentally Fatigue life of steel leaf spring and composite leaf is also predicted. Compared to steel spring, the composite leaf spring is found to have 67.35 % lesser stress, 64.95 % higher stiffness and 126.98 % higher natural frequency than that of existing steel leaf spring. A weight reduction of 68.15%isalsoachievedbyusingcomposite. It isalso concluded that fatigue life of composite is more than that of conventional steel leaf spring. Senthilkumar Mouleeswaran et al.

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[8] reported that leaf spring showed vertical vibrations due to irregularities of load. A leaf spring stored a potential energy in the form of strain energy and dissipated slowly. So due to this a maintenance of leaf spring material is also an important factor like minimizing the modulus of elasticity in longitudinal direction and maximizing the strength. R.B. Charde et al. [9] explained that the deflection in spring shows that potential energy is stored in the form of strain energy due to impact load and elastic nature of material used in manufacturing of leaf spring. The paper here shows the study of failure, stress, deflection, and bending behavior of leaf spring. This approach is actually based on the cantilever beam theory and actual prototype is considered under static loading condition. Stress analysis is considered from fixed end to 15, 125, 235, and345 mm for leaf spring. The results in the paper easily explained with the help of figures and graphs shown below. Their results also concluded that the analytical equation fails to measure the maximum stress value in the master leaf and it only useful to know the maximum value of stress at the support. So the experimental and finite element method is suitable for the evaluation of resulting stress away from the support. In the ir present study master leaf cannot obey the rule of cantilever beam theory but when we add another full length leaf spring the theory is validated.

III. PROPOSEDWORK

The achievement of weight reduction with adequate improvement of mechanical properties has made composite a very good replacement material for conventional steel. Selection of material is based on cost and strength of material. The composite materials have more elastic strain energy storage capacity and high strength to weight ratio as compared with those of steel, so multi-leaf steel springs are being replaced by mono-leaf composite Springs. The paper gives the brief look on the suitability of composite leaf spring on vehicles and their advantages.

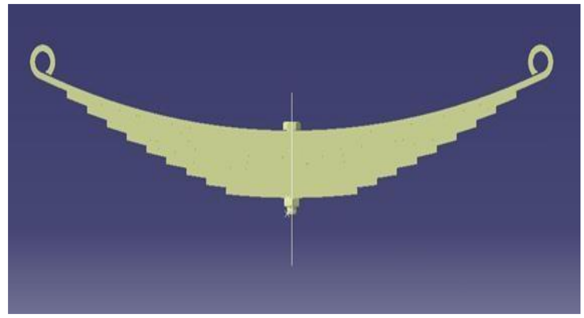

Figure2:Model of Leaf Spring.

3.1StructuralandFatigueanalysisofLeafspring

CASE 1:- MATERIAL - MILD STEEL

Save CATIA Model as .iges format

→→Ansys → Workbench→ Select analysis system → static structural → double click

→→Select geometry → right click → import geometry → select browse →open part → ok

→→ select mesh on work bench → right click →edit

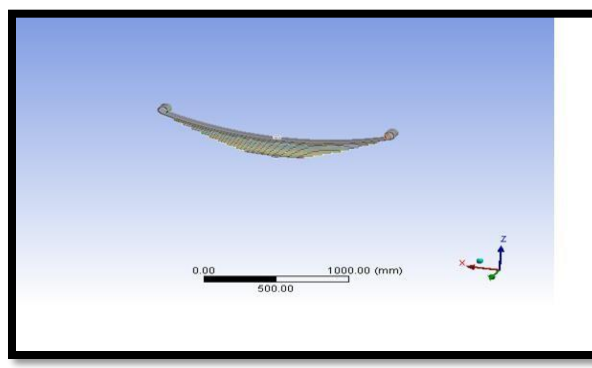

Figure3:Analysis.

Double click on geometry → select geometries → edit material →

MATERIAL PROPERTIES OF STEEL

Density	:	0.00000785kg/mm³
Young's modulus	:	20000Mpa
passions ratio	:	0.3

Select meshon left side part tree→right click→ generate mesh →

Index in Cosmos
Mar 2024, Volume 14, ISSUE 1
UGC Approved Journal

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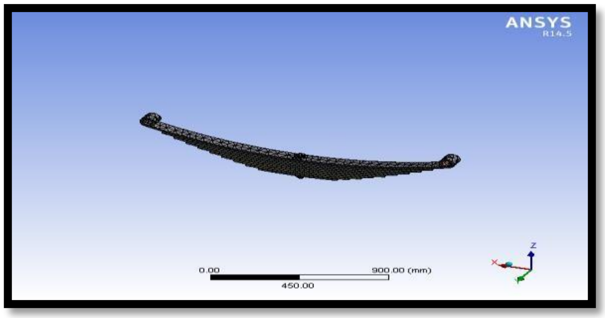
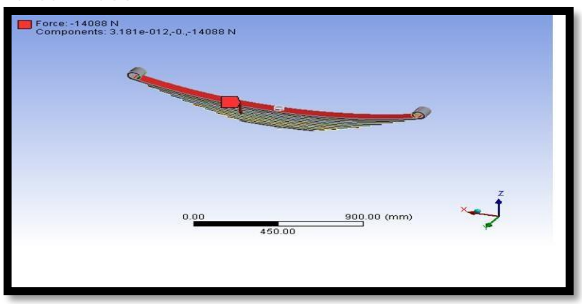


Select staticstructuralrightclick→insert→select force-14088N



Select displacement→selectrequiredarea →click on apply →put X,Y,Z component zero

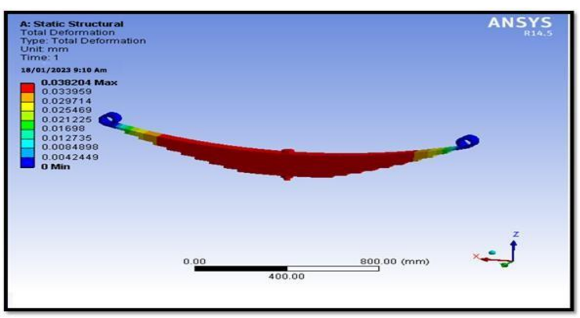


Figure4:Total Deformation

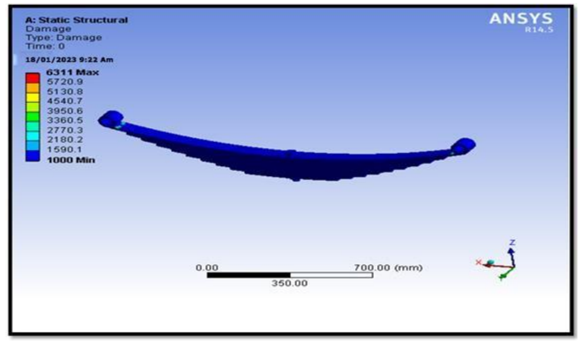


Figure5:Von-Mises Strain

FATIGUE ANALYSIS:

Solution right click → insert → fatigue → fatigue tool

Solution right click → insert → fatigue → life

Solution right click → insert → fatigue → damage

Solution right click → insert → fatigue → safety factor

Right click solution → evaluate all result

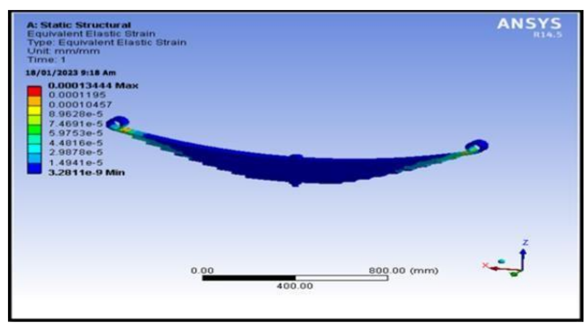


Figure6: Damage

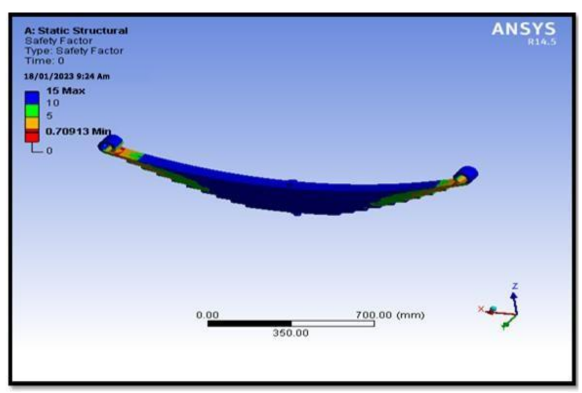


Figure7:Safetyfacto

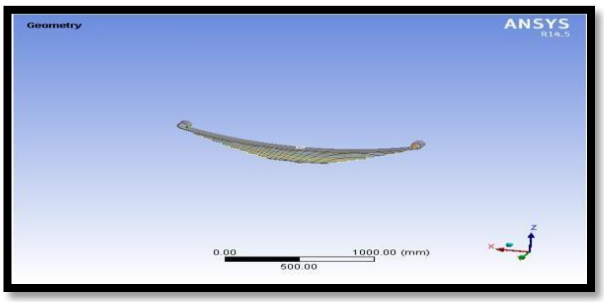
MODEL ANALYSIS

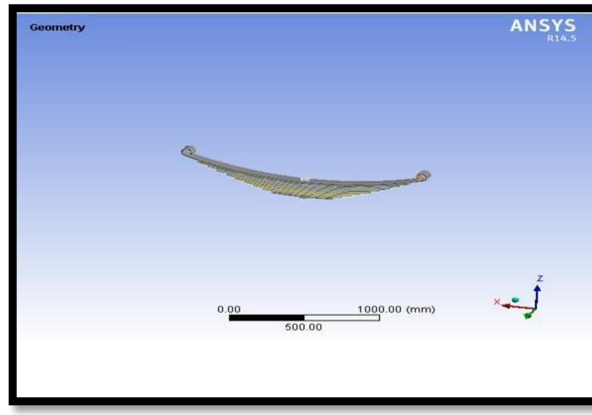
Save CATIA Model as .iges format

→→Ansys → Workbench→ Select analysis system → model → double click

→→Select geometry → right click → import geometry → select browse →open part → ok

→→ select mesh on work bench → right click →edit





Double click on geometry → select geometries → edit material →

MATERIAL PROPERTIES OF STEEL

Density : 0.00000785kg/mm^3

Young's modulus : 20000Mpa

passions ratio : 0.3

Select mesh on left side part tree → right click → generate mesh →

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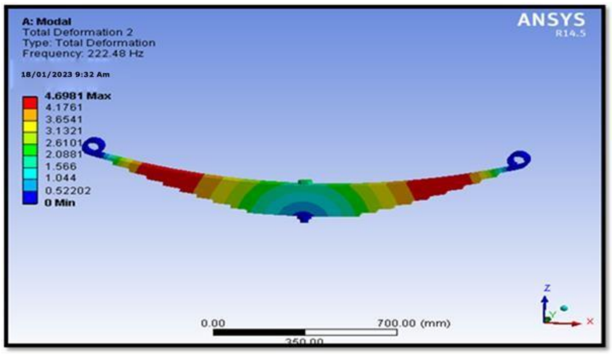
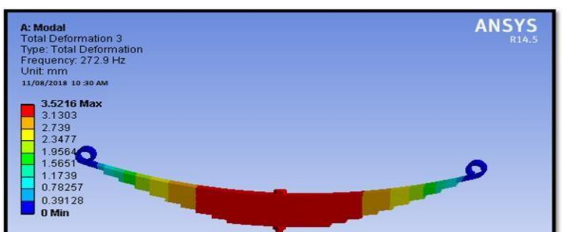


Figure8:TotalDeformation2



FATIGUE ANALYSIS

	Mild steel	Carbon epoxy	S2 glass
Life	1e6	1e6	1e6
Damage	6311	6311	4627.4
Safety factor	15	15	15

Figure9:ModelAnalysis.

STRUCTURAL ANALYSIS

For mild steel

	Mode1	Mode2	Mode3
deformation	5.5234	4.6981	3.5216
Frequency(Hz)	63.928	222.48	272.9

For S2 Glass

	Mode1	Mode2	Mode3
deformation	9.841	8.3931	6.2781
Frequency(Hz)	23.883	82.522	101.45

Figure9:TotalDeformation3.

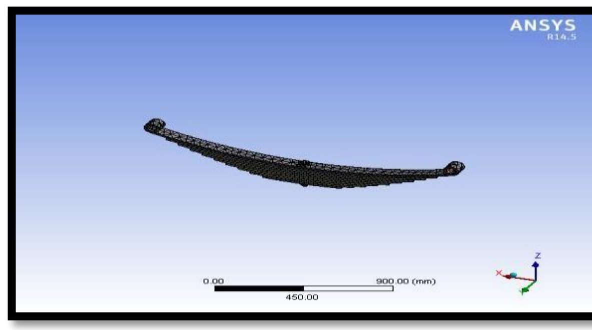


Figure10:MaterialPropertiesofS2Glass.

IV. RESULTS ANDDISCUSSIONS

MODALANALYSIS

For Carbon epoxy

	Mode1	Mode2	Mode3
deformation	13.107	11.149	8.3568
Frequency(Hz)	31.803	110.68	135.76

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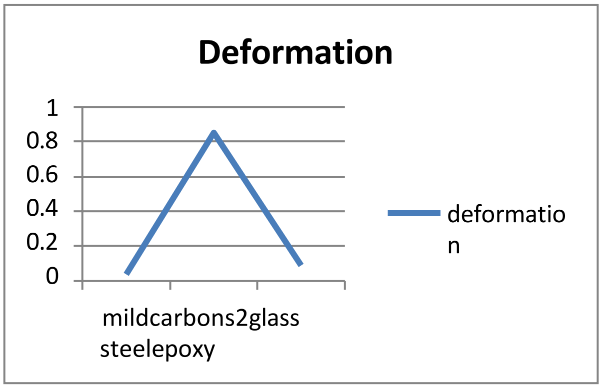
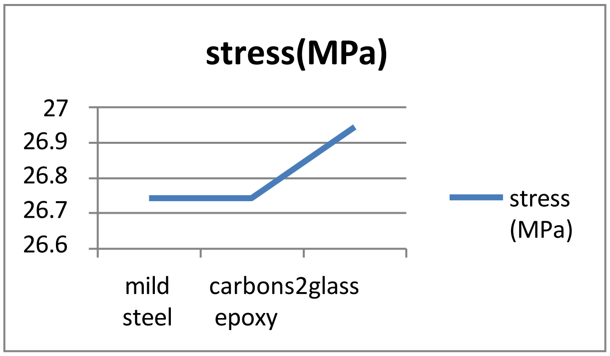
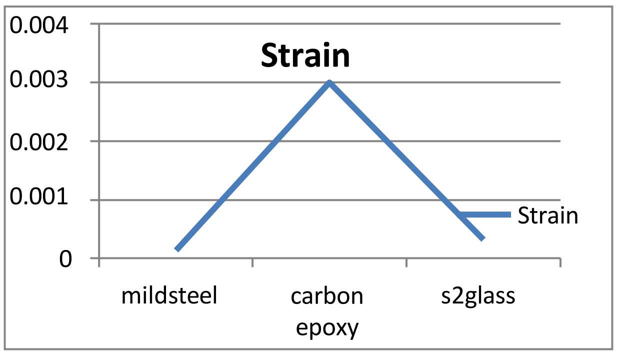
Graphs







V. CONCLUSION

For the Ashok Leyland Viking heavy automobile, a falling leaf spring is designed in this thesis. The information for the version's specs is taken from the internet. For the lots at 14087.5 N, springtime of falling leaves has been created. Mathematical techniques have been used to construct theoretical estimates for measurements of fallen leaves in the spring time at various scenarios with varied thickness, camber, span, and number of leaves. With the help of the goods steel, carbon fibre, and epoxy, this thesis has been evaluated.
By applying layer stacking analysis, architectural and modal analyses are carried out for just compounds on the entire fallen leaf spring assembly as well as for a single leaf. The findings show:

- Compared to the permitted tension and anxiety, the worries in the composite fallen leaf springtime of layout are significantly lower.
- Compared to normal steel springs with a similar layout, composite leaf springs have a greater strength to weight ratio.
- A composite spring that uses the S 2 Glass epoxy product weighs five times as little as a steel spring. The mechanical performance of the spring will improve with less weight.

It is clear from this assignment that using composite carbon Epoxy is advantageous. The main drawbacks of composite leaf springs are that under poor road conditions, the matrix product's reduced susceptibility to cracking may cause some of the spring's lower fibres to break. Loss of the ability to communicate flexural tightness may result from this. However, this is dependent on how the road is. This type of problem won't exist on a regular road. Compound leaf springs

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made of polymer matrix composites maintain great toughness under harsh conditions.

The steel fallen leaf spring's breadth is maintained constant, and variations in all-natural regularity with regard to fallen leaf thickness, span, camber, and number of leaves are investigated. The current study shows that whereas natural regularity increases with increasing camber and practically continuously with increasing leaf count, natural regularity decreases with in creasing span. The excitation frequency for

various highway aberrations is compared with the inherent regularities of multiple parametric combinations. Due to the nearly same geometric conditions of spring, with the exception of the number of leaves, the values of natural frequencies and excitation regularities agree for both springs.

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