ABSTRACT
In order to conserve natural resources and economize energy, weight reduction has been the main focus of automobile manufacturer in the present scenario. Weight reduction can be achieved primarily by the introduction of better material, design optimization and better manufacturing processes. The introduction of FRP material has made it possible to reduce the weight of spring without any reduction on load carrying capacity. 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. The objective of the present work is design, analysis and fabrication of composite leaf spring. The finite element results using ANSYS software showing stresses and deflections were verified with analytical and experimental results. The design constraints were stresses and displacement. Compared to the steel spring, the composite spring has stresses that are much lower, the natural frequency is higher and the spring weight is nearly 85 % lower with bonded end joint and with complete eye unit. The attempt has been made to fabricate the FRP leaf spring economically than that of conventional leaf spring.

1. INTRODUCTION
Increasing competition and innovations in automobile sector tends to modify the existing products or replacing old products by new and advanced material products. In order to conserve natural resources and economize energy, weight reduction has been the main focus of automobile manufacturers in the present scenario. Weight reduction can be achieved primarily by the introduction of better material, design optimization and better manufacturing processes.

A suspension system of vehicle is also an area where these innovations are carried out regularly. More efforts are taken in order to increase the comfort of user. Appropriate balance of comfort riding qualities and economy in manufacturing of leaf spring becomes an obvious necessity. To improve the suspension system, many modifications have taken place over the time. The suspension leaf spring is one of the potential items for weight reduction in automobiles as it accounts for 10% - 20% of the unsprung weight. This achieves the vehicle with more fuel efficiency and improved riding qualities.

Inventions of parabolic leaf spring, use of composite materials for these springs are some of these latest modifications in suspension systems. This seminar mainly focuses on the implementation of composite materials by replacing steel in conventional leaf springs of suspension system. The introduction of composite materials was made it possible to reduce the weight of leaf spring without any reduction on load carrying capacity and stiffness. Since, the composite materials have more elastic strain energy storage capacity and high strength to weight ratio as compared with those of steel, multi-leaf steel springs are being replaced by mono-leaf composite springs.

2. LITERATURE REVIEW
A number of research papers have been published on the structural analysis and fatigue testing of leaf springs. A brief review of some selected references on this topic is presented:

- Patunkar and Dolas [1] in their research paper discussed the analysis of composite mono leaf spring made of glass fiber reinforced plastic. Initially conventional leaf spring has been tested for static conditions. Then simulation was done for the composite spring of glass fiber under the same static load condition. The comparison of the deflection and the stress distribution has been carried out. It has been observed that there is large deflection in the conventional spring than composite spring. Conventional leaf spring also possesses more weight than composite leaf spring.

- Krishan and Aggarwal [2] in their work presented the analysis of multi leaf spring using finite element methods. This work has been carried out on a multi leaf spring having nine leaves used by a commercial vehicle. It was having two full length leaves in which one is with eyed ends and seven graduated length leaves. The material of the leaf spring is SUP9. Bending stress and deflection were the target results. A comparison of both i.e. experimental and FEA results have been conducted. When the leaf spring was fully loaded, the variation in the deflection was 0.632 % in experimental and FEM results.

- Dhoshi et al. [3] have discussed the analysis and the modification of the leaf spring used in tractor trailer using FEM. An analytical model was used for finding out the correct dimensions of the multi leaf spring for given loading conditions. Then stress distribution was observed in FEM for the same spring modeled. It has been observed that there is no much difference in the stresses obtained by analytical and FEM results. So some modifications in the spring were tested. It has been found that if number of leaf springs were reduced from 17 to 13 in this case there is not much difference in the stress distribution and also the design is safe. This can achieve the weight reduction approximately by 6 Kgs. and cost reduction by 20%.

- Shokrieh and Rezaei [4] in their paper discussed the optimization of the composite leaf spring. The FEM results were verified by the existing analytical and experimental solutions. Then shape and the weight optimization were carried out. It has been observed that composite leaf spring saves the 80% of the weight comparing the conventional spring by increasing the thickness linearly and decreasing the width hyperbolically. Again the natural frequency of the composite leaf spring is higher than the conventional one.
• Kainulainen [5] in his thesis discussed the analysis of the parabolic leaf spring failure. Initially the failed spring was observed and dynamic simulator was used for measurement of load and moment. FEM analysis was carried out for conventional spring followed by the experimental study. It has been observed that for static loading the stress is concentrated at the middle portion of the spring but for the impact loading the stress concentration takes place near to the eye end along the driving direction. Sometimes the spring is a large twist of S type curve in impact loading. It has been found that there is large difference between in the static stress in FEM and experimental. But for stresses in driving conditions there is not much difference in the stresses.
• Krason and Wysocki [6] in their paper discussed the vibration analysis of the simplified model of the suspension system. The subject of the paper deals with the forced vibrations of the rear suspension of the biaxial vehicle fitted with the double spring spatial shell model and the viscous damper, under the force pulse input with the given transient response. The play between the master and auxiliary spring is a specific feature of the double spring design. Numerical tests were taken for three variants of the viscous attenuation. The numerical analysis of the suspension model with the geometrical nonlinearities, viscous attenuation, and time-varying load was taken with the use of the finite element method. The selected results of the model tests in the form of the suspension relative displacements (speeds) and deformations (stresses) for the selected points of the master and auxiliary spring against time have been presented. The complete model of the suspension system makes possible to examine the influence of various inputs on the interoperation and the phenomena associated with the dynamic response of such a complex system.
• Venkatesan and Devrajan [7] in their paper discussed the analysis of the composite leaf spring in light commercial vehicles. The objective of the work was to compare the load carrying capacity, stiffness and the weight reduction. The development of a composite leaf spring having constant cross sectional area, where the stress level at any station in the leaf spring has been considered constant due to the parabolic type of the thickness of the spring, has proved to be very effective. The study demonstrated that composites can be used for leaf springs for light weight vehicles and meet the requirements, together with substantial weight savings. The 3-D modeling of composite leaf spring is done and analyzed using ANSYS. A comparative study has been made between composite and steel leaf spring with respect to weight, cost and strength. From the results, it has been observed that the composite leaf spring is lighter and more economical than the conventional steel spring with similar design specifications. Composite leaf spring reduces the weight by 85 % for E-Glass/Epoxy, over conventional leaf spring.
• Rahman et al. [8] in their work discussed the non linear analysis of the parabolic spring. This paper studied response of a leaf spring of parabolic shape, assumed to be made of highly elastic steel. Numerical simulation was carried out using both the small and large deflection theories to calculate the stress and the deflection of the same beam. Non-linear analysis has been found to have significant effect on the beam’s response under a tip load. It has been seen that the actual bending stress at the fixed end, calculated by nonlinear theory, is 2.30-3.39 % less in comparison to a traditional leaf spring having the same volume of material. Interestingly, the maximum stress occurs at a region far away from the fixed end of the designed parabolic leaf spring.

3. CONCLUSION
The leaf spring is design by considering as it is behave like a cantilever beam. For the analysis purpose ANSYS software is selected as it gives good result. The fabrication of constant width constant thickness composite leaf spring is done by hand lay-up method. The spacers are tested experimentally by conducting a single point bending test. In almost all the paper it is concluded that composite leaf spring is lighter, more economical than the conventional steel spring with similar design specifications. Advantages such as reduction in noise, increasing in comfort ride.

4. FUTURE WORK
A review suggests that in forthcoming efforts, analysis of Mono Composite leaf spring could be best possible with Finite Element Method with ANSYS. The future work is to design the Mono Composite leaf spring used for Light commercial vehicle. For fabrication of Mono Composite leaf spring used for Light commercial vehicle the hand-layup technique will be use as it is more economical than the other method of fabrication. A stress analysis is going to perform using suitable finite element Analysis software like ANSYS 14. The experimental test has to be carried on both steel and composite leaf spring and compared the result. Fatigue analysis is required to find the life of Mono Composite leaf spring used for Light commercial vehicle.

REFERENCES