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Discussion

Authors' response to discussion on "Lateral vibration of a composite stepped beam consisted of SMA helical spring based on equivalent Euler-Bernoulli beam theory"

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All the works mentioned by Sinha and others on the subject of the dynamic characteristics of helical springs are now acknowledged by the authors. The present study was intended to propose a relatively simplified approach for the analysis of the vibration of composite stepped beams incorporating segments of helical springs and other beam-like structures. In order to simplify the modelling, the displacement of the helical spring was assumed to be a small deformation, and only the lateral deflection was considered. This assumption was also fully justified by our experimental results which were presented in this study. One of the advantages of the current simplified approach was that the equivalent flexural bending stiffness could be employed in the vibration analysis of the composite stepped beam structure. The goal of our work mainly focused on linear and lateral vibration of the spring. The nonlinear coupling between the axial and lateral deformation was never the subject of our work, nor was the transient response of the helical spring due to axial impact.

We note the comment of Sinha, whereby the use of the equivalent flexural stiffness of a helical spring in pure bending has already been mentioned by Timoshenko [1] and Costello [2]. This was overlooked in our article and we are sorry for not mentioning their contribution in the paper. However, it should be noted that the approach used by Costello was via the solution of the governing differential equations and only the problem with pure bending was presented. In contrast, our work employed the energy approach in the solution, and more combinations of different loadings were presented and discussed. As far as the new findings are concerned, our paper reports on the application of shape memory alloy (SMA) helical spring in the semi-active suspension platform and the feasibility of this has been demonstrated.

Several works mentioned by Sinha are related to the impact response of helical spring subjected to axial and twisting loadings. However, that topic was out of the scope of our paper. We do respect and recognise the contributions made by previous researchers, and we intend to be sure that every relevant work will be acknowledged in forthcoming manuscripts.

References

[1] S. Timoshenko, *Strength of Materials: Part II Advanced Theory and Problems*, third ed., D. Van Nostrand Co, 1956.
[2] G.A. Costello, Large deflections of helical spring due to bending, *ASCE Journal of Engineering Mechanics Division* 103 (3) (1977) 481–487.

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