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A semi-analytical state-space approach for 3D transient analysis of functionally graded material cylindrical shells

Key words: State space method, Numerical inversion of Laplace transform, Differential quadrature method, Functionally graded material, Cylindrical shells

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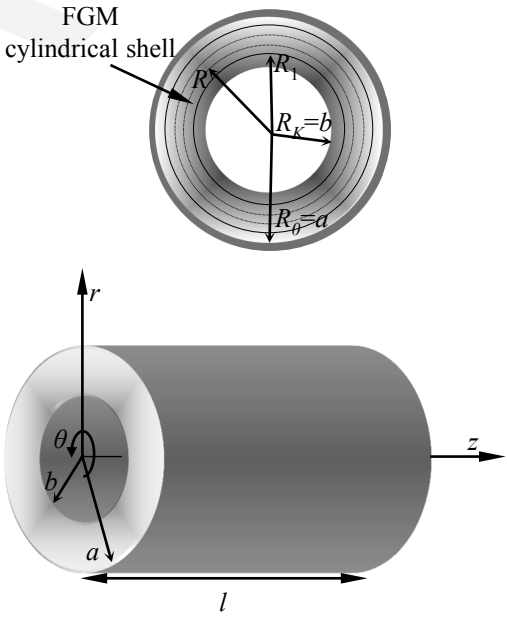
- A good understanding of the mechanical behavior of functionally graded material (FGM) cylindrical shells is necessary for designers and researchers.

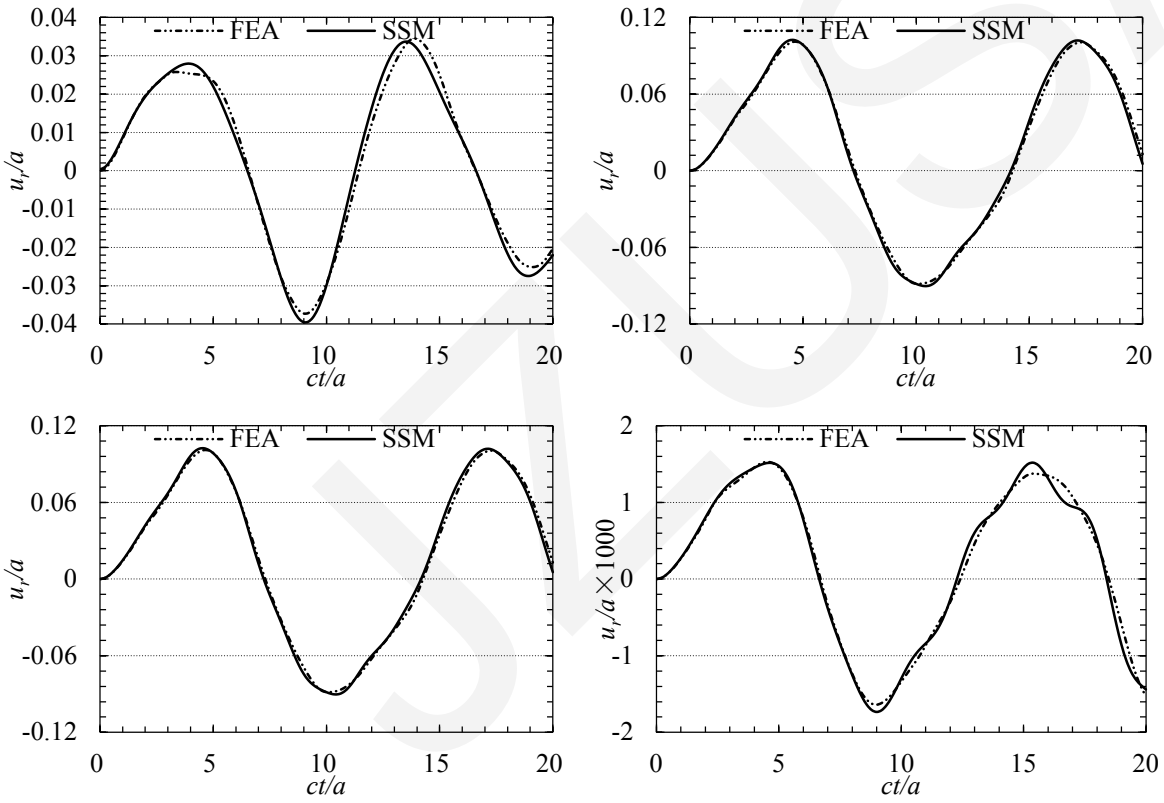
- The three dimensional transient response of FGM cylindrical shells under various boundary conditions has not yet been analysed.

- An semi-analytical approach integrating the state space method, differential quadrature method, and Durbin's numerical inversion method of Laplace transform is developed

- Four kinds of boundary conditions are considered: Clamped-Clamped (C-C), Clamped-Simply supported (C-S), Clamped-Free (C-F) and Simply supported-Simply supported (S-S)

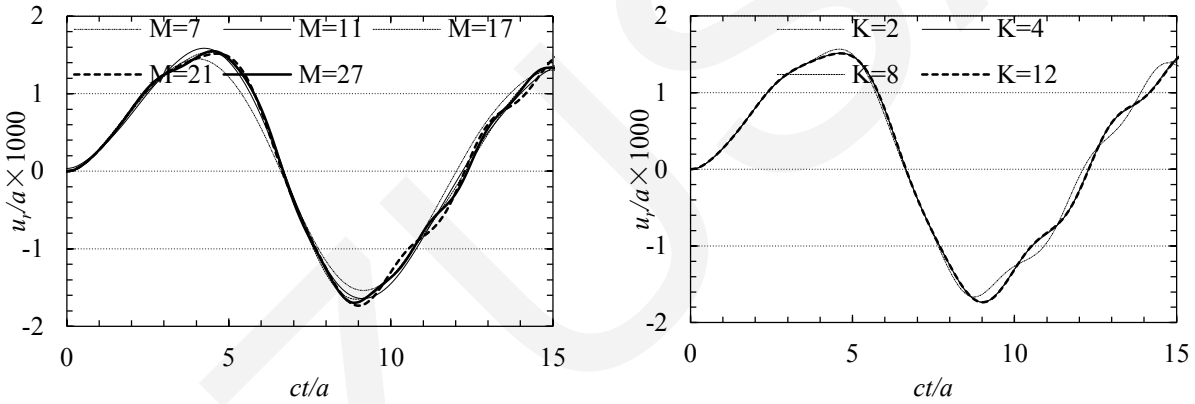


- A comparison between the results generated by the proposed method and by the finite element method shows that the two methods predict nearly the same results



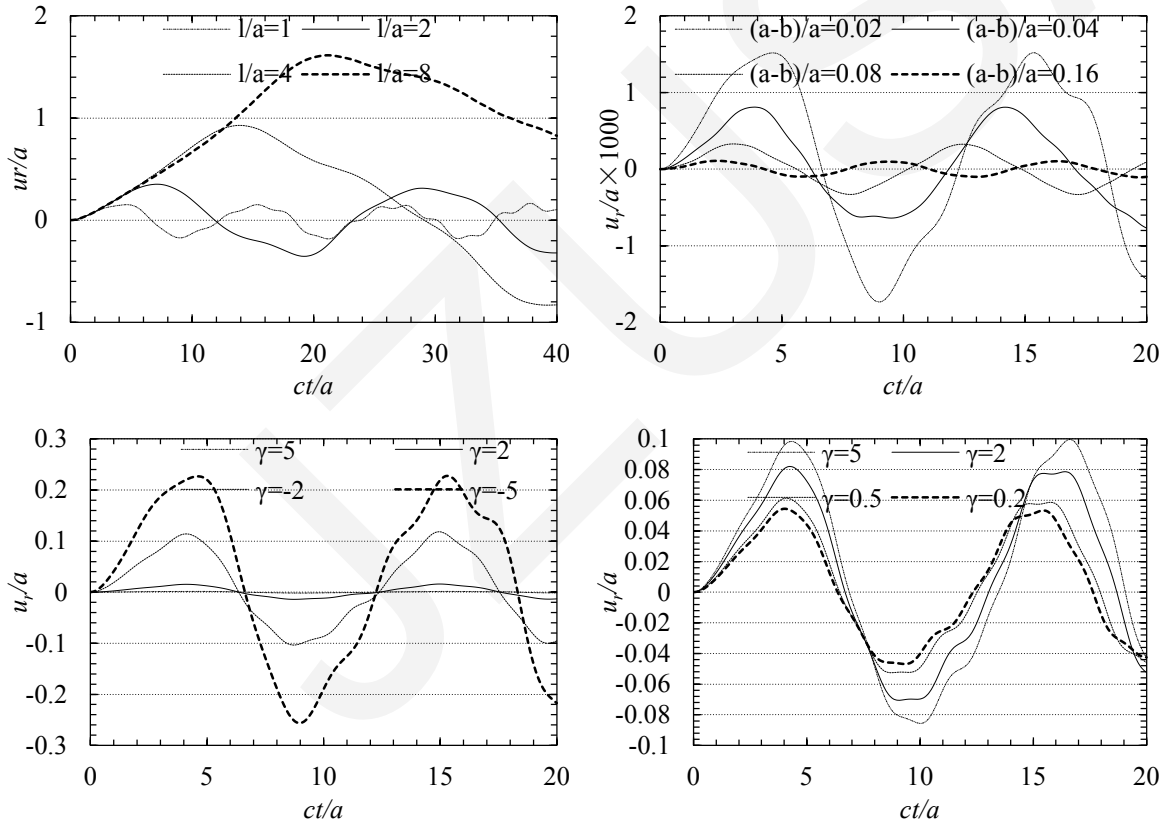
The time histories of the normalized deflection u_r/h at a chosen position ($x=(a+b)/2$, $y=0$, $z=h/2$) of FGM cylindrical shells subjected to transient loads obtained by the proposed method and finite element method. (a) Case 1; (b) Case 2; (c) Case 3; (d) Case 4.

- Convergence studies for different numbers of sampling points along the length direction and the layer numbers along the radial direction are carried out. It is shown that the proposed method has fast convergence rate.

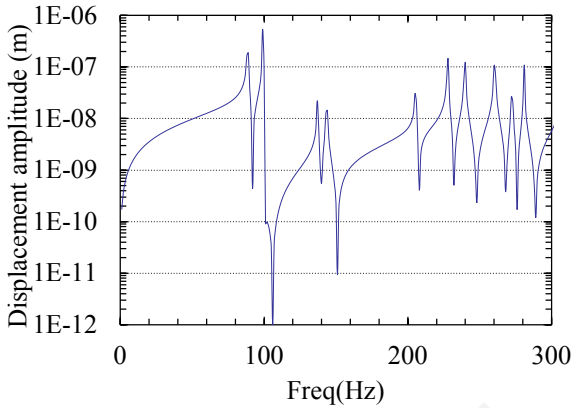


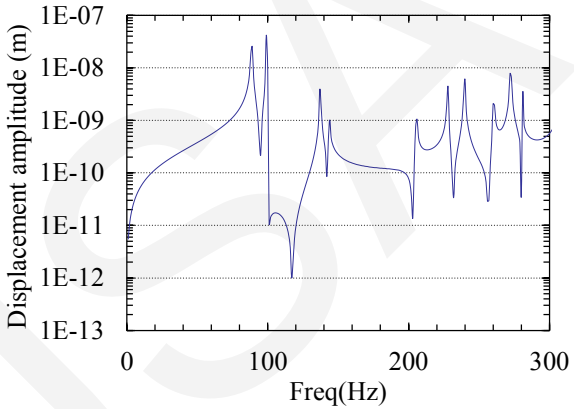
The time histories of the normalized deflection u_r/h at a chosen position ($x=(a+b)/2$, $y=0$, $z=h/2$) of FGM cylindrical shells. (a) With different numbers of sampling points along the length direction; (b) With different layer numbers along the radial direction.

- The effects of the length/outer radius ratio (*l*/*a*) and the (outer radius-inner radius)/outer radius ratio ((*a*-*b*)/*a*) on the transient response of FGM cylindrical shells are examined
- The effect of functionally graded (FG) index *γ* on the shell response is studied

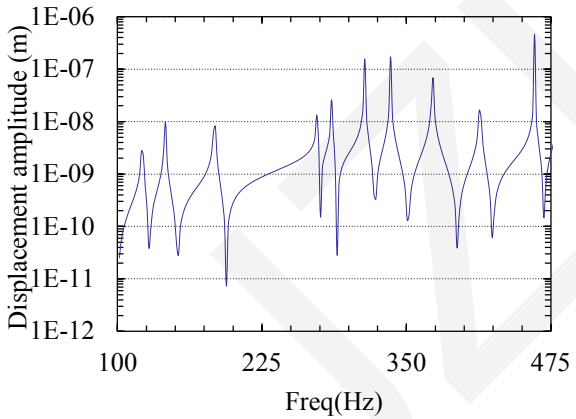


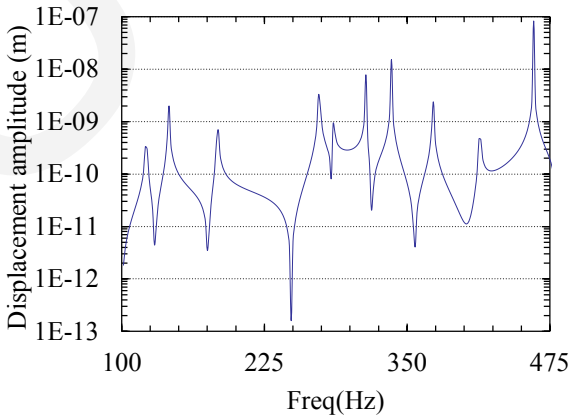
- The effects of the load frequency and duration are investigated。





Shell A





Shell B

It is shown that the cylindrical shells resonate at the natural frequency.

Conclusion

- A three dimensional semi-analytical method is proposed to analysis the transient response of FGM cylindrical shells with arbitrary boundary conditions at the edges, by employing the state space method (SSM), differential quadrature method (DQM), Laplace transform and its numerical inversion method.
- At the edges, four kinds of boundary conditions are considered: *Clamped-Clamped* (*C-C*), *Clamped-Simply supported* (*C-S*) and *Clamped-Free* (*C-F*) and *Simply supported-Simply supported* (*S-S*).
- The proposed method has fast convergence rate with the increasing sampling number along the length direction and the increasing layer number along the radial direction.
- The results obtained in this paper can serve as benchmark data in further research