Periodic structures with a transition zone: three amplification phenomena

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Publication date
2021

Document Version
Final published version

Citation (APA)
Faragau, A. B., de Oliveira Barbosa, J. M., Metrikine, A., & van Dalen, K. N. (2021). *Periodic structures with a transition zone: three amplification phenomena*.

Periodic structures with a transition zone: three amplification phenomena

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Introduction

Periodic systems under the action of moving loads have attracted the attention of researchers in the past century. These problems pose academic challenges and are of high practical relevance due to their application in railway, road, and bridge engineering, among others.

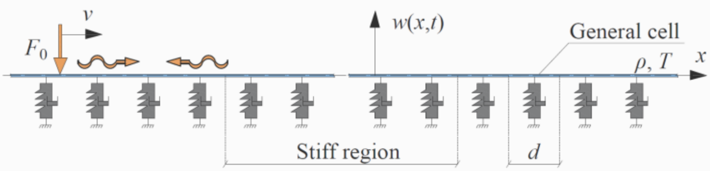

Figure 1: Model schematics.

Despite the numerous studies on periodic systems, few are dedicated to the influence of a local inhomogeneous region, a so-called *transition zone*, on the dynamic response. The **objective** here is to present three phenomena that can lead to response amplification in periodic systems with a transition zone.

1. Wave-interference phenomenon

The waves generated by the moving load outside the transition zone are reflected almost entirely by the stiff region if the frequencies of the waves are in one of the pass bands of the stiff region. This almost complete reflection leads to wave interference close to the moving load, which in turn leads to response amplification.

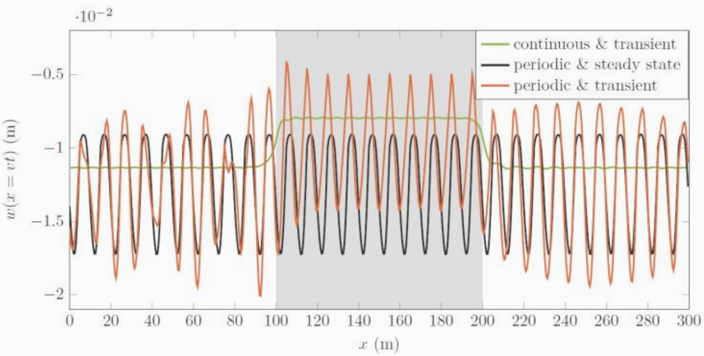

Figure 2: Displacement evaluated under the moving load; the location of the stiff zone is indicated by the grey background.

Results show that this mechanism is of importance when the velocity of the load is slightly higher than one of the resonance velocities in the soft regions. Also, for small lengths of the stiff zone energy can be tunnelled to the soft domain leading to a reduced amplification of the response.

2. Passing to a critical velocity

The second phenomenon is the passing from non-resonance velocity in the soft region to a resonance velocity in the stiff region. This causes resonance to occur inside the stiff region leading to a drastic amplification of the response mainly inside the stiff region. Results show that this mechanism leads to the biggest response amplification between the three phenomena.

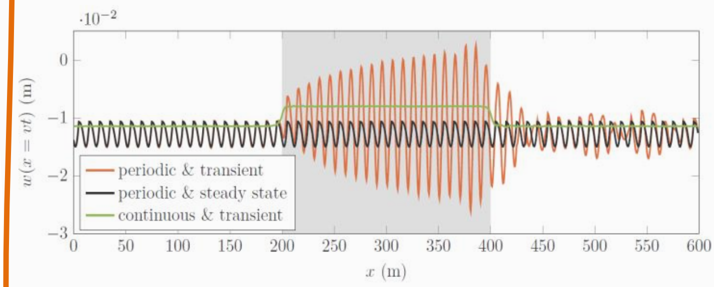

Figure 3: Displacement evaluated under the moving load; the location of the stiff zone is indicated by the grey background.

3. Wave-trapping phenomenon

The third phenomenon is the wave trapping inside the stiff region. For some specific values of the wavenumber and frequency of the waves generated in the soft region, these waves can get trapped inside the stiff zone potentially leading to response amplification around and inside the stiff zone. Results show that this mechanism leads to response amplification inside the stiff region even when the moving load is relatively far away from it. However, for reasonable values of damping, this mechanism is not as pronounced as the other two.

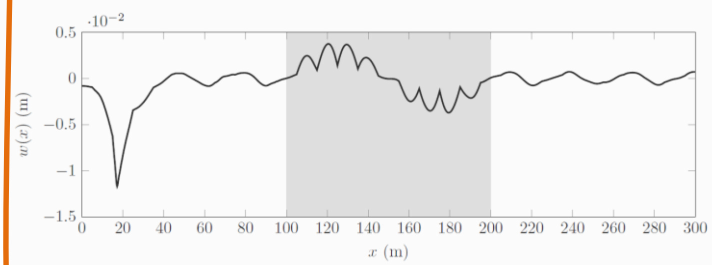

Figure 4: Snapshot of the displacement field; the stiff zone is indicated by the grey background.

Conclusions

The amplification of stresses and displacements in the transition zones can lead to numerous fatigue and wear problems in the catenary system and in the energy collector of the train. These three phenomena can be considered as additional constraints of the design parameters at transition zones such that these amplifications are avoided.

Acknowledgements

This research is supported by the Dutch Technology Foundation TTW (Project 15968), part of the Netherlands Organisation for Scientific Research (NWO), and which is partly funded by the Ministry of Economic Affairs.

Toegepaste en Technische Wetenschappen

PhD progress

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