# Improving Ride Comfort of a Soil Compactor based on the NSS Embedded into the Seat's Semiactive Suspension

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Three dynamic models (1-D, 2-D, and 3-D) of a soil compactor are established to research the vehicle's ride comfort via numerical simulation and experiment. Based on the efficiency of the semi-active control (SAC) of the Fuzzy-PID controller and the negative stiffness structure (NSS), a new suspension of the driver's seat equipped with the SAC and NSS is proposed to further improve the soil compactor's ride comfort under the various working conditions of the vehicle on the elastoplastic soil ground. The reduction of the root-mean-square seat acceleration ($a_{ws}$) in the time domain and the power-spectral-density seat acceleration (PSD) in the frequency domain is chosen as the objective function. The study indicates that the seat's acceleration response in the time domain with the 1-D, 2-D, and 3-D models of the soil compactor is similar. However, the $a_{ws}$ and maximum PSD acceleration of the driver's seat with the 1-D model are higher than that of the 3-D model by $35.9\%$ and $58.5\%$, while the acceleration response and PSD acceleration of the driver's seat with the simulation of the 3-D model are similar to the experiment. Therefore, the different dynamic models of the vehicle remarkably affect the investigation result. With the driver's seat suspension equipped with the SAC and NSS, the $a_{ws}$ and maximum PSD acceleration of the driver's seat are strongly decreased by $80.1\%$ and $87.6\%$ compared to the seat's passive suspension without the SAC and NSS. Additionally, these values are also lower than that of oth the SAC and NSS under various simulation conditions. Consequently, the driver's seat suspension equipped with the SAC and NSS could be used to further improve the ride comfort of the soil compactor.

## 1. INTRODUCTION

Existing studies indicated that the driver seat's vertical acceleration and the cab's pitching angle of soil compactors were very high, and they greatly affected the ride comfort and working efficiency of the driver.[1–3] To improve the vehicle's ride comfort, the traditional rubber isolations of the soil compactor cab had been replaced by using hydraulic mounts.[4] The semi-active control of the cab's hydraulic mounts was studied based on a combination between the fuzzy controller and proportional-integral-derivative controller (Fuzzy-PID controller).[5,6] The soil compactor's ride comfort had been significantly improved. However, the vertical vibration response of the driver's seat was still very high according to the standard of ISO 2631-1 (1997).[7] Especially in the condition of the soil compactor moving and compacting on the elastoplastic soil ground. This is a problem that still exists and it has not been completely resolved yet. To solve this issue, the passive suspension of the soil compactor seat needs to be studied and improved.

In the research of the seat's suspension systems, in order to improve the driver's ride comfort, the air spring system of the driver's seat had been used.[8,9] Additionally, based on the optimal control of the fuzzy controller, the genetic algorithm, and the Fuzzy-PID controller, the semi-active control (SAC) of the driver's seat suspension was also studied and developed.[10–12] The results showed that the SAC of the driver's seat suspension using the Fuzzy-PID controller remarkably improved the vertical acceleration response of the driver's seat. In addition, a new design of the negative stiffness structure (NSS) using steel springs had been also researched and applied for the seat passive suspension of the vehicles.[13–15] The different structures of the NSS using the steel spring, air spring, and roller spring were studied to improve the NSS's efficiency.[16] The optimization of the NSS's design parameters was also given to enhance the isolation efficiency of the NSS.[17,18] The result showed that the seat passive suspension added by the NSS greatly improved the driver's seat in both the time and frequency regions. Experimental studies were also performed to prove the actual efficiency of the NSS.[15,19] Besides, based on the magnetic char-