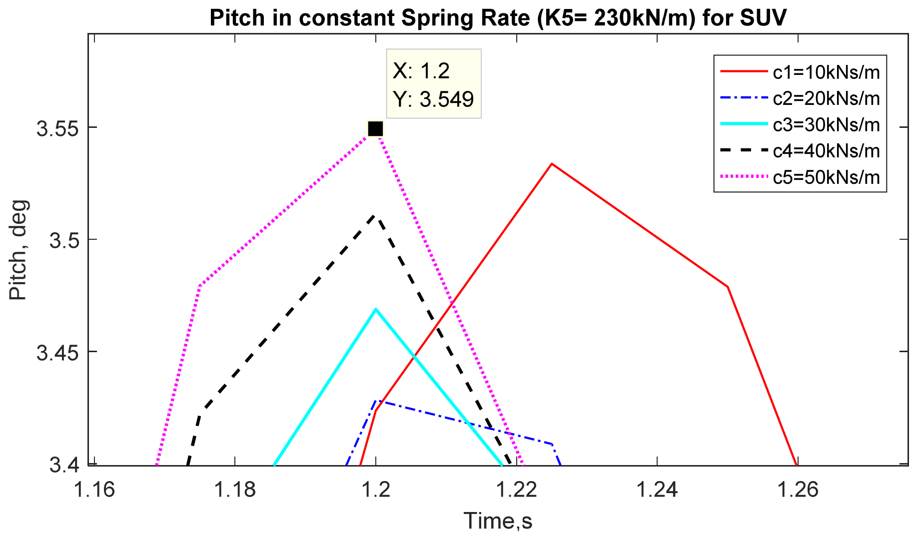


Fig. 8. Pitch at constant spring rate (k_5 = 230 kN/m) for SUV at overshoot region

TABLE II summarizes the overshoot pitch value of the SUV at different spring stiffness and damping. Fig. 9 shows the overall results for SUV in graphical form. It can be noted that the different spring stiffness and damping value the performance of the vehicle suspension system. Basically, the spring stiffness and damping value of suspension system will be selected depending on the vehicle parameter. If the vehicle has a heavy mass on the vehicle body, the spring stiffness and damping value should be higher to support the vertical motion of the vehicle body when hit a bump or driving through an uneven road. It is because suspension spring able to support the weight of vehicle body and passenger while a damper able to absorb and reduce the bounce force that exerted on the vehicle body. From overall simulation result for SUV, it can be noted that damping value is more important in vehicle compare to spring stiffness. It is because the damper will absorb the vertical force that affect the pitch motion on the vehicle body and reduce the bounce force from the road surface transmit to vehicle body while the spring of suspension only hold the vehicle body from the shock impact. So, in order to achieve the comfort of the vehicle, it need to select the optimal value of spring stiffness and damping which are suitable with the parameter of the SUV. From the figure, it can be observed that at lower values of damping and spring stiffness, the suspension produce the lowest overshoot.

TABLE II
Overshoot (pitch, deg) for SUV

Spring stiffness, kN/m	**Damping value, kNs/m**				
	c_1 = 10	c_2 = 20	c_3 = 30	c_4 = 40	c_5 = 50
	Overshoot, degree				
k_1 = 130	3.221	3.224	3.335	3.418	3.480
k_2 = 153	3.307	3.278	3.370	3.442	3.498
k_3 = 189	3.429	3.354	3.419	3.476	3.523
k_4 = 200	3.460	3.375	3.433	3.486	3.530
k_5 = 230	3.534	3.428	3.469	3.511	3.549

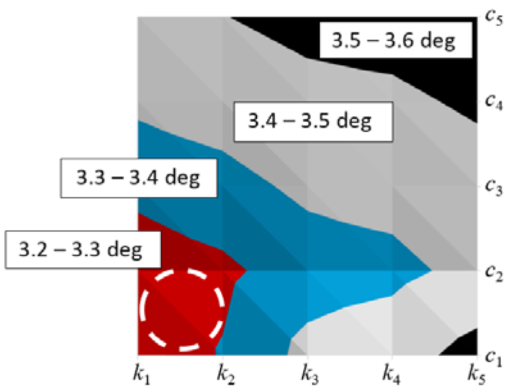
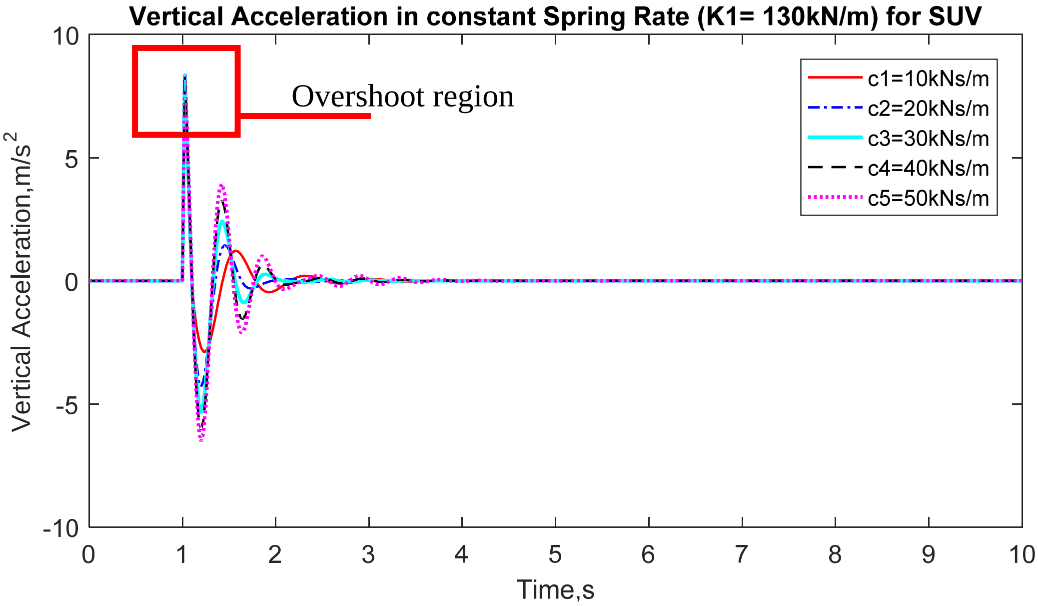
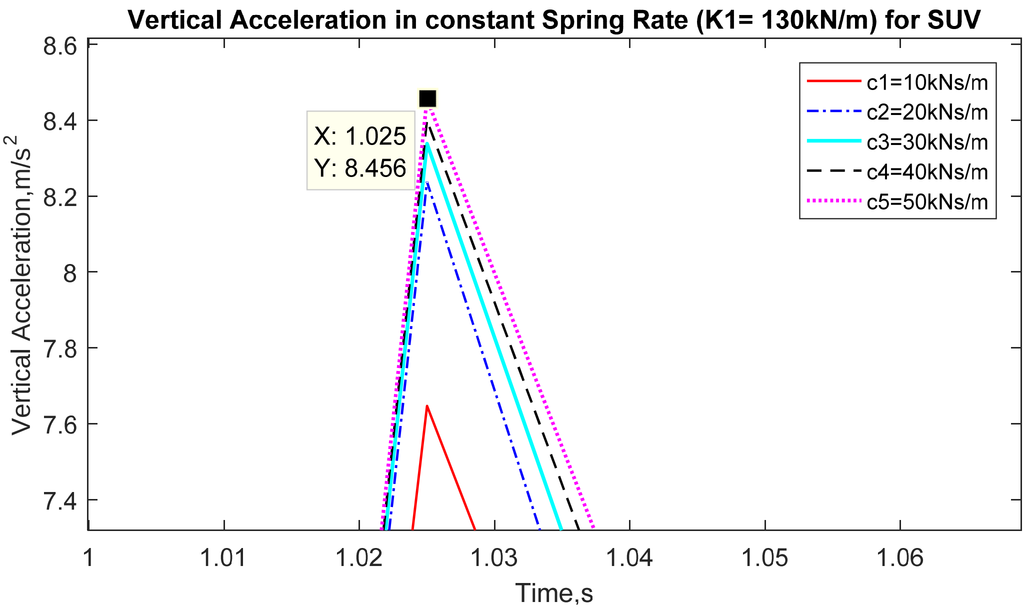


Fig. 9. Overshoot (pitch, deg) for SUV

Fig. 10 until Fig. 14 show that the result of vertical acceleration overshoot of the SUV at different value of spring stiffness and damping. It can be observed the effect of vertical body acceleration based on the five-different value of damping with constant spring stiffness on the SUV. For example, the vertical vibration overshoot is 8.456 m/s^2 for damping value c_5 = 50 kNs/m and spring stiffness k_1 = 130 kN/m (Fig. 10(b)). Damper is the important component of the suspension system to absorb the undesirable force from the road exerted on the vehicle body. So, in order to improve the comfort of SUV, it is needed to determine the optimal damping value that are able to reduce the overshoot value of vertical body acceleration. It can be noted that from the simulation, the higher the value of damping on the SUV, the lower the overshoot of the vertical body acceleration. TABLE III summarizes the values of overshoot that experienced on vertical body acceleration with various spring stiffness and damping. It can see that the lowest overshoot value that experienced on vertical body acceleration on the SUV is at spring stiffness about 130 kN/s and damping value about 10 kNs/m. Fig. 15 shows the distribution of vertical vibration overshoot at different damping and stiffness. It can be observed that the lowest value of overshoot is at the range of c_1 and k_1.



(a)



(b)

Fig. 10. Vertical acceleration at constant spring rate (k_1 =130 kN/m) for SUV (a) Overall results, (b) Overshoot region enlarged

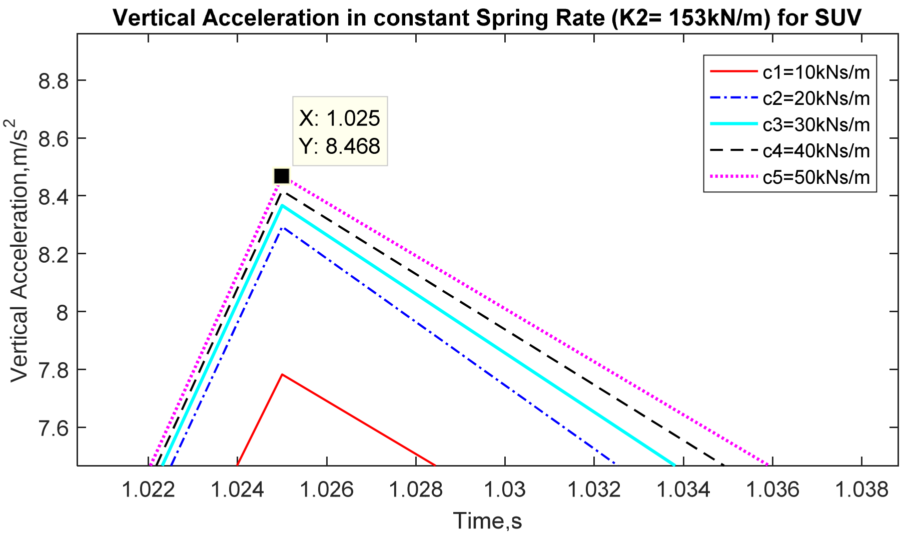


Fig. 11. Vertical acceleration at constant spring rate (k_2 =153 kN/m) for SUV at overshoot region

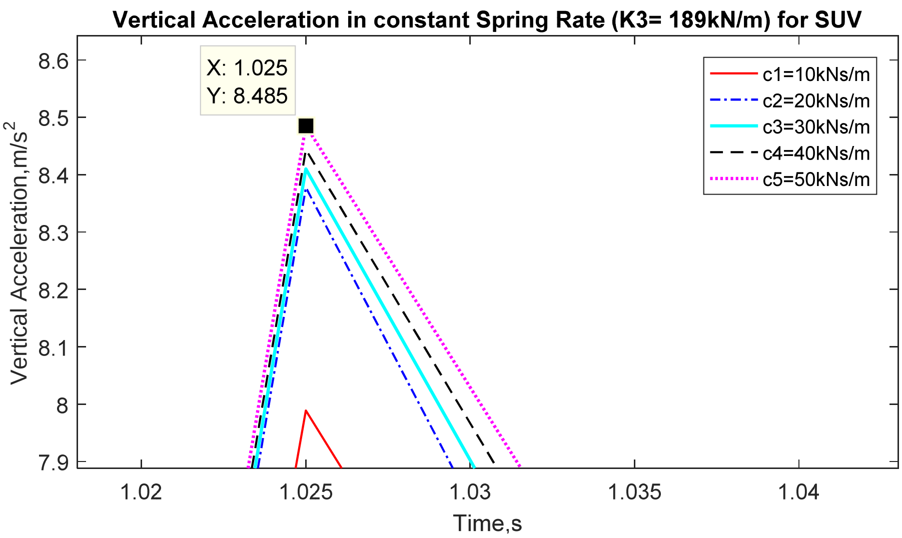


Fig. 12. Vertical acceleration at constant spring rate (k_3 =189 kN/m) for SUV at overshoot region

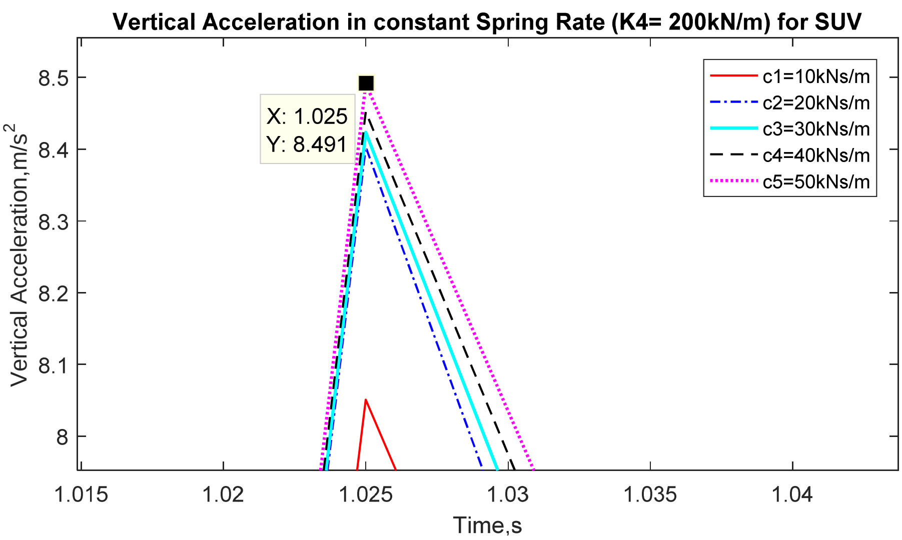


Fig. 13. Vertical acceleration at constant spring rate (k_4 =200 kN/m) for SUV at overshoot region

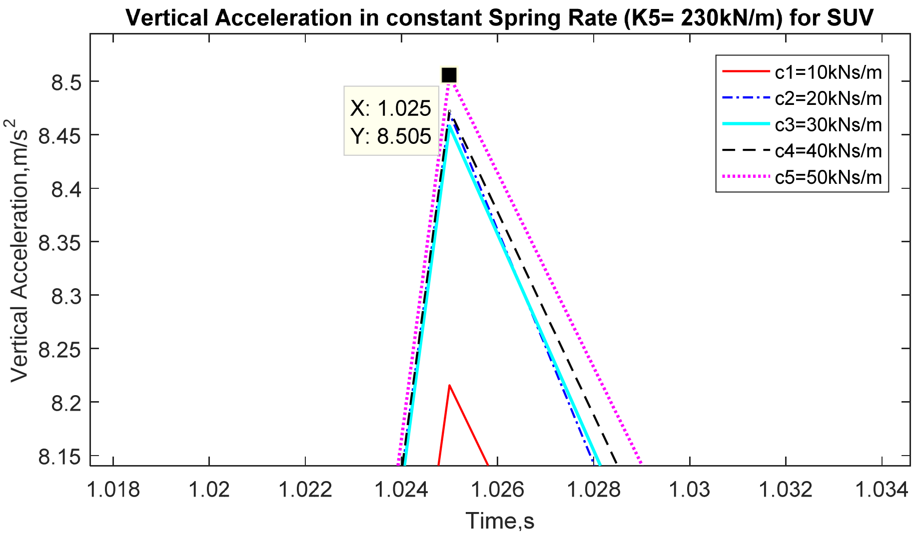


Fig. 14. Vertical acceleration at constant spring rate (k_5 =230 kN/m) for SUV at overshoot region

TABLE III
Overshoot (vertical acceleration, m/s^2) for SUV

Spring stiffness, kN/m	**Damping value, kNs/m**				
	c_1 = 10	c_2 = 20	c_3 = 30	c_4 = 40	c_5 = 50
	Overshoot, m/s^2				
k_1 = 130	7.467	8.470	8.338	8.400	8.456
k_2 = 153	7.783	8.403	8.367	8.417	8.468
k_3 = 189	7.989	8.378	8.410	8.444	8.485
k_4 = 200	8.051	8.293	8.423	8.452	8.491
k_5 = 230	8.216	8.238	8.458	8.473	8.505

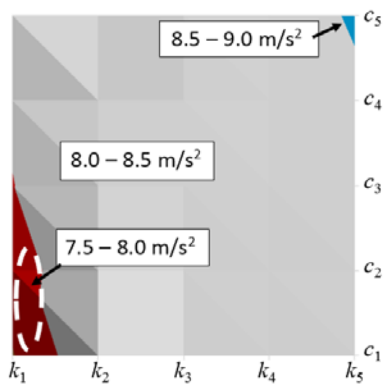


Fig. 15. Overshoot (vertical acceleration, m/s2) for SUV

IV. Conclusion

Pitch motion of the vehicle body represents the motion the vehicle between front body and rear body. In this study, a 4DOF pitch plane half car ride model is used to simulate the performance of a SUV at a 0.1 m step input. The performance of the vehicle is determined through overshoot responses of the pitch and vertical vibration at different spring stiffness's and damping values. Since smaller value of overshoot is considered as good in term of suspension response, the tuned parameters for both pitch and vertical vibration performance is in the range of 130 to 153 kN/m and 10 to 20 kNs/m. These values can be used later for actual vehicle tuning and comfort performance.

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