

Road Conditions and Engine Mount Displacement of Sao Paulo and Boston

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ABSTRACT

This paper describes the displacement of the engine mount when a vehicle was driven in Sao Paulo, Brazil, and in Boston, U.S.A. The both areas were characterized by large displacement inputs to the engine mounts. In Sao Paulo, the input in the normal speed range was larger than in Boston, and the frequency was about ten times as high. Also, a large peak that cannot be measured in other regions was found here.

This peak was due to the uneven roads and steep slopes in Sao Paulo.

1. Introduction

In addition to supporting the engine as a rubber vibration isolator, the engine mount is an important component that reduces the transmission of engine vibration to the vehicle body.

In the development stage, it is important to design sufficiently durable rubber and bracket after assessing the input on the mount so that the vibration isolator characteristics can perform well over an extended time. In particular, larger input values are important when designing strength and durability.

On the other hand, it has been determined that road conditions in different areas of the world have their own characteristic tendencies in displacement input on the engine mount. Therefore, it was decided to measure engine mount displacement on an actual vehicle in Sao Paulo, Brazil, a region with particularly larger input, and Boston, which has relatively larger input in the USA. The displacement measurement results were used to examine how the road conditions affect the displacement behavior.

2. Road Conditions

This section describes the road conditions in Sao Paulo and Boston. Generally, road surfaces in Sao Paulo are rough with the following characteristics.

- (1) There are many brick paved steep slopes with many

- intersections and frequent parking on slopes (Fig. 1(a)).
- (2) Residential roads are a mixture of brick and asphalt paving with deep undulations (Fig. 1(b)).
- (3) There are many wide drainage ditches with large and steep V shape (Fig. 1(c) and (d)).

Boston, which has rough road surfaces relative to other places within the U.S., has the following characteristics.

- (1) Many slightly distorted asphalt road surfaces (Fig. 2(a)).
- (2) Deep indentations due to many manholes (Fig. 2(b)).
- (3) Many road surfaces with deep undulations (Fig. 2(c)).
- (4) Streetcar tracks on road surfaces (Fig. 2(d)).

3. Displacement Measurement Method

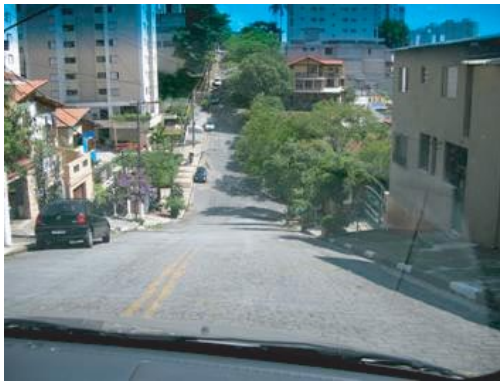
Displacement measurements were taken on routes of regular roads in urban, central areas, with one circuit measuring a few dozen kilometers in Sao Paulo and Boston. Highway driving was not included, as the routes were based on urban driving routes.

One of the methods of measuring engine mount input is to attach a strain gauge to the installation bracket. However, accurate measurements from low to high amplitude, behavior typical of rubber, are challenging to obtain by this method.

Therefore, to measure the input as directly as possible, potentiometer-type linear displacement transducers were installed (Fig. 3) near the bracket joints for displacement in both the up and down and front and rear directions to

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(a) Brick road steep slope



(b) Mixture of Brick road and asphalt paving with high waviness



(c) Large and wide drainage ditch with steep pitch



(d) Road surface at a drainage ditch in intersection

Fig. 1 Unique road surfaces in Sao Paulo



(a) Slightly distorted asphalt road



(b) Many indentations on road surface by manholes



(c) Undulating road surface



(d) Existence of streetcar track

Fig. 2 Unique road surfaces in Boston

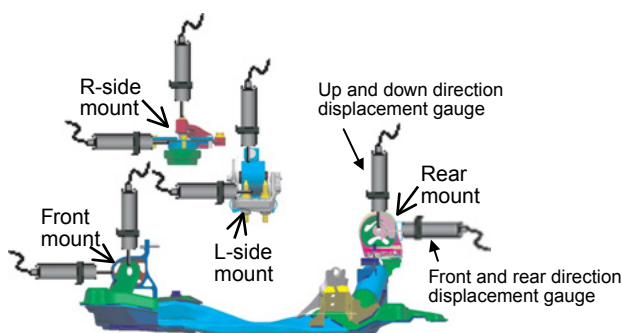


Fig. 3 Installation of engine mount displacement gauges

be measured, and the transducers were then synchronized. From this, the displacement that was generated by the input and obtained at the mount and bracket joint was considered the actual displacement, enabling displacement behavior in two dimensions to be assessed.

The displacement values measured with the displacement transducers were converted to load using the displacement-load curve that had already been measured for the mount, and was used in the actual development.

A 1.7L 4AT medium-size test vehicle was used for the measurements. The same test car was transported to the test locations to reduce individual vehicle variations and measurement driving tests were performed without making changes to, for example, the suspension settings.

4. Measurement Results

Figure 4 shows the displacement locus chart of each mount point when driving with the traffic flow on an urban route. The input direction of the mount displacement in San Paulo is about the same as that in Boston. In addition, it was discovered that the displacement of the rear mount was especially large, even though the frequency was low (Fig. 5).

When the driving conditions that generated this particularly larger displacement were analyzed a momentary tire skid was assumed to have been generated when starting the vehicle on a steep slope, and that the drivetrain generated momentary resonance and larger displacement in response.

In Sao Paulo, there are many intersections on slopes where drivers often have to stop. In addition, the asphalt has come off in some areas of the road surface, and other areas have brick roads. Furthermore, when there is insufficient load on the front drive wheels on steep slopes, a momentary tire skid may be generated (Fig. 6).

Meanwhile, the input examination for each route has clarified that this larger input is not generated even when passing over large gaps in the road in Sao Paulo, such as over regular drainage ditches.

Then, the same measurements performed with a medium-size vehicle were made with a small-size vehicle to check the variation between vehicles for larger input generation when starting on a steep slope. When a momentary skid was generated on the same steep slope on an urban route, the results showed the same characteristic peak for the mount displacement as shown

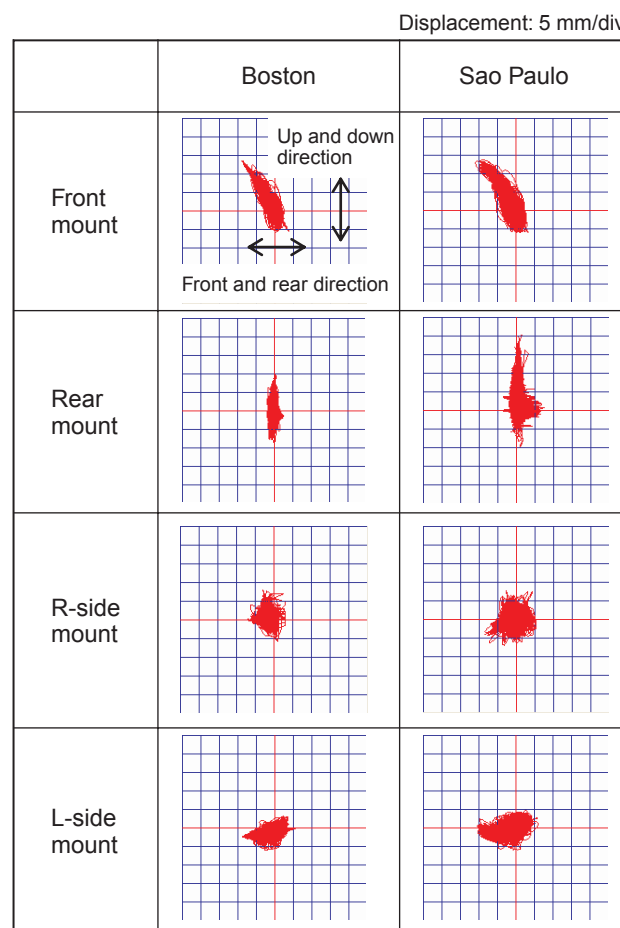


Fig. 4 Comparison of displacement between Sao Paulo and Boston

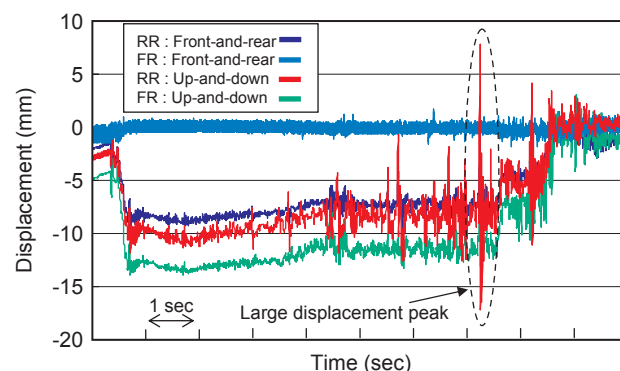


Fig. 5 Displacement of front and rear mount during starting with squeal on steep slope in Sao Paulo

in Fig. 5. However, the mount with the peak in the small-size vehicle was not the RR mount as in the medium-size vehicle, but the largest input was shown by the L-side mount (Fig. 7). This is likely to be because of the variations in the characteristic values of the spring-mass system due to differences in the vehicles types and layouts of the engine, drive system and engine mount.

While driving for the measurements in Sao Paulo the driver felt the vehicle shaking a lot because of the rough and undulating road surface conditions.

Therefore, the displacement frequencies of each mount were compared as follows: to perform the statistical distribution analysis for the displacement input the figures were multiplied by the number of circuits required if a total of 100 000 km were to be driven on the urban route, which had a distance of a few dozen kilometers. As a result of the comparison of all the displacement frequencies, the frequency in the Sao Paulo region was determined to be about 10 times higher than that in the Boston region (Fig. 8, Fig. 9).

In addition the larger displacement of approximately -18 mm, for the rear mount was generated by a skid while

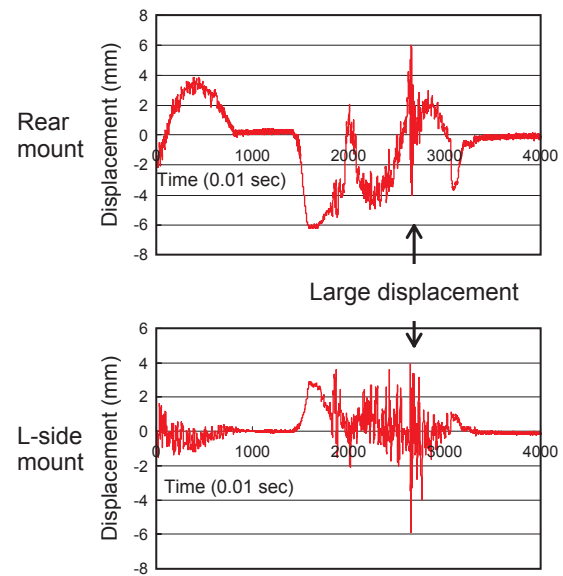


Fig. 7 Small car displacement of rear mount and L-side mount during starting with squeal on steep slope (up-and-down direction)



Example of road surface where squeal occurs in irregular section

Fig. 6 Typical steep slope in Sao Paulo

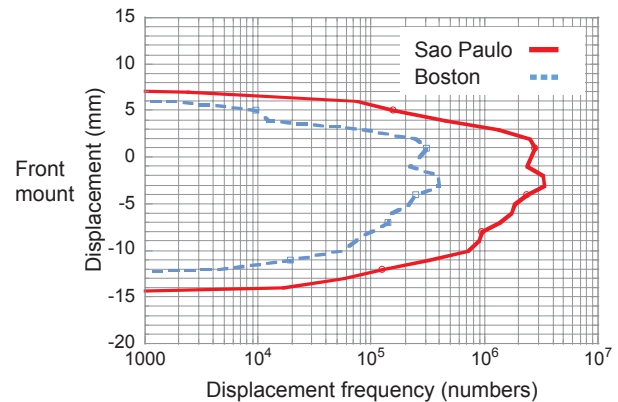


Fig. 8 Front mount comparison of displacement frequency for 100000 km between Sao Paulo and Boston (up-and-down direction)

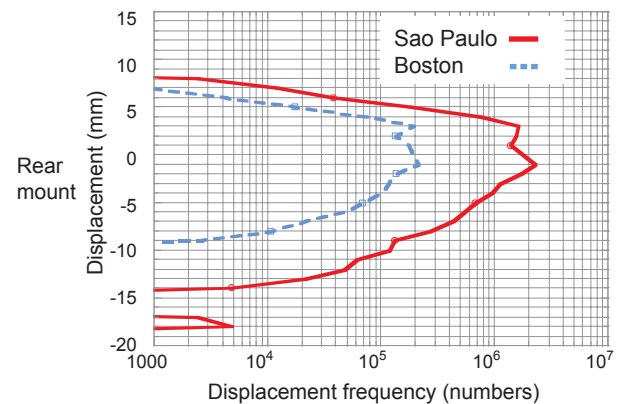


Fig. 9 Rear mount comparison of displacement frequency for 100000 km between Sao Paulo and Boston (up-and-down direction)

driving on a steep slope, however, the occurrence frequency was lower.

The following reasons may help clarify why the input frequency in Sao Paulo is higher than that in Boston.

- (1) Many locations of exposed brick road exist.
- (2) At some locations, the asphalt paving on the brick road has come off or asphalt paving is incomplete, so the road is an uneven mixture of brick road and asphalt. The many inputs are generated when passing over the boundaries between these areas.
- (3) Drainage ditches are everywhere and the vehicles often enter the ditches at normal speed, generating a larger input.
- (4) There are many intersections at the end of downhill slopes, at which the vehicles are likely to contact the ground because of slope differences between the road and drainage ditches.

5. Conclusion

It was determined that larger input existed for engine mounts in the market due to road surface influences when driving.

In particular, in the Sao Paulo region, resonance was found to occur between the engine and drivetrain due to tire skids when starting on steep slopes, causing some mounts to generate a larger displacement.

Durability is an important factor in the design of an engine mount, so larger inputs should be incorporated into the measurement data. For this reason, it is important to assess actual inputs in the market.

Different vibration test conditions in the unit durability evaluation of mount units were set for different regions during development, including the results of this examination. Particularly for Brazil, in addition to the conventional vibration test conditions, vibration test conditions to match input equivalent to that when starting on steep slopes were set as needed.

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