Design and performance evaluation of a normal translation vibration transmissibility test assembly
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ABSTRACT – For the efficacy of new material for passive isolation application to be confirmed, it must undergo a test run. For this reason, a proper test rig is needed. This paper presents the design of a test rig for a force vibration transmissibility test. The test rig was designed in accordance with the technical standard BS EN ISO 10846-2, with additional advantages such as high flexibility and ample test room space. The test rig has been tested after it has been fully developed with lattice structure samples with varying strut diameter sizes as test elements. The results show that good transmissibility curves are attainable. The resonance frequency of lattice samples shifted to the higher frequency region due to increased stiffness as the strut diameter increased. The results from the tests demonstrated that the developed test rig can be used for transmissibility tests with minimal noise.

1. INTRODUCTION

The first step in resolving a problem caused by unwanted vibration is to stop the source of the vibration. [1]. Else, the installation of a vibration control system is needed [2]. A vibration isolator is a commonly used vibration control system to negate the destructive effects of vibration by isolating the system of interest from the vibration source. A passive vibration isolator is an entirely mechanical system; therefore, it needs to be able to support the mass load from the system of interest. Thus, it is often referred to as resilient material. Owing to this, the resilient material needs to have enough strength to sustain the mass load. But this also results in a higher natural frequency, which diminishes the efficacy of the isolator in the low-frequency region. Hence, a good balance between stiffness and natural frequency must be determined for a specific application. In order to do this, resilient materials must be tested by experimentation to determine their suitability.

Several studies reported the design of test rigs. Nandurkar et al., (2017) come out with a test rig and conducted static analysis on the design [3]. Though, the study focuses on the test rig parts instead of its feasibility in practice. Kothawade et al., (2014) made a test rig to measure transmissibility [4]. But the study does not follow technical standards BS EN ISO 10846-2 that used dynamic vibration exciter, instead, they used a DC motor. Fonseca (2011) included the force transmissibility study in his master's thesis; however, the test setup did not use a test rig but an experimental assembly consisting of two force sensors [5]. Another study by Salim (2016) used a transmissibility test rig available in the government research facility, the Malaysian Rubber Board, however, this test rig is not accessible besides being more suitable for large size test elements [6]. Therefore, this study reports on the design of the custom vibration transmissibility test rig. The test rig was designed to follow the technical standard BS EN ISO 10846-2 and refer to the test rig by Salim (2016) as DATUM [6]. Besides that, the test rig was also designed with added features such as high flexibility, ease to use, and can be reused for different sizes of test elements.

2. TEST RIG DESIGN

The test rig was designed with a big block of heavy base and square steel plates assembled with four threaded rods and nuts. The benefits of this design are straightforward configuration to reduce costs, take a short period of production time and consist of many loose parts which can be easily replaced if needed. Furthermore, with a low-rise base setting, more test room space can be achieved for larger sizes test elements. In terms of flexibility, the developed test rig can fit two sizes of vibration shakers, this is illustrated in Figure 1. These benefits can ensure that the test rig is usable for a wide range of test elements. In addition, the test rig was padded with low stiffness rubber sheets at the shaker mountings and the base of the test rig as shown in the similar Figure 1. By doing this, no ambient vibration from the floor can disrupt the test and the vibration from the shaker can only be transmitted thru the transmission path and not via the threaded rods frame.

3. PERFORMANCE TEST

Transmissibility tests have been performed to assess the performance of the test rig with lattice structures made with varying strut diameter sizes ranging from 3 mm to 5 mm. Although the technical standard BS EN ISO 10846-2 is made to measure dynamic stiffness, the test rig's goal is the same: to collect credible data on exciting and transmitted forces. Therefore, two independent force sensors were used to measure the exciting and transmitted forces. Random excitation signals ranging from 0 to 750 Hz were used to excite the lattice samples. The dynamic data analyzer recorded the input data from both force sensors to generate the transmissibility graphs. The transmissibility curves from the test are shown in Figure 2.
Figure 1 Illustration of test rig in the experimental setup.

Figure 2 Transmissibility plots for lattice structure with varying strut diameter size.

The plots show obvious and typical transmissibility plots with discernible regions, amplification, resonance, and isolation with minimal noise. The transmissibility ratio is $T=1$ at the low frequency which progress and peaked when the operating frequency matched the natural frequencies at resonance and the transmissibility ratio is less than 1 at high frequency. As expected, the resonance frequency of lattice samples shifted to the right from the increased stiffness as the strut diameter increased.

4. CONCLUSION

This study presents a test rig designed for the transmissibility test of resilient elements for vibration isolation application. The test rig was designed to comply with the technical standard. The test rig also has ample room space and can mount two different sizes of shakers as added advantages so that it is reusable for many other test elements for the same test. The results from the test run show that good transmissibility plots can be obtained with very minimal noise. Therefore, the developed test rig can be used with utmost confidence to produce reliable transmissibility results.

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