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Design of a Test System for Compressibility and Resilience Performance Measurement of Floor Coverings

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Abstract

The quality of floor coverings is evaluated according to their resistance to texture deformation. The most important factors affecting the texture deformation of floor coverings are static loads causing the compression of floor coverings, thereby the appearance of floor coverings deteriorated unfavorably. The compressibility and resilience performance of floor covering determine the appearance retention level of pile yarns. There are two types of tests to determine the compressibility and resilience performance of floor coverings namely; thickness loss after prolonged heavy static loading and thickness loss after brief moderate static loading. In this study, it is aimed to design a test system for compressibility and resilience performance measurement of floor coverings. The test system will be capable of automatically applying necessary pressure for both brief moderate static loading and prolonged heavy static loading tests. By providing these two tests and the thickness measurement by a solo device, the test procedures will be achieved automatically.

Keywords: Compressibility, Carpet, Resilience, Static loading, Floor covering

Yer Döşemeliklerinin Sıkıştırılabilirlik ve Rezilyans Performans Ölçümü için Bir Test Sistemi Tasarımı

Öz

Yer döşemeliklerinin kalitesi, yüzey deformasyonuna karşı gösterdiği dirence göre değerlendirilmektedir. Yer döşemeliklerinin yüzey deformasyonunu etkileyen en önemli faktörler, yer döşemeliklerinin sıkıştırılmasına ve böylece yüzey görünümünün bozulmasına neden olan statik yüklerdir. Yer döşemelik ürünlerinin sıkıştırılabilirlik ve rezilyans performansı hav ipliklerinin görünüm muhafaza etme seviyelerini belirlemektedir. Yer döşemeliklerinin sıkıştırılabilirlik ve rezilyans performansını belirlemek için iki tür test kullanılmaktadır. Bunlar; uzun süreli ağır statik yüklemeden sonra kalınlık kaybı ve kısa süreli orta statik yüklemeden sonra kalınlık kaybıdır. Bu çalışmada, yer döşemeliklerinin sıkıştırılabilirlik ve rezilyans performanslarını ölçmek için bir test sistemi geliştirilmesi amaçlanmıştır. Test sistemi hem kısa süreli orta statik yükleme hem de uzun süreli ağır statik yükleme testleri için gerekli basıncı otomatik olarak uygulayabilecektir. Bu iki test ve kalınlık ölçümünün tek bir cihazla yapılmasının sağlanması ile test prosedürleri otomatik olarak gerçekleştirilecektir.

Anahtar Kelimeler: Sıkıştırılabilirlik, Halı, Rezilyans, Statik yükleme, Yer döşemelikleri

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1. INTRODUCTION

Textile floor coverings are commonly used textile materials by people in their living areas. They are not only used to provide sound and heat insulation but also for aesthetic appearance in houses, hotels, conference rooms etc. [1].

Textile floor coverings are exposed to many stresses during usage which adversely affect their surface texture. Some of the influential stresses are static and dynamic loads. These loads cause a texture deterioration on floor covering surface. The most commonly used tests to assess the compressibility and resilience performance of floor coverings are thickness loss after brief moderate static loading and prolonged heavy static loading [1-3].

In static loading tests, a floor covering thickness measurement device and a loading mechanism are required for determination of thickness differences before and after the loading and recovery periods [4]. For static loading tests, at first sight, the thickness of the specimen is measured under 2 kPa pressure by the thickness measurement device, then the specimen is loaded with the required value of pressure according to the related standard. After the loading period, the specimen is maintained unloaded for a specific time period according to the standard and after that the thickness is measured again. The deformation of the specimen is stated as the thickness loss. According to the available standards, for prolonged heavy static loading test, the thickness of the floor covering is measured by the thickness measurement test device, then the floor covering specimen is loaded for 24 hours under 700 kPa load. After this period, the load is removed and the thickness of the specimen is measured immediately. The floor covering specimen remains unloaded for 24 hours recovery period. In the next step, the thickness of the specimen is measured after the recovery period again [5,6]. Similarly, for brief moderate static loading test, at first sight, the thickness of the specimen is measured by the thickness measurement device, then 220 kPa load is applied for 2 hours. At the end of 2 hours load application period, the thickness of the specimen is measured under 220 kPa load. After the loading process is completed, the specimen is remained unloaded. The thickness of the specimen is measured for 15 minutes, 30 minutes, and 60 minutes recovery periods. Testing of five specimens is essential for both static loading tests. The required time for testing one sample of floor covering for the brief, moderate static loading is 10-10.5 hours, whereas it is 48 hours for prolonged heavy static loading [4,7,8]. For each of the aforementioned tests, a floor covering thickness measurement device and a different loading apparatus are required. This situation causes important investment costs for scientific and production mill laboratories. Different brands of floor covering test devices are available, either national or imported [9-12].

Furthermore, it is very laborious to follow up the both test procedure for an operator. The procedure is prone to personal operator faults. Consequently, it should be more convenient to make these tests by a solo test device by eliminating the probable operator faults and by decreasing the investment cost of laboratories.

Several studies have been conducted to develop testing instruments or to measure the properties of textiles. Mecit and Roye presented a test method to investigate the compression behavior of spacer fabrics. It was concluded that the proposed testing way can be applied to measure the compression behavior of spacer fabrics [13]. Fujimoto et al. developed a sensor to measure the surface property of pile materials. The developed sensor was found to be able to quantify the friction that has previously been difficult to be measured [14]. Yao and Li presented a measurement system and new test method based on a virtual instrument for integrated evaluation of fabric handle. The system is able to measure, record, and analyze the thermal and mechanical sensory properties of textile materials [15]. A measurement method of fabric touch feels which named fabric touch tester was reported by Li et al. Four different modules namely; compression, thermal, bending, and surface were used to simultaneously measure the fabric touch feel, which significantly reduce the testing cost [16]. A developed testing equipment for determining the wear viability of various lunar wheel tread materials with service lives of up to ten years and 10000 km was presented by Joshua et al [17]. Sengupta et al. [18] in their research presented a testing instrument for measuring bending behavior for technical textiles. The proposed instrument is able to test a wide range of fabrics with different thickness and structures. In addition, the developed instrument can be set for required speed and sample size. As it can be seen from previous studies, there is an effort to provide a user-friendly and versatile textile test device for accurate, precise, low cost and high-speed test procedure. However, a developed design or system for providing a solo test device for thickness measurement and static load application for floor coverings has not been studied yet.

In this study, it is aimed to design a multi-functional and innovative test system for measurement of thickness loss after static loading tests by using an automatic solo test device.

2. REASONS FOR DEVELOPING A NEW TEST SYSTEM

The test system will be capable of automatically applying the necessary pressure for brief, moderate static loading test, prolonged heavy static loading test, and thickness measurement in relation to relevant standards, by a solo test device. In this way, it will be possible to perform the tests that need to be accomplished with three test devices: thickness measurement gauge, Figure 1.A, brief, moderate static loading test device and prolonged heavy static loading test device, Figure 1.B, by only utilizing the proposed test device. By this way, the investment cost of floor covering performance test laboratories can be decreased considerably. Moreover, providing these different procedures by the newly developed system will minimize the place requirement of the laboratory.

The test system will be superior to the existing test devices for providing the following features:

- Obtaining accurate and precise thickness property measurements in a computer environment.
- Tests will be implemented automatically not manually.
- Having the results of tests automatically analyzed and immediately after the test.
- All the tests can be implemented by only one technician.
- Minimizing the place requirement of the laboratory.
- The developed test system will be able to test samples of thicker materials such as 3D fabrics.

The loading, unloading and thickness measurements can be implemented automatically for the aforementioned tests. The test results can be automatically obtained and digitally stored. It will be much easier to get the test results for statistical analysis in a digital environment.

A B

Figure 1. A) Carpet thickness measurement gauge, B) prolonged static loading test device

3. PRINCIPLE OF OPERATION

Figure 2 represents the 3-D isometric view of the prototype and its components. The reason behind using the screws and the hex nuts as the feet of the test device is to ensure its balance by calibrating them before conducting tests.

The working principle of the prototype is, receiving the instructions from an interface that will be designed by the App designer editor of MATLAB software. A USB connection between MATLAB and Arduino will be used to control each component of the prototype.

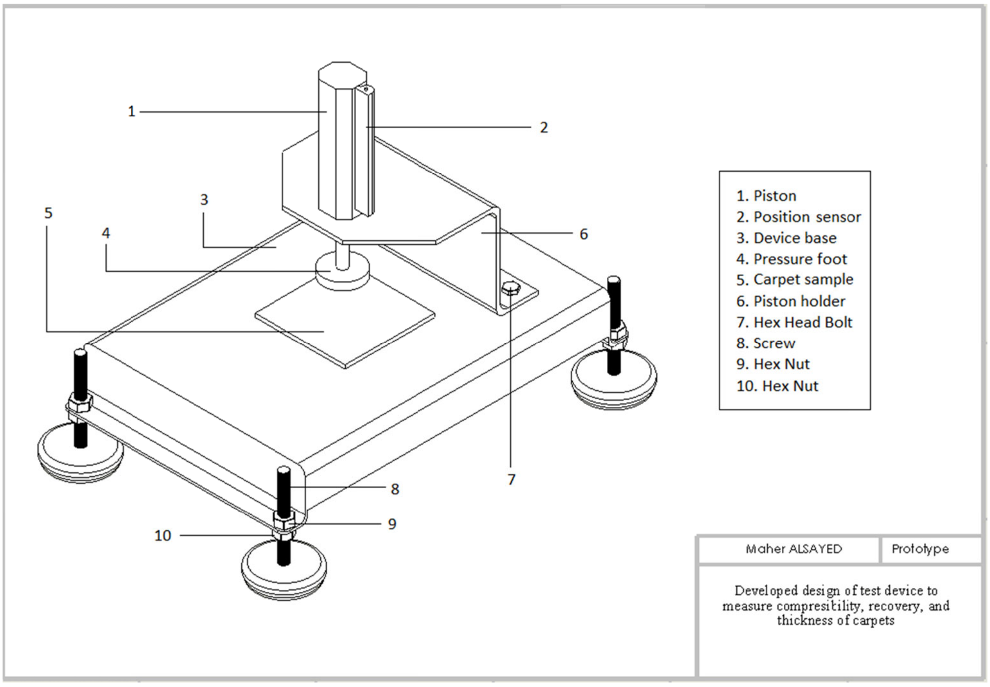

Figure 2. 3-D isometric view of the prototype and its components

The test will initialize when the solenoid receives a command to be opened, from the main controller, then the piston will move down due to the provided air from the pressure regulator and the piston will press on the sample through its pressure foot. The pressure foot will be made of Aluminum for two reasons; reaching light loads while conducting the tests such as 2 kPa and benefiting from the hardness of Aluminum which is required for high loads of tests such as 220 kPa, and 700 kPa as defined in the related standards. The piston will apply the required loads on the sample. The value of applied load will be detected precisely and continuously during the loading duration of test procedure by a load cell which will be located under the sample. The measured values of loads will be sent to the main controller to be compared with the required load value. If the measured value is correct, the supplied air pressure will be kept constant, otherwise, a feedback signal will be sent to the pressure regulator to regulate the supplied air pressure. This closed loop feedback operation will be carried out during the pressure application.

The position sensor, which is attached to the piston, will play an essential role in determining the stroke of the piston continually. With the help of the position sensor, the thickness of the sample will be measured. All the obtained measurements will be stored and displayed in the interface of MATLAB software.

Basically, the system will be able to implement the required pressure (2 kPa) for thickness measurement and finally the thickness loss after the brief moderate or prolonged heavy static loading tests will be determined.

The steps of the tests are explained below in Figure 3.

The following diagram, Figure 4, represents the control block diagram of the prototype.

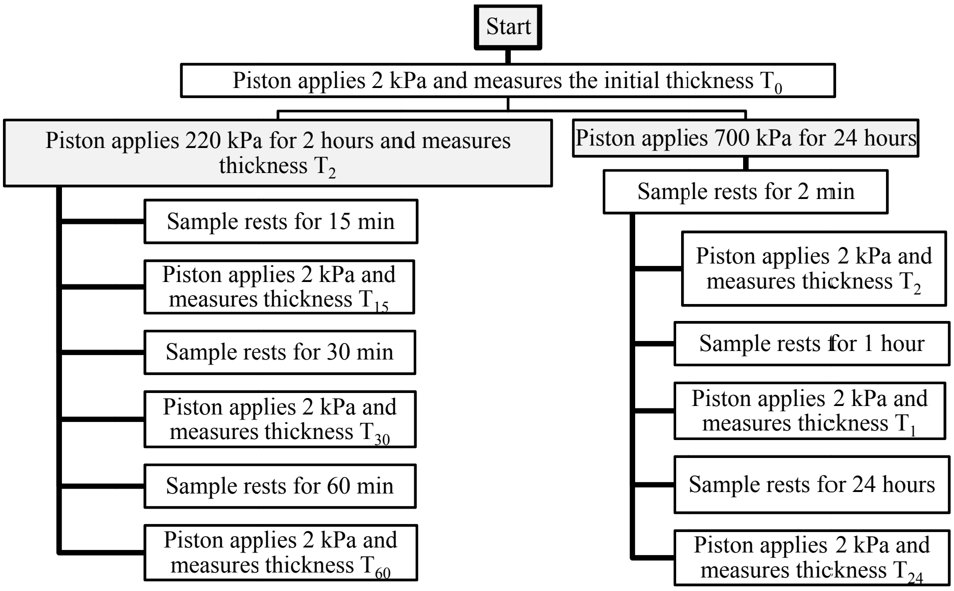

Figure 3. Thickness loss after brief, moderate and prolonged heavy static loading tests

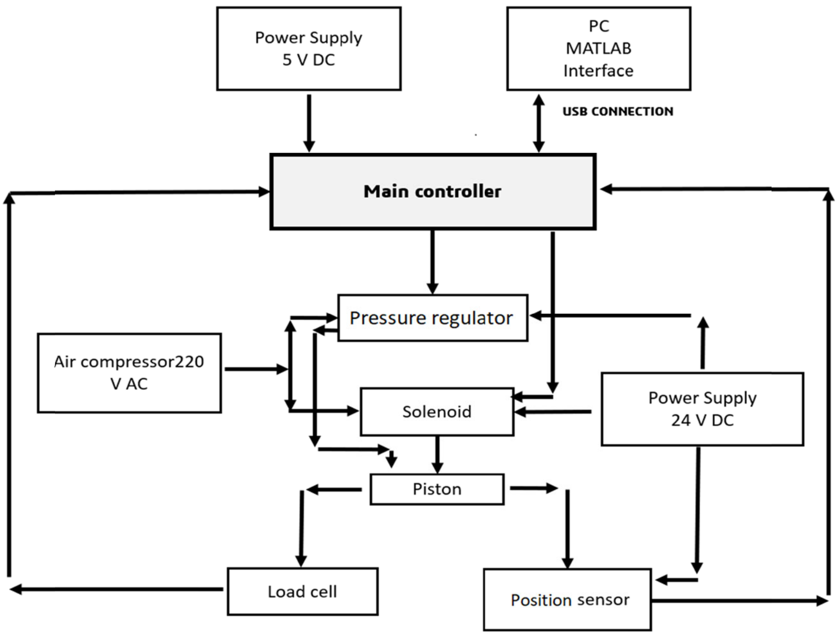

Figure 4. Block diagram of the communication in the testing process

The main controller is the core of the control circuit. By the cooperation between the main controller and the position sensor, the thickness values will be measured.

The main controller is responsible for;

- Generating required signals to send commands to the pressure regulator and the solenoid valve
- Receiving data from the load cell and the position sensor
- Reading and writing data to the user interface

Figure 5 represents the pneumatic circuit and the movement system of the test device. It can be noticed that the piston moves linearly and perpendicularly on to the device base. The piston has 9 cm stroke and makes this stoke in 1 second. The moving component of the mechanism is the piston. The degree of freedom of the piston in the presented mechanism is 1 since the piston is able to move linearly in one direction (up and down). Figure 5 explains the pneumatic circle of the test device and its components. The two-position and three-way 3/2 pneumatic solenoid valve is the responsible component for the determination of movement direction. 3/2 refers to two working positions and three ports in the piston body, namely 1 the inlet port, 2 and 3 are the outlet ports, as it is shown in Figure 5. The inlet port 1 is where the air is supplied to the valve, port 2 is where the supplied air pushes the piston, and port 3 is where the exhausted air goes outside the circuit. When the circuit is closed, the solenoid allows the air to go to the upper part of the piston, thereby the pressure of air P1 becomes bigger than the pressure of air in the lower part of the piston P2 so the piston goes down, and vice versa.

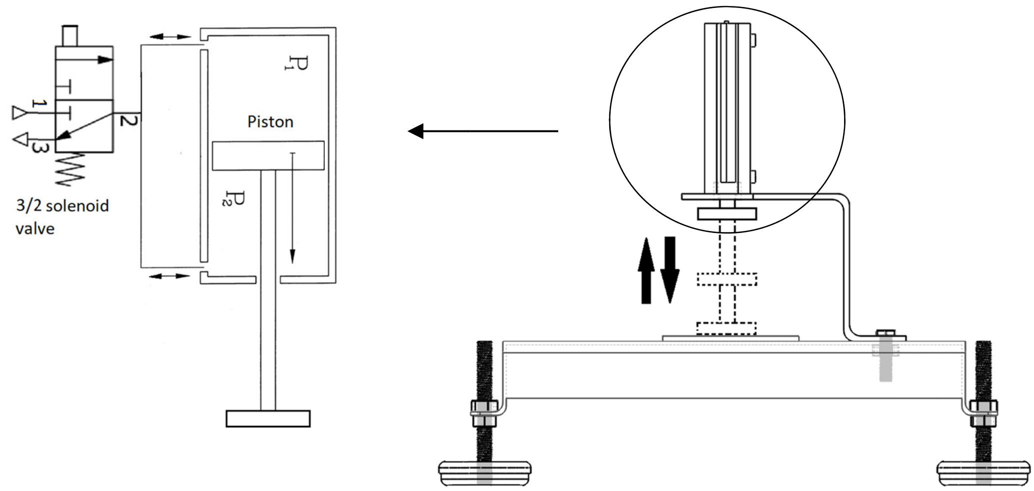

Figure 5. The pneumatic circuit and the movement system of the test device

4. CONCLUSIONS

In this research, a multi-functional and innovative test system design was presented for compressibility and resilience performance measurement of floor coverings. The developed test system will be capable of automatically applying necessary pressures for brief, moderate static loading test and prolonged heavy static loading test for necessary time duration. The system will also get the thickness measurement in relation to relevant standards. Therefore, the investment cost of floor covering performance test laboratory can be decreased considerably.

The test results can be obtained automatically and saved digitally. It will be much easier to get the test results for statistical analysis in a computer environment. The loading, unloading and thickness measurement can be done automatically for the aforementioned tests. In this way, the personal testing faults and difficulties of following the loading periods can be eliminated, thereby the measurements can be done more precisely.

5. ACKNOWLEDGMENT

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