Innovation on Accessible and Low Cost Deflection Measurement Devices

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Abstract: Deflection occurs mostly in structures, especially those that accept lateral loads. Excessive deflection can cause damage, especially in the supporting structure therefore deflection must be measured but the deflection measurement device is still expensive so the application is limited. Modification of the deflection measurement device can be done using an optical mouse. The ability of optical mouse is expressed in the ability to scan the number of points in each area, the bigger the smaller the displacement that can be measured. we use a cheap mouse and the results show the mouse is able to measure deflection to accuracy of about 0.04 mm. Optical mouse is cheap so it is expected to use it more widely, except for practitioners and universities, it is hoped that it can also be used in vocational schools where the needs are large but the budget are limited.

1 INTRODUCTION

Monitoring of building structure deformation and durability testing of materials and structures is a very important process in development and production with the aim of maintaining safety and strength of the structure. Deflection occurs a lot in structures that cause deformation so it needs to be monitored by measuring it, especially when receiving maximum loads. Fibre optic sensors used for monitoring bridges (Yoneyama and Ueda, 2012). However the cost of fibre optic sensors is too high and the installation of the sensors is not easy for existing bridges. Another approach to bridge deflection measurement is the use of noncontact measurement method for example photogrammetry, moiré and laser scanning. A laser system has a potential to measure deflection distribution of bridge by scanning, however, at higher cost. Structural deflections represent a critical response parameter often measured for structural health monitoring (Attanayake et al., 2011). Laser tracker records position coordinates at few discrete points while laser scanner captures points of clouds representing deformed and undeformed shapes of a structure. These technologies present distinctive advantages, capabilities and limitations for field applications. Innovations in deflection measurement devices that are low cost (Guo and Wei, 2015) have to be created. This research tries to make a cheap deflection measurement device from a computer mouse. This aims to expand the use of these devices in practical and academic environments. This research is limited to the use of optical mouse to read shift points only in one direction (Ali and Al-garni, 1996), (Simm et al., 2016). Computer mouse that are modified only for one-way shifts. It is mainly for measuring very small distances. Deflection is very small, so it is precisely measured by this tool. The depth of drilling holes that require high accuracy can also be measured with this tool (Peng et al., 2007). There are still many kinds of very small distance measurements in daily work. This can be seen from the development of tools that are getting smaller in size so that the size needs to beaccurate in the design and manufacture. Vocational school students and university students really need to develop skills in designing and manufacturing tools or machines. Of course this cannot be separated from the use of measuring instruments. A cheap measuring instrument can be used even though it is not as precise as a high-tech measuring instrument which of course is expensive. However, the main objective is for students to master the basic principles of measurement that will not be separated from design. Cheap measuring instruments are expected to be used more widely so that it will increase the number of students who have better skills to support their future. The rest of this paper is structured as follows. After this introduction of study, some previous study related to this research are presented in theoretical background, materials and methods. Result and discussion presents

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findings and lessons from the test and the innovation of measurement device. Finally, the conclusion presented including the implication of this study.

2 METHODOLOGY

The beam that receives the lateral load will be deflected according to the resultant direction of the load. In this study the beam (4) only accepts the concentrated load (5) in the middle of the span in a vertical direction. Therefore the point shift that occurs is only one direction, namely vertical deflection. The load is increased little by little so that the deflection that occurs also increases. Deflection is a change in the shape of the beam from horizontal to curve in the direction y due to the vertical loading. The deformation of the beam is very easily explained based on the deflection of the beam from its position before experiencing loading. Deflection is measured from the initial neutral surface to a neutral position after deformation occurs. The assumed configuration with neutral surface deformation is known as the elastic curve of the beam. Deflection that occurs along the beam can be determined by making a form of equation which is often called the curve deflection equation (or elastic curve) of the beam. Structural systems are placed horizontally especially for carrying lateral loads, i.e. loads that work perpendicular to the axial axis of the beam. Deflection is measured only at one point, which is near the point of loading. Mouse is one of the computer hardware that receives input in the form of movement, button pressure and scroll. The mouse used is a type of optics that does not use a mechanical system at all but uses a laser beam to detect shifting points. Technology in the optical mouse makes its performance far more precise than the type of mouse with a mechanical system. In recent years all digital accessories are no exception the mouse leads to the wireless trend. This mouse does not require a cable to transmit movement signals but via wireless messages received by the receiver device on the chip. With a wireless mouse, the installation will be more flexible on a series of research tools; it can even be installed at long distances according to the specifications of the mouse. But this type of mouse requires a battery in operation, considering that it has no cable so that the weight increases. Optical mouse (1) as a deflection measurement device is connected to a beam near the loading point. Shifting the point of the beam position or deflection at the point being reviewed is recorded directly at every second. The beam used is in the form of iron plate or rectangular cross section beam. This aims to make the beam only deflects in one direction and does not experience bending in the other direction due to loading. The plate cross section size is adjusted to the length so that the plate is still in a straight state when it is not loaded. This aims to fulfil the requirements in using the formula for deflection and slope equations derived from the moment equation.

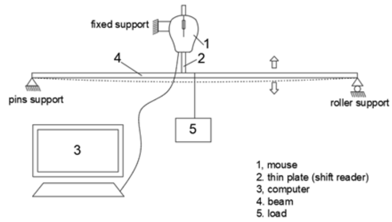

Figure 1: Deflection measurement scheme

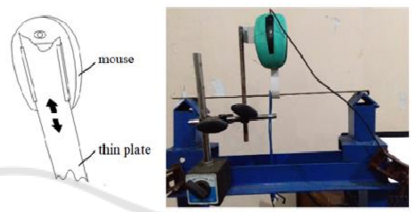

Figure 2: Mechanism of shift reader

The slope along the beam is zero when there is no load. Beams are supported by pins and roller orsimple beams so that there must be no shift in the horizontal direction. The load is applied to the beam little by little. Every second there is an increase in load and deflection. Additions to the load are carried out slowly so that changes in data can be read clearly in each second. Point shift will be recorded by the shift reader consisting of a thin plate (2) mounted on the mouse, but this plate can still be shifted. Data are recorded and displayed on a computer screen (3) with the help of program in the form of numbers and can be graphed. The graph shows the amount of deflection in each second. If an error occurs such as installing a shift reader on a beam that is connected to a mouse or a load movement that is not supposed to be, then it can be analysed from the graphic form.

3 RESULT AND DISCUSSION

The test is carried out by giving a concentrated load on 3 specimens in the form of iron plate. Iron plate cross section is 22,0 mm x 2,7 mm. Load is given manually because of the small beam size so it cannot use load cell because the load is small. The load is given gradually with a weight increase of 6.38 N as many as three steps. The data taken from this study is the amount of deflection that occurs near the point of loading. A shift reader that connects the mouse and specimen is made of thin plates that are flexible or from paper. The way the thin plate works is like using a computer mouse that is installed with a small distance from the bottom side of the mouse. If the beam has a deflection, the thin plate shifts so that there is a point shift and recorded by the mouse. The underside of the mouse is mounted on a rail so that the thin plate can move or shift freely but the distance to the underside of the mouse remains The results of deflection measurements are displayed in graphical form with deflections on the axis and seconds on the ordinate as follows.

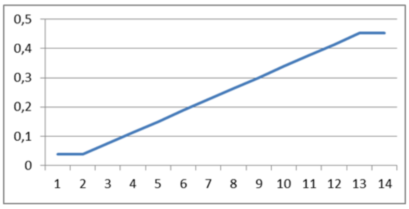

Figure 3: Graph of deflection with load start at 0 N

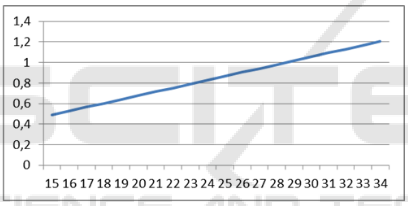

Figure 4: Graph of deflection with load start at 6,38 N

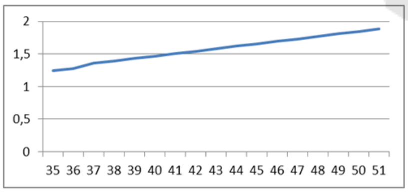

Figure 5: Graph of deflection with load start at 12,77 N

This measurement device has given result both magnitude and graph of deflection. The mouse computer is capable of detecting point shifts in very small distances as shown in the table results of measurement of deflection. In this study the shift of points read only one direction, has not been able to read the shift of points in various directions (Chen et al., 2018) , (He et al., 2017), (Yang et al., 2018). Therefore the test object must be ensured that there is no shift in the other direction. This is done by attaching the beam to a strong support even though the rod is free to move because it is a simple beam. The point shift on the beam from the horizontal position to the deflection, which is downward, is read accurately because the beam is not in contact with the reader on the mouse, that is the laser (Szade et al., 2015) , (Maekawa et al., 2016) . However, the mouse is mounted on a fixed pedestal and does not shift following the shift of points on the beam. Therefore the point that is read is only at a certain position so that it is necessary to move the field along with the beam because of the area of the beam is small when viewed from the side. The field is in the form of a thin plate tied to the beam and passed to the gap under the mouse with the smallest possible distance. The point shift is read from the side or direction perpendicular to the direction of deflection. The cross section and the length of the test object are chosen with the consideration that they can be deflected in small loads and not deflected due to the load itself. This is intended so that the condition remains qualified in thecalculation of deflection (Ghuku and Saha, 2018). Another consideration is that the beam must be weighed little by little so that the increase in the deflection magnitude can be read every second. However, loading is not done with load cell because load cell are only for large load.

4 CONCLUSIONS

At the beginning of the load 0 N it turns out there has been a deflection of 0,038 mm. This happens because there is a place or container for loads that have their own weight and has not carried load yet. As shown in Figure 3, in the 1st and 2nd second, there had been a deflection due to the weight of the container. This is evidenced by the same initial conditions for specimens 2 and 3, namely at the time of load 0 N the amount of the deflection is 0,038 mm. The average increase in the amount of deflection on the specimen 1 per second is 0,03 mm. With the same steps of experiment for specimens 2 and 3, the average amount of deflection increase is the same for each second which is equal to 0,03 mm. The results of this study were the cheap mouse can measure deflection with accuracy about 0,04 mm. This innovation of measurement device proves that it will be easy and cheap for practical and academic environments.

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