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DIGITAL IMAGE CORRELATION TECHNIQUE FOR ANALYSIS OF STRUCTURAL COMPONENTS OF DIFFERENT STIFFNESS UNDER STATIC LOADING

Tadeusz SZYMCZAK[*], **Adam BRODECKI**[**], **Dariusz RUDNIK**[*], **Zbigniew KOWALEWSKI**[*,**]

[*]Motor Transport Institute, Centre for Material Testing, ul. Jagiellonska 80, 03-301 Warsaw, Poland
[**]Department of Experimental Mechanics, Institute of Fundamental Technological Research, ul. Pawinskiego 5B, 02-106 Warszawa, Poland

[1] tadeusz.szymczak@its.waw.pl, [2] abrodec@ippt.pan.pl, [3] dariusz.rudnik@its.waw.pl, [4]zkowalew@ippt.pan.pl

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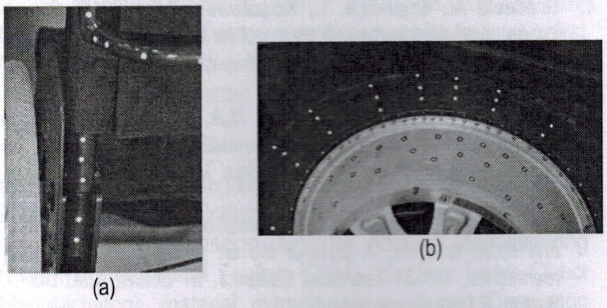
1. INTRODUCTION

Digital Image Correlation (DIC) technique is a method of measurement that is used in fundamental research applications, such as the mechanics of materials and components. The DIC method is employed to determine full-field strain distributions in 2D or 3D coordinate systems. This requires an usage of specimens marked with a special grey-black dot pattern on the measurement gauge (GOM, Chu 1985, Lord, 2009; Szymczak et al., 2016; 2018). One can indicate another application of the DIC system. It is often used in kinematic properties measurement of complex structural components. In this case, markers imposed on the selected zones are tracked by the DIC system (Figs. 1, 2). These markers take the form of white-black circular spots of various dimensions, ranging from 0.4 to 25 mm, (GOM). In terms of lighting conditions, the top layers of some of the markers have a fluorescence cover and are distributed with respect to the major axis of the component being tested (Fig. 1a). For objects without a significant major axis, the markers can be located in a stochastic manner, or in the expected deformation zones (Fig. 1b)



(a) (b)

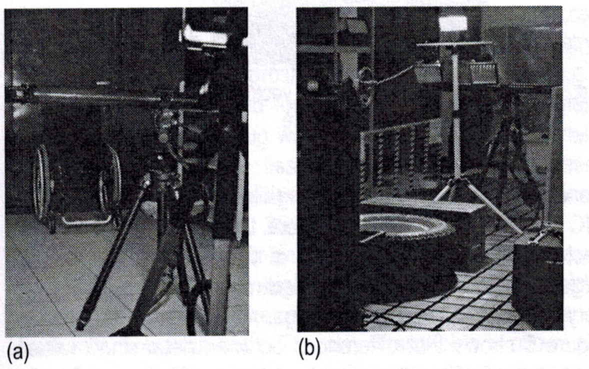
Fig. 1. Distribution of markers on selected components of a wheelchair (a) and entire wheel (b) tested using a PONTOS 5M DIC system

If the lightning conditions are insufficient for DIC measurements, an additional light source should be used (Fig. 2). Positioning of the extra light is dependent on a design of the testing station, dimensions and location of the object being tested. If a height of the tested object is close to the position of DIC's measuring tube, then it is recommended to locate the light source behind the station (Fig. 2a). In the opposite case, the lamp should be located between the tested object and DIC system, (Fig. 2b).

The DIC system can be used for both static (GOM, 2010) and dynamic testing (GOM). An analysis of the available literature on the DIC system's usage in the analysis of structural components indicates that this method is suitable for tests under cyclic loading (Berger, 2010; Bagersada, 2012; Brinkman, 2017; Brodecki et al, 2018). However, the number of articles that have been focused on the DIC application is still insufficient. Therefore, the aim of this paper is to examine the DIC system in determining a deflection of structural components having very different geometry and dimensions under static loading.

2. DETAILS OF THE EXPERIMENTAL PROCEDURE

Two different objects were tested: a wheelchair (Fig. 1a) and a wheel from the Sport Utility Vehicle (SUV) (Fig. 1b). Due to the limited lighting available in the test room, additional lamps were used.



(a) (b)

Fig. 2. The PONTOS 5M DIC system used in our experiments: (a) the wheelchair; (b) the SUV wheel

All tests were conducted at room temperature under static loading. For the wheelchair, the weight was applied by means of 25kg bags. A Saginomiya hydraulic servomotor, of ±30 kN loading capacity was chosen for examination of the SUV wheel .

For the wheelchair, the loading of 1.5 kN was selected in order to reflect an maximum weight of the wheelchair user. In the case of tyre of the SUV wheel it was 11 kN.
Assessment of the objects behaviour was carried out by analysis of displacement variations in a 3D coordinate system under both loading and unloading.

3. RESULTS

The results of DIC experiments are presented in the form of images with vectors, fringe plots and diagrams of deflection/displacement variations versus time (Figs. 3-5). In the case of the wheelchair, which had a lot of different components in different positions, the DIC observations should be presented at various orientations with respect to the object (Fig. 3). An analysis in different arrangements allows to capture deflection distributions in the 3D coordinate system. Thanks to them the largest component and any differences between the components deflection can be easily indicated (Fig. 3).

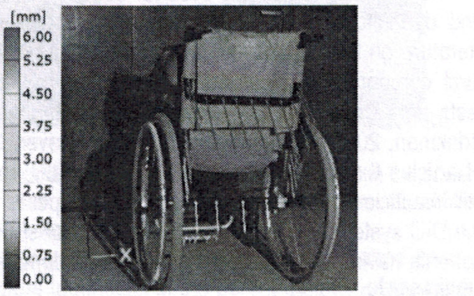


Fig. 3. Distributions of resultant vectors in the wheelchair under the loading of 1.5 kN, the rear view

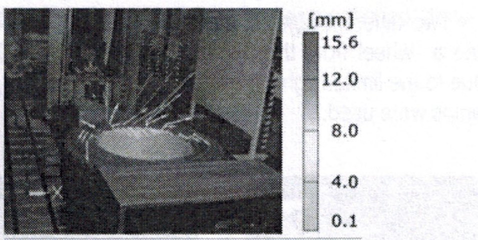


Fig. 4. Distributions of the resultant vectors in the SUV wheel under the loading of 11kN for the tire

Results of the SUV wheel testing illustrate the usage of the DIC system in experiments where the components are deflected with respect to all axes of the 3D system, even for large displacements. The DIC technique also is suitable for very small deflection values (Figs. 4, 5). Data presented in Figure 5 shows that differences between determined values may vary significantly, sometimes even 30 times. Among many advantages of the DIC system one can indicate a possibility of data presentation as a function of time either under loading (Fig. 5), or unloading. A comparison of data from loading (Figs. 4, 5) and unloading enables determination of permanent deflection.

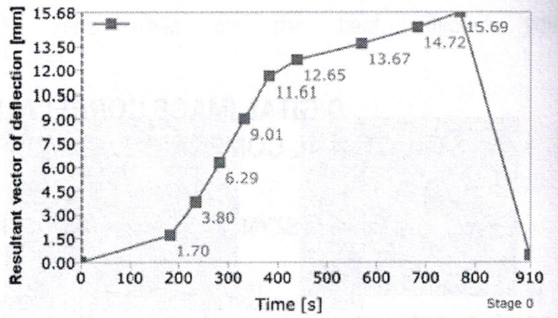


Fig. 5. Resultant vector of the SUV wheel's tire deflection, under static loading of up to 11 kN

4. SUMMARY

Application of the DIC technique in testing of structural elements under loading often requires additional light sources.
DIC is especially suitable for examination of elements with different arrangements and stiffness.
It allows small and large values of deflections to be captured in 3D coordinate systems. Besides of the typical results from DIC investigations such as movies, images and vectors, also all data may be captured in the digital form for further elaboration.

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