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New Mechanical Property Detection Method of Inland River Wharf

Haicheng LUO, Bailin ZHOU
School of River & Ocean Engineering, Chongqing Jiaotong University, Chongqing, 400074, CHINA

Abstract: Researches on mechanical property of inland river overhead vertical wharf are mainly based on the numerical analysis, model experiment and field test. With the rapid development of science and technology, the disadvantages of traditional strain test technology increasingly prominent. In order to obtain the strain field, the displacement field and the relationship between load and deformation of wharf structure more conveniently and reasonably, this paper presents two new detection methods, including the high speed camera imaging technology based on digital speckle (DSCM) and the pressure sensitive paint technology (PSP).The application of these two methods can quickly and accurately get the work mechanism and the energy distribution of structure, providing the reference for the optimal layout design of wharf structure to make more actual judgment.

Keywords: Wharf; Strain; Displacement; DSCM; PSP

1. Introduction

As a hub for the transfer of land and water, Inland River Overhead Vertical Wharf[1] is essential in cargo transport; at the same time, the terminal structure always bear the combined effect of various complex loads, load cases consisting of hundreds, coupled with the influence of various environmental factors, wharf will be faced with defects and damage crisis. Therefore, we must make wharf structure reliability and safety testing, in order to ensure the stability of the structure. The traditional Mechanical Characteristic Testing Method is to attach strain gauges on the surface of the component parts, and then paste glue, welding and Seal work[2], However, method operated complicatedly, wires criss-cross, data interface cluttered mess, and strain gauges fall off easily, it is difficult to ensure the quality and efficiency, and even destroy completion of components. article describes two scientific and rational, anti-interference ability, stable and convenient method for measuring mechanical properties. PSP has the advantages of detecting speed, high efficiency, convenience and operating easily, it also panoramically expresses pressure distribution anywhere of the model surface, in the relevant field of aerodynamics, it gets great concern, and steps up to development of the structure detection gradually; DSCM is an accurate a reliable, high-sensitivity and optical-mechanical measuring technology, it is widely used abroad in materials testing, the structural model and the physical testing , has developed into an extremely powerful tool for conventional and non-contact deformation measurement and analysis under routine or complex conditions; Two novel detection technology can quickly acquire train field, the displacement field and the relationship between load and deformation.

2. New Testing Method

2.1. PSP Technology

PSP was first applied to the aerodynamic test, making surface stress testing by smearing paint on the surface of component . Through technical improvements, so that we make use into the mechanical properties test trials of inland upright wharf, The design is based on the measurement system of optical pressure that established by ourselves, using a CCD camera aperture and the intensity of the excitation light source to calibrate results. Equipment consist ofBāokuò four parts, namely, an ultraviolet light source, stress testing equipment, CCD camera system and computer image processing system[3] as shown in Figure 1.

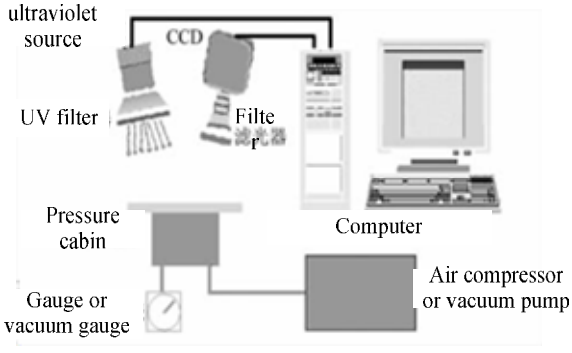

Figure 1. PSP Measurement System Diagram

Working mechanism: when the component bears loads, ultraviolet light source illuminates component surface

coated with PSP, stimulate electrons make orbit leapfrog and release fluorescence[4] then CCD camera collects data by take photo, finally attain pressure cloud image by computer image processing system . PSP will release light with different intensity and different colors according to different load pressure, pressure and the presence of fluorescence intensity image correspondence mappings degree paint glowing under ultraviolet light and its surface is proportional to the pressure, so sensitive pressure paint color technology to fully reflect the component surface pressure distribution. technology rely on to Port Orchard model as Figure 2 show.

Figure 2. Structural static / dynamic test system

According to the color change in various parts of the experiment, we can fully understand the stress concentration and unfavorable position in member, test hope to obtained image color as ABAQUS software simulated stress diagram, like Figure 3 as shown in cloud image color under the impact force of middle water level.

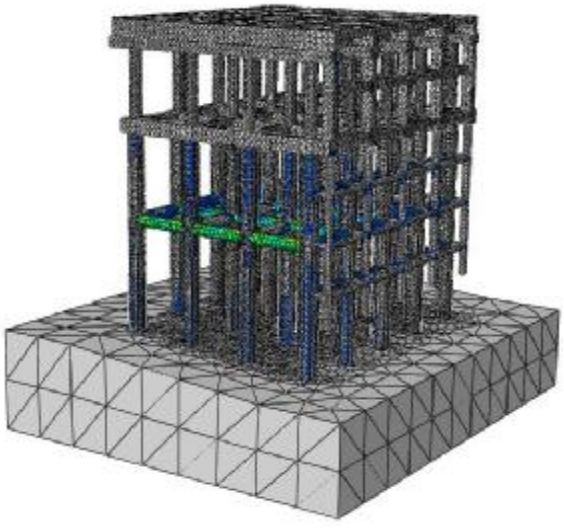

Figure 3. Color diagram of Port Orchard

According to a lot of test to determine the stress value of different colors, therefore , the stress value and concentration of wharf can be defined by discoloration. From Fig.3, Pier color contrasting results at a glance, and then compare with colors represent the value, can quickly grasp the working mechanism and mechanical properties of the pier。Port Engineering hall also studying some kind of paint will be able to change color independently under pressure situations without CCD camera and post-processing system ,that is easy and quick to grasp the general outline of load distribution and delivery terminals, thereby make wharf design. Currently, the University of California make use of the principle of the gold nanoparticles change color when meeting pressure, they create the polymer film, when the pressure increases, the film will change color from blue to purple, and finally to red, so you can reflect the amount of pressure according to the color change. Meanwhile, Japan recently invented a new type of liquid crystal with a certain viscosity, synthesized by moshu store and a common fluorescent material, when the fluorescent material pressed, can absorb energy of specific electromagnetic waves, and released light in the form of a certain color to the excess energy according to its own configuration, therefore, these two materials are very valuable reference object.

Advantages: NDT, convenient comprehensive detection, color contrast, quickly and accurately, anti-interference ability etc. Disadvantages: smear trouble, difficult to clean, easy to be contaminated by dust. At present, this technology is only applied to the portion of the field ,aerodynamics of flight force tests and certain food packaging, they are not applied into Mechanical Characteristic Testing of Inland River Overhead Vertical Wharf, and the structure study of various hues sensitive pigment has got lots of achievements, But the theory does not get completely in-depth research, the real case rarely to be applied, so this technology should be improved, this method only work as summarized explore ,hope readers to joint research efforts.

2.2. DSCM Technology

DSCM Working mechanism: when members are subjected to loads, the high-speed camera choose comparison chart of speckle before and after component deformation, we can accurately obtain the strain field of components After image processing technology that programmed by MATLAB numerical software[5]. In original state image, selected the sub-region including $(2n+1)\times(2n+1)$ pixel around the center displacement point $p(x,y)$, the images before and after deformation shown as Figure 4.

The image need to select the meshing styles, then search uses Newton iteration method, compare with the same size of sub-region image, gray intensity distribution of

the digital image in member before and after deformation hold constant. Gray value exists one to one relationship[6-7], the correlation coefficient is:

$$C(u,v)=\frac{\sum_{i=1}^{m}\sum_{j=1}^{m}\left[f(x_i,y_j)-\bar{f}\prod g(x_i+u,y_j+v)-\bar{g}\right]}{\sqrt{\sum_{i=1}^{m}\sum_{j=1}^{m}\left[f(x_i,y_j)-\bar{f}\right]^2}\sqrt{\sum_{i=1}^{m}\sum_{j=1}^{m}\left[g(x_i+u,y_j+v)-\bar{g}\right]^2}}$$

Using the correlation coefficient fitting to obtain a continuous surface, surface adopt binary polynomial fitting [8], the fitting function is:

$f(x,y)=a_{00}+a_{10}x+a_{01}y+a_{20}x^2+a_{11}xy+a_{02}y^2$ Using the least squares method, at the extreme of correlation coefficient in the surface should be met:

$$\frac{\partial f(x,y)}{\partial x}=a_{10}+2a_{20}x+a_{11}y=0$$

$$\frac{\partial f(x,y)}{\partial y}=a_{01}+2a_{02}y+a_{11}x=0$$

Thus, comparing with original state image, the displacement values of center point in sub-region after deformation,can be calculated.

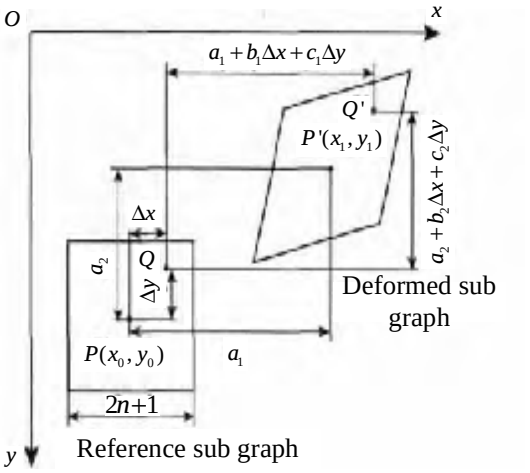

Figure 4. Displacement deformation of center point

Test simulates Orchard Port <pile of steel and reinforced concrete model test(excluding base)>, the surface of steel casing concrete pile has set up traditional measuring instruments- displacement table. The top of the structure bears grading load, respectively ,torque load size are 20KN.M, 30KN.M and 40KN.M, as Figure 5 show.

Experiment attain images before and after deformation near the third displacement table of the top of the pile through high-speed camera , select the image and mesh, after MATLAB processing, can get displacement cloud images before and after deformation, specifically shown in Figure 6, Figure 7 and Figure 8.

Finally compared with the value of the two measurements to verify the accuracy and reliability of the new technology .

Figure 5. Pile of steel and reinforced concrete model test

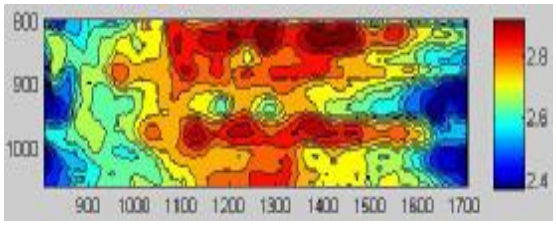

Figure 6. Displacement cloud image of 20KN.M torque

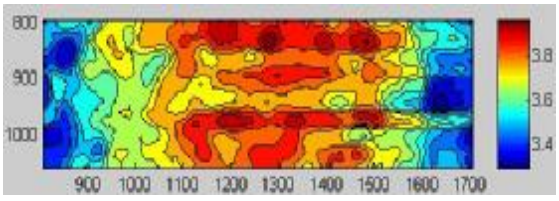

Figure 7. Displacement cloud image of 30KN.M torque

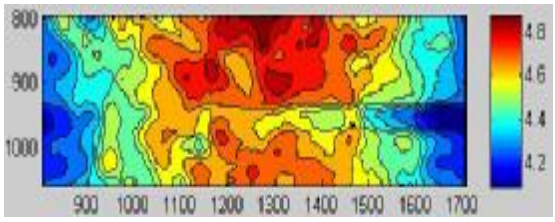

Figure 8. Displacement cloud image of 40KN.M torque

From the displacement field cloud images that created by DSCM ,we can clearly find characteristics of the top of steel casing when bear torque :

From top to bottom, displacement becomes smaller, darker location is the focal point of strain, later get the energy distribution of the pile , understand the mechanical properties of composite structures combine steel and reinforced concrete, and grasp weaknesses position and destruction modes.

Compare with three displacement field cloud images ,we can find the bigger torque is, the bigger displacement field changes piles get, and the more energy is received,

we can also understand the what discipline of energy transfer and work rules interface of the node is , include displacement field and the relationship between load and deformation.

Meanwhile, in order to confirm the accuracy of new method, we compare the results of image processing and the data the displacement table measuring , the values shown in Table 1.

Table 1. Comparative results of DSCM and displacement table

Torque	20KN.M	30KN.M	40KN.M
DSCM	2.76mm	3.74mm	4.77mm
displacement table	2.88mm	3.87mm	4.96mm
error	4.17%	3.36%	3.83%

From the table shows, the error exist in the allowable range, so the new technology can accurately measure the component displacement, has the advantages of non contact, nondestructive, panoramic view of integrity, accurate and reliable. Through the processing of new technology, we can quickly grasp work mechanism and mechanical properties of the structure strain and strain gradient that varied with load.

3. Conclusion and Suggestion

Two novel detection methods ,Both of DSCM and PSP have advantages of NDT, the overall sampling, accurate and reliable, saving manpower and time, and the image in contrasting colors. They also obtain the strain field, the displacement field and the relationship between load and deformation have great potential in Mechanical Characteristic Testing of Inland River Overhead Vertical Wharf with rationality and feasibility. New technology Completely meet the testing requirements of member deformation, have got much achievement and made up for the shortcomings of traditional test methods. However, in order to provide the reference for the optimal layout design of wharf structure and make more actual judgment. both two promising methods still need readers to make continuous improvement and innovation.

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