

Programming Module for Making Report in Bridge Loading Test

Haocheng Chang.A¹, Jianming Lu¹, Huaijian Li¹, Jianyong Song¹, Ke Chen¹ and An Zhao¹

¹Research Institute of Highway, Ministry of Transport, 100088, China

ABSTRACT

Bridge load testing is generally used to evaluate the bridge's actual load capacity when the bridge has just been finished, repaired or retrofitted. Before carrying out the test, it is necessary to calculate the stress and displacement of observation points on specific sections of the bridge. During this process, the accuracy of the calculation and the convenience of the report output are of great importance. However, the existing software, which requires experts to deal with the huge task of preparing data and picking up results, is not so easy to handle. Moreover, sometimes even experienced experts cannot easily determine the exact positions of critical cross sections in the bridge model. These problems may lead to an inaccurate result and thus more troublesome work. Considering the fact that new Load Testing Specifications for Highway Bridges (LTSHB) is about to be published in China, we have developed the software Bridge Loading Test analysis system (BLT) in order to provide experts with a better understanding of the new specifications and enable them to conduct bridge load testing more conveniently. This paper introduces the key module of BLT compiled with VB.net, which is easy and convenient to use.

INTRODUCTION

Using beam elements or solid elements, BLT can automatically generate a spatial FEM model, which is based on the input parameters, of the bridge structure. Moreover, it can also be used to analyze the static and dynamic character of bridge structures, calculate efficiency ratio of load tests, list the result data of observation points, etc.

Before analyzing an established bridge model, we need to define key points to be observed on the model. Traditionally, those conducting load tests decide the arrangement of observation points manually according to their own experience. However, it would be more efficient to derive it from a defined computer model that

follows a fixed pattern. Additionally, those conducting load tests should concentrate on finding out the certain pattern. After reading LTSHB, the authors have summarized some regulations and developed a computer program which could automatically offer users one recommended arrangement of observation points.

Before carrying out the load test, the staff needs to write the experimentation plan report. Also, the final result reports are needed after the test is done. It requires workers to spend too much time on writing reports which are all in the same key. As we know, computers are always good at dealing with things in the same pattern like reports and it is highly efficient to output reports when a template and a solution can be provided. In this paper, the authors demonstrate how to automatically generate test reports with Microsoft Word or Microsoft Excel. We program a module of BLT, which can accomplish this task well, with Microsoft.Word.dll and Microsoft.Excel.dll in a VB.net compiled environment.

Finally, several cases have been applied with BLT gaining great success. Here, one of them will be shown in this paper.

OBSERVATION POINTS ARRANGEMENT

The design flow of observation point arrangement is shown in Figure 1.

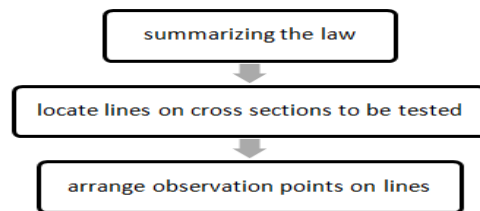


Figure 1. Design flow chart of observation points arrangement.

Summarizing the specifications. After having carefully studied things proposed in the LTSHB, some regulations could be concluded. It is easy to determine that observation points always distribute on the bottom and both sides of cross sections. Here, if we were to set the length of the bottom edge as L, it would become the main controlling factor. The strategy of observation points’ arrangement on each side could be concluded as Table 1.

Table 1 Recommended Observation Points on Each Edge.

Bottom edge (m)				Left edge(m)	Right Edge (m)	
L<1	1≤L≤2	2<L<5	L>5	Random L	L≥5	L<5
1(s)+1(d)	3(s)+1(d)	5(s)+1(d)	5(s)+2(d)	2(s)	2(s)	0

Here, “s” is for stress and “d” is for displacement. These regulations could apply to different kinds of girder cross section. Here are some instances shown in Figure 2~9.

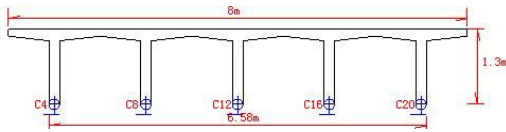


Figure 2. Arrangement of displacement observation points of t girder.

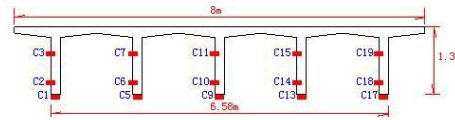


Figure 3. Arrangement of stress observation points of t girder.

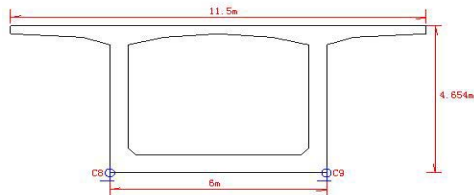


Figure 4. Arrangement of displacement observation points of single cell box girder.

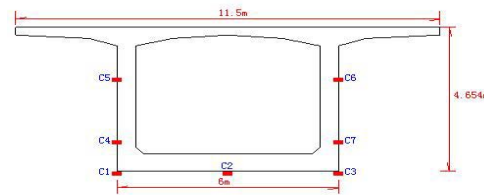


Figure 5. Arrangement of stress observation points of single cell box girder.

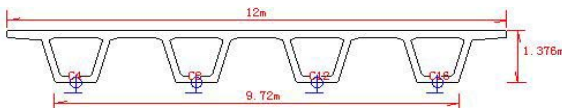


Figure 6. Arrangement of displacement observation points of multiple box single cell girder.

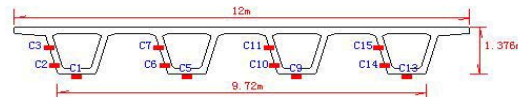


Figure 7. Arrangement of stress observation points of multiple box single cell girder.

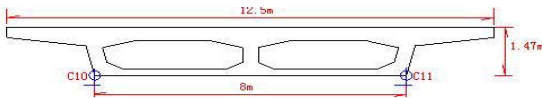


Figure 8. Arrangement of displacement observation points of single box multiple cell box girder.

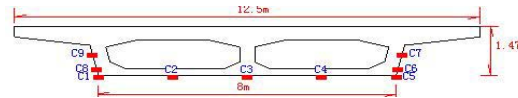


Figure 9. Arrangement of stress observation points of single box multiple cell box girder.

Locate Observation Points. Before locating these points on cross sections to be tested, we need to determine the lines of the cross section on which points locate, using geometrical relationship. Take the multiple cell box girder as an example. The image of cross section is shown in Figure10.

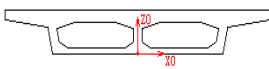


Figure 10. Cross section

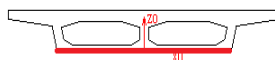


Figure 11. Find the line

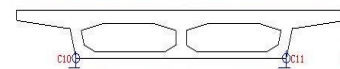


Figure 12. Find test points

In the above figures, X0 and Z0 are two coordinate axes. If we want to find the bottom line of the section, the program will locate the line with two endpoints which have a minimum value along the Z0 direction, or only one if the bottom inclines (Figure 11).

Having gotten the location of the line, the uniformly distributed observation points on the line can be easily worked out following the rules we have mentioned above (Figure 12).

REPORT OUTPUT

To program the module for BLT reports, the authors have referred to many previous reports of bridge load tests and then set up a Word template in Microsoft Word, which includes the parts of a report (Figure 13) and things that are often mentioned in a load test report, such as title, catalogue, some fixed statements, standards and style of diagram and text. Then, the authors have created bookmarks in particular positions of the template.

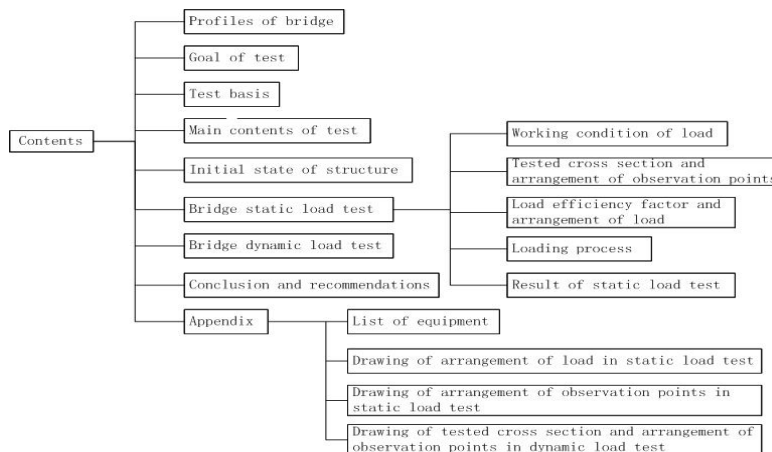


Figure 13. Main contents of report.

When the module of output reports is used, the program will invoke the template, search the locations of these bookmarks, insert contents into these positions and come out with a complete test plan report. The data table, chart and text in the report is defined and calculated by BLT.

In this module, a solution of graphic output is designed, through drawing pictures in the VB component picturebox and views of the model in BLT are also shown. Based on this, the authors developed a new drawing method including labeling and displaying, then used the improved one to draw pictures in a frame, and then saves them as a bitmap which has a very small file size. Some changes can also be made to the bitmap such as expansion in a certain direction and clipping by redrawing in

another frame. Some drawings of graphic output including elevation drawing of arrangement of cars, section drawing of arrangement of cars and drawing of arrangement of (stress observation) points are shown in Figures 14, 15, 16.

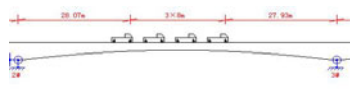


Figure 14. Elevation drawing of arrangement of cars.

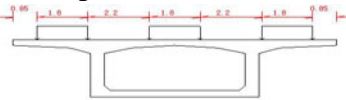


Figure 15. Section drawing of arrangement of cars.

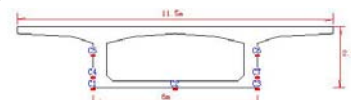


Figure 16. Section drawing of arrangement of points.

Additionally, a pattern of making final test reports has also been designed. In the program, the authors use functions in Microsoft.Excel.dll to read data from Excel files. As long as users input data from the test into Excel files and choose to read it in the program, then the program can automatically compare the data from calculation and experimentation, figure out verify coefficient and finally draw a conclusion. The final test reports are similar to those that are generated by more traditional methods.

APPLICATION OF BLT

In this section, a project that has applied BLT will be introduced for readers to have a better understanding of BLT.

This project is a bridge test on one overpass. This bridge is on the main line of highway 304 from TongLiao in Liaoning province to BaoKang in Inner Mongolia. It is 77.6 meters long and 12.5 meters wide, with a design speed of 80 km/h and a design load of Chinese Highway Level 1. Its superstructure is prefabricated partially prestressed concrete continuous box girder and its infrastructure uses rib abutment with a drilling filling pile foundation. The No.1 and No.3 pier are double-column piers and the No.2 pier is a rectangular pier. We conducted a bridge load test on it in 2013.

In this project, we first used the BLT to set up a model, and the calculation work was based on the model. The two-dimensional model is shown in Figure 17.

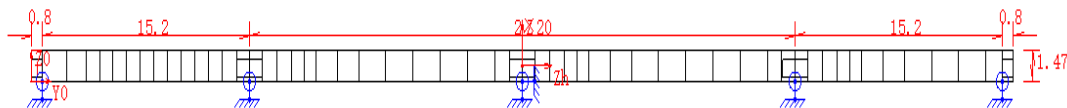


Figure 17. Two-dimensional model.

In the static load test, there are three working condition with different car loads, aiming to test different cross sections. Cross sections that are highlighted in the picture are control cross-sections, where we arrange observation points. The control cross-sections come out automatically by BLT and this is another function of BLT.

After the working condition has been defined, we can use BLT to do observation points-clothing work. The principle of this module has been referred to

above, and the only thing that users need to do is click a button named “arrange points” and layout plans will be shown. Figure 18 is the layout plan for working condition 1 and there is an explanation below it.

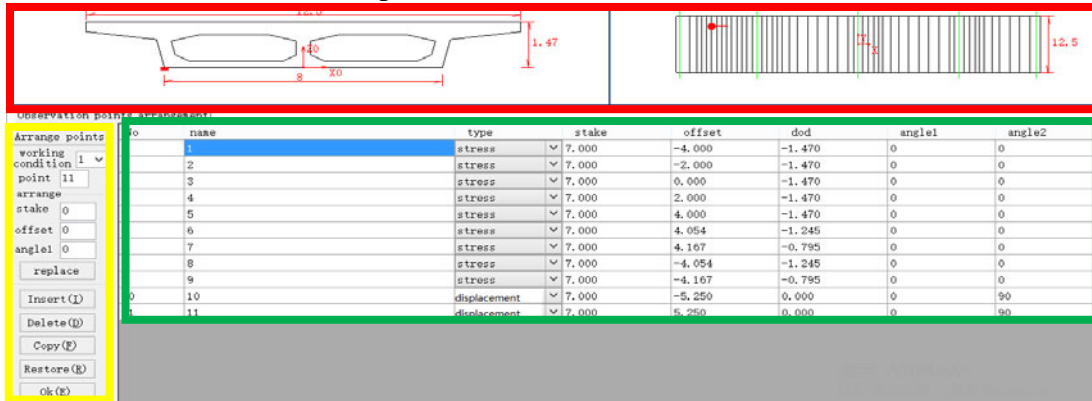


Figure 18. Arrangement of observation points in working condition 1.

In the red box (the one on the top) are two pictures of cross section and bridge deck and when you select points’ data, which includes serial number, name, category, stake number, distance off deck and center line and angles from left to right in order, listed in the green box (the one on the right), then the point will be shown in the pictures of cross section and plan as a red point and a blue point separately. Some operating buttons are listed in the yellow box (the one on the left).

After a series of working condition definition, loads definition, observation points’ definition and calculation, we can conduct the test report using this software. Some parts of the report are shown in the following pictures, Figure 19 and 20.

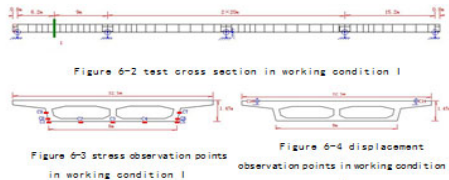


Table 6-2 data of observation points in working condition 1

No	name	type	Stake (m)	offset(m)	d(m)	axial deviation angle(degree)	horizontal angles (degree)
1	Point 1	stress	7.0	-4.00	-1.47	0	0
2	Point 2	stress	7.0	-2.00	-1.47	0	0
3	Point 3	stress	7.0	0.00	-1.47	0	0
4	Point 4	stress	7.0	2.00	-1.47	0	0
5	Point 5	stress	7.0	4.00	-1.47	0	0
6	Point 6	stress	7.0	4.05	-1.25	0	0
7	Point 7	stress	7.0	4.17	-0.80	0	0
8	Point 8	stress	7.0	-4.05	-1.25	0	0
9	Point 9	stress	7.0	-4.17	-0.80	0	0
10	Point 10	displacement	7.0	-5.25	0.00	0	90
11	Point 11	displacement	7.0	5.25	0.00	0	90

Note: Points in this table is shown in the picture as C. There are two types of observation points stress observation points and displacement observation points. Stake refers to location of cross section in corresponding working conditions. Offset means horizontal distance from observation points to center of bridge and d represents vertical distance from observation points to bridge’s deck.

Figure 19. Arrangement of observation points

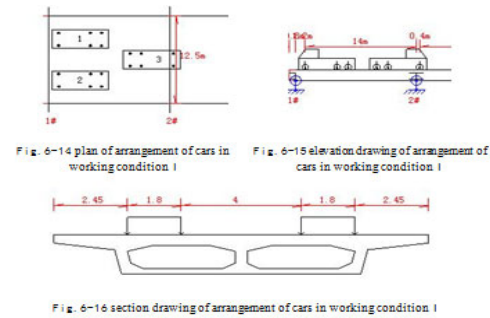


Table 6-9 data of arrangement of cars in working condition 1

No	Type of car	Direction	Stake (m)	Offset (m)
1	1	Backward	2.000	-2.900
2	1	Backward	2.000	2.900
3	1	Forward	16.400	0.000

Figure 20. Arrangement of car load

Part of the results including theoretical calculation value, measured value and calibration coefficient are shown in Table 2 and Table 3 separately. And there are also drawings of three-dimensional model and displacement nephogram in Figure 21 and Figure 22.

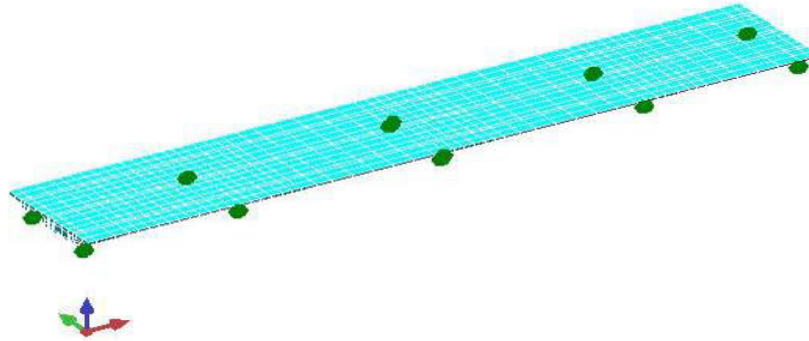


Figure 21. Three-dimensional model.

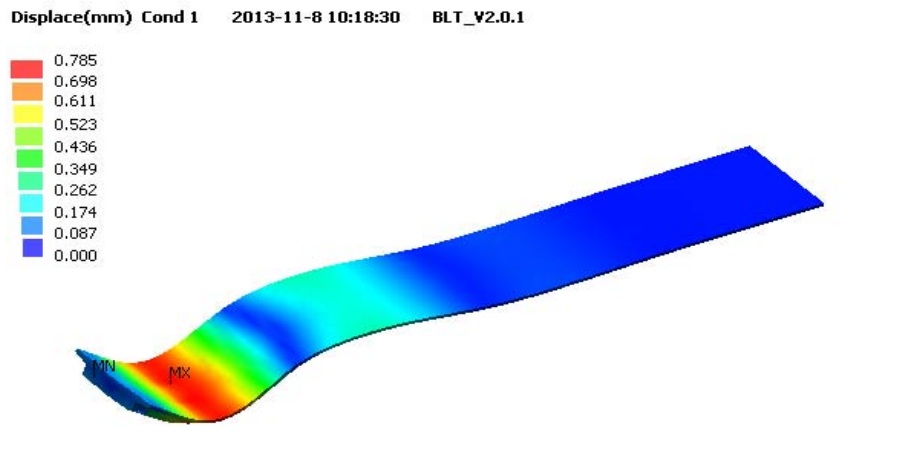


Figure 22. Displacement Nephogram of working condition 1.

Table 2 Result of Displacement in Static Load Test.

Working Condition	Observation Points	Measured Value/mm	Calculated Value/mm	Calibration Coefficient	
I	Cross section1	Upstream	-0.8	-1.0	0.80
		Downstream	-0.8	-1.0	0.80
III	Cross section 2	Upstream	-0.6	-0.8	0.75
		Downstream	-1.0	-1.2	0.83

Note: direction of displacement -is downward

Table 3 Result of Stress in Static Load Test.

No	Measured Value/MPa	Calculation Value/MPa	Calibration Coefficient
C1	1.123	1.215	0.924
C2	0.765	0.870	0.879
C3	0.891	0.916	0.973
C4	0.789	0.873	0.904
C5	0.987	1.215	0.812
C6	-	0.935	-

**Note: 1 tensile stress is positive, compressive stress is negative;
2 “-” means that observation point has been destroyed.**

The calibration coefficients are between 0.75 to 0.98, which are in the reasonable range, and measured values are all less than calculation value. The calculation result worked out by BLT is credible.

CONCLUSION

This module development mainly achieves two functions of BLT. One is the automatic arrangement of observation points and the other is the quick output of test results. The program is mainly based on LTSHB—which have been designed for bridge tests, and which can provide experts with a targeted and efficient approach—and is scientific and reliable. Those who conduct load tests can use it to save themselves both time and effort; it will make their work both easy and convenient.

REFERENCES

- LI Guo-hao, Bridge and structure theory [M]. Shanghai Science and Technology Literature Press.2000:25-29.
- ZHU Cheng. Mechanics of Materials, I [M]. Higher Education Press.1958:120-125.
- WANG Mao-cheng, Finite element method [M]. Tsinghua University Press, 2003:251-256.
- Ke Chen, Jianming LU. (2005). Bridge Test Analysis System Study. Journal of Highway and Transportation Research and Development 22.5: 87-92.
- Ministry of Transport of the People's Republic of China. (2012). Load Testing Specifications for Highway Bridges (in Chinese)
- KeChen and Jianming Lu. (2004). Study of Analysis System for Bridge Testinging, Xth International Conference on Computing in Civil and Building Engineering, 2004, Weimar, pp. 300-301.