INFORMATION TECHNOLOGY USED IN HIGHWAY AND BRIDGE ENGINEERING

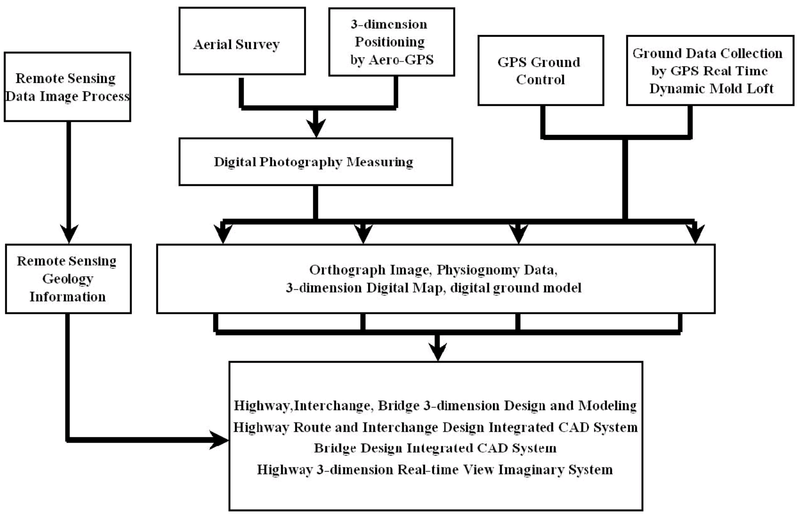
Lu Jianming[1], Chen Ke[1]
1.Research Institute of Highways, 100088, Beijing, China
(lujianming@263.net, chenkezi@163.com)

Summary

With the speedy development of transportation of China, especially construction of many high-grade highways, some information technology successes have been achieved in the highway and bridge engineering, such as survey, design, construction and maintenance etc. In this paper, some applications about information technology in the highway engineering were introduced and some bridge professional software developed by RIOH (Research Institute Of Highways) in recent years was also introduced.

1 Information Technology Used in Highway Engineering

To promote the application of information technology in the survey and design of the highway engineering, MOC (Ministry of Communications) of PRC had set up project for special research about the integrated system of GPS, Aerial Survey, Remote Sensing and CAD software. It devoted a great deal of manpower and material resources to generalize and apply the new technology in this area. In this project, we focused our efforts on the research of following technologies: aerial orientation by GPS in aerial-photography area of highway, superposition technology of digital ground model and route design model, translating and editing of computer image, spatial model for highway and bridge and their management of data information. The main contents of this project were demonstrated in Fig.1.



gohtm.com/scripts/processed as follows:

a) The integration of GPS, aerial survey, remote sensing and CAD technology was realized. Based on the advanced and new technologies, the integrated technology incorporated by the field survey, the data processing of office work and the design with CAD technology.

b) The auto-surveying for the strip area was realized through the GPS aided aerial triangular surveying technology. It satisfied the precision demand of the large-scale aerial survey for highways, reduced the 50% of the field workload of aerial survey, and enhance 3 times of efficiency for the office refining work of aerial survey.

c) The network cooperation patterns were formed. The combination of the digital photography measuring system and the digitally reconstructed simulating image processor and analytical image processor, can quickly collect the data of the topographic information on a large scale.

d) The digital ground model system was developed. The system has many practical functions such as the opened data interface, the global and fast constructing of triangle mesh model based on the abundant data with the topographic characteristics, the detecting coarse errors, the real-time adding or deleting or updating or moving on points and lines, the interpolation of the longitudinal and transverse section as well as the forming and using the contour line.

e) The CAD integrated system for the route and the interchange was developed. The system has many functions such as the database management of the design project, mutually allocation of the lines on the horizontal and the longitudinal plane by the "line element method", the dynamic real-time drag of the lines, the synchronous renovation of the graphics and data, the longitudinal routine slope design without sequence like used to, the intelligent auto-design and the visualized mutual dynamic modification of the transect, the filling and excavating design of the highway roadbed, the drainage deign of the side ditch, the automatic mutual adjustment of the volume of the earth and stone and the automatic 3-dimensional modeling for roadbed.

f) The integrated CAD system for the bridge design was developed. The system has many functions such as the database management of the design project, the digital member database, the preview of the full orientation 3-dimension model, the real-time compiling and updating of the graphics, the toolbox of the mutual plotting of the structural construction drawing for the any structures such as the T-shape beam and the hollow plate etc.

g) The 3-dimension modeling CAD system for the bridges (abbr. Bridge3D) was developed. The system has the functions of 3-dimension modeling including the girder bridge, the cable-stayed bridge, the suspension bridge and the arch bridge etc. It can be combined with the 3-dimension ground model and the 3-dimension route model to construct an integrated 3-dimensional design model for the route or the large-scaled interchange. The system has the virtues of rational design parameter and convenient operation. It was a good beginning of the bridge design from 2-dimension to 3-dimension. Simultaneously, the interface of Bridge3D and the bridge layout CAD software, the interface of Bridge3D and the finite element software for the structural analysis, the interface of Bridge3D and the many bridge plotting software and so on, all above made Bridge3D more extensively applied. The development of Bridge3D filled up the vacancy in the design software on 3-dimensional for the bridge engineering. The famous 3-dimensional design software for the civil engineering route, such as the InRoad, MOSS, Card/1 etc, have the strong function in the route design, but the function modules was absent for 3-dimensional bridge design.

h) The rapid superposition of the digital ground model and the design scenario was realized. The digital ground model combining with the 3-dimensional geometry model of the route and the interchange as well as the bridge, the comprehensive model for the highway can be set up. The operations such as the arbitrary cutting and the section interpolating can be performed on this comprehensive model.

i) The real-time view system of the imaginary scenery for the highways design was developed. The 3-dimensional image model was combined with the comprehensive highway model and the digital orthography. The scene disposal and the multimedia demo can also be performed.

Using these achievements, the engineering surveyors and designers can take full advantage of the digital ground model and the remote sensing geology pictures for the route selection of highways and the 3-dimension geometric designs of the highways and bridges. The comprehensive application of this project, improve the efficiency of engineering survey and design as much as 2 to 9 times, which is shown in Fig.2. The transition of engineering survey and design from 2-dimension to 3-dimension depends on the development of the information technology.

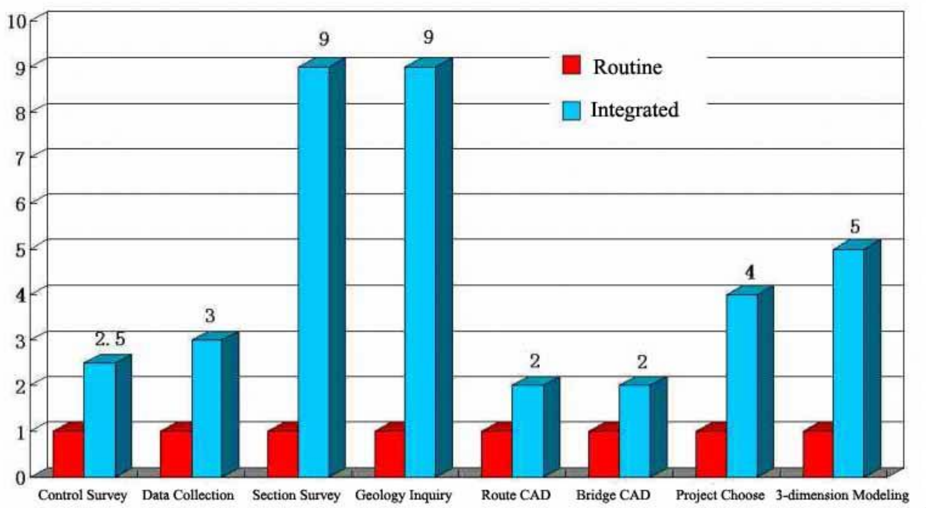


Fig.2 Efficiency of Engineering Survey and Design

2 Bridge Professional Software

2.1 Bridge Structure Design System

For a long time, RIOH has made a great deal of research on information technology aided construction control analysis in the course of the construction of bridge engineering. Bridge Structure Design System, Chinese name abbr. GQJS, had been developed together by many experts in MOC and had been applied to bridge engineering since 1978. During more than 20 years, it was used widely and verified in many actual bridge engineering projects with modified and perfected continuously by many bridge experts.

This software was applicable to the analysis for all kind of the routine bridges, such as the simple-supported beam, the continuous beam, the steel truss bridge, T-shape rigid-frame bridge, the continuous rigid-frame bridge, the arch bridge and the cable-stayed bridge, whose construction method can be incremental launching, simple-supported beam during construction and then changing to continuous beam after construction, cantilevered assembling, cantilevered casting, integral assembling and integral casting in site and so on.

The characteristics of this software are friendly and visual interfaces, powerful calculation capacity with high speed, practical function for graphic check and various modes of results browsing. This system is capable of the analysis of construction procedure and design live load by influence line. With it, DXF files of AutoCAD can be imported and turned into the information of element section. The module of results browsing is with splendid and practical contents, quick access of the calculated results and all kinds of figure drawing (including curve figure, envelope diagram, color nephogram on inner force, stress, displacement and influence line). It can produce precamber table of every stage, which is very useful in bridge construction control. It also can draw graph of force, stress, displace, influence line in Auto CAD. Some interfaces of GQJS are shown in Fig.3 to Fig.10.

Since it was easy to learn and easy to use for general engineer as well as its extensive application, the software has been applied extensively to highway and bridge engineering of China. This system has been used in hundreds of practical bridge's design and examination with good effect.

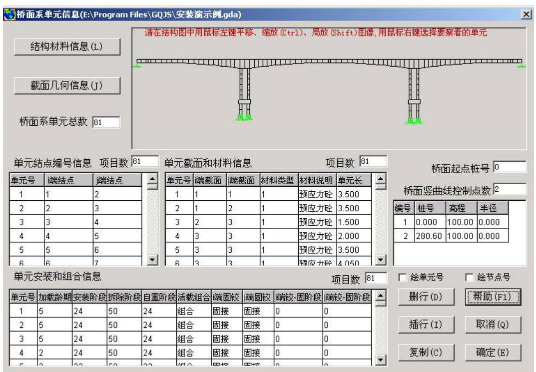


Fig.3 Deck Element Information

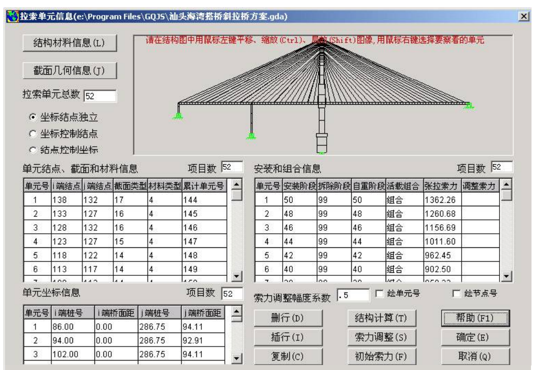


Fig.4 Cable Element Information

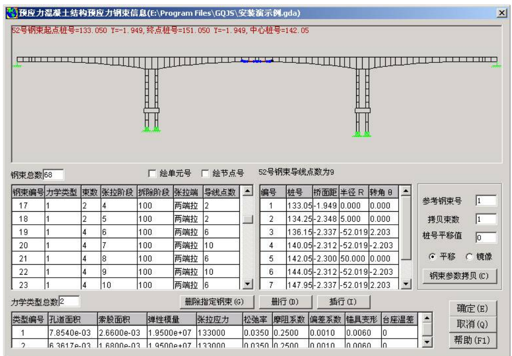
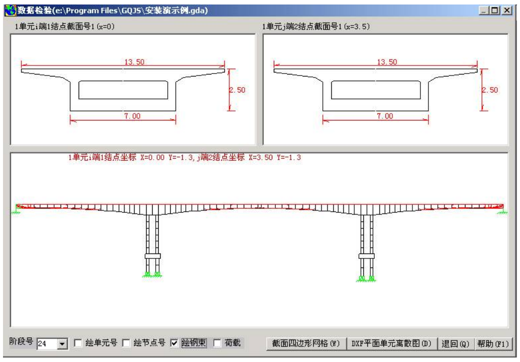


Fig.5 Prestressed Bar Information

Fig.6 Construction Stage Information



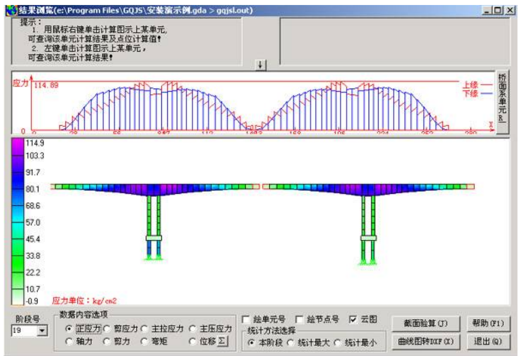
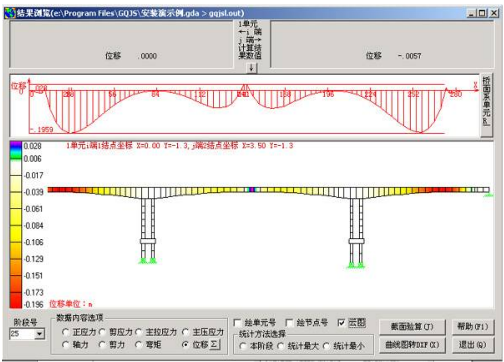


Fig.7 Data Check With Plot On Interface

Fig.8 View Stress Results On Interface



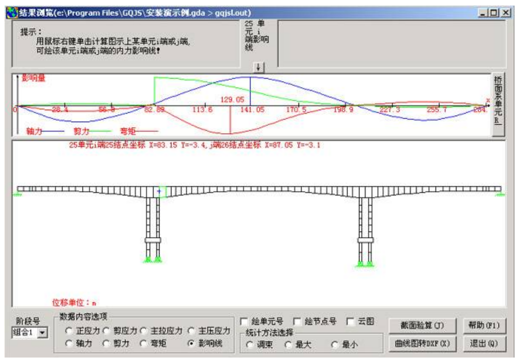


Fig.9 View Displacement Results On Interface

Fig.10 View Influence Line On Interface

2.2 Analysis System of Bridge Test

In recent years, RIOH is developing a new set of professional software used in bridge load test named Analysis System of Bridge Test, Chinese name abbr. QLJC.

In this software, engineering practice is considered adequately in modules designing. According to horizontal and vertical curve parameter of route line and cross section parameter, spatial modeling can be established conveniently without calculating large numbers of coordinates. There are two meshing methods to be chosen for users, three-dimensional beam element and 12-nodes solid element. 12-nodes solid element is a good meshing method with fewer elements, higher calculated efficiency and enough precision.

Loading module of system is designed according to bridge test loading process. We are concerned about the change of structure before and after loading. Therefore, in order to simplify the data structure, the test load includes concentrated and vehicle loads only, as fig.11. According to Chinese codes of bridge test, the efficiency ratio of test loading should be in a range between 0.95 and 1.05. In the system, the module of efficiency calculation is supplied in this system to calculate the efficiency of test load according to the information of test load and designing standard load. Users can adjust the parameter of test load based on initial calculated results. Through pilot calculation with several times, the best test plan will be determined, at the same time the diagram of analysis results of test load efficiency can be output for writing test report (fig.12).

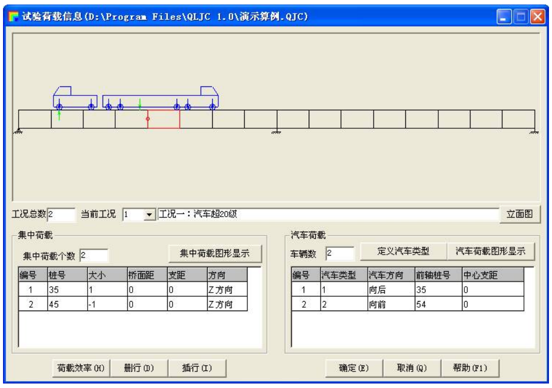


Fig.11 Test Truck Load Information

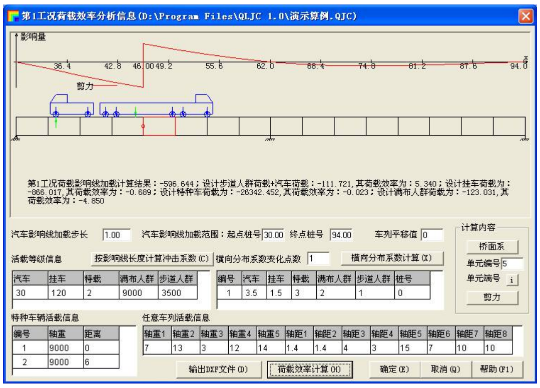


Fig.12 Analysis of Test Load Efficiency

Distribution and type of observation points can be recorded in order to pick up calculated values of displacement, stress and strain accurately (fig.13). Post-processing of the system has functions such as reading calculated results of observation points (fig.14), natural frequency of structure and viewing distortion shapes of test stages and modal shapes at random direction and ratio of amplification (fig.15, fig.16). Recently, QLJC has been applied to some bridge tests analysis in Shan Dong province of china.

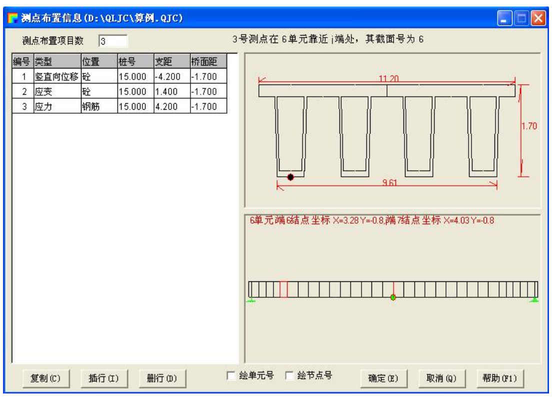


Fig.13 Observation points Information

Fig.14 Observation Results On Interface

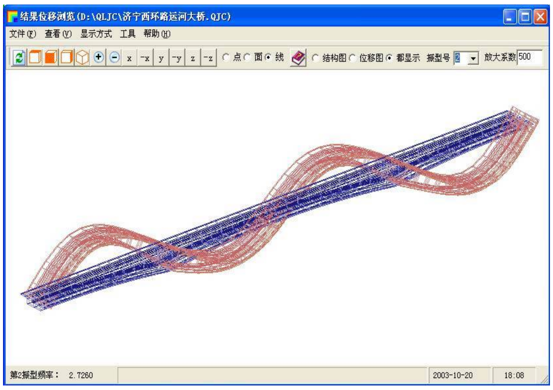


Fig.15 Natural mode of vibration

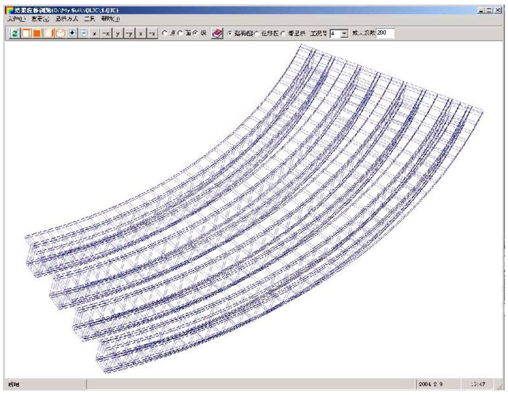


Fig.16 Displacement Results View

3 Conclusions

Using GPS, Aerial Survey, Remote Sensing and CAD, the engineering surveyors and designers can take full advantage of the digital ground model and the remote sensing geology pictures for the route selection of highways and the 3-dimension geometric designs of the highways and bridges.

Since our bridge professional software easy to learn and convenient to use for general bridge engineer, the software have been applied extensively to bridge engineering of China. Bridge professional software is the achievement combining traditional way with information technology.

4 References

Jianming Lu, “Application of CAE in Engineering of HuMen Suspension Bridge”, Proceedings of the Eighth International Conference (ICCCBE-VIII), Stanford University, August 2000,Vo2

Jianming Lu, Xuefeng Zhang and Zhengyu Yang, “Visual CAD Software On Bridge Structure”, Proceedings of the Ninth International Conference (ICCCBE-IX), Taipei, Taiwan, April 3-5, 2002,Vo2