Research on the Selection of Coordinate System of "Multi-conformity"

Yong Lei1,*, Lihui Wang1, Zhu Chen2, Chuanjian Ren1, and Zhihong Wang1

1Guizhou University of Engineering Science, School of Mining Engineering, Bijie Guizhou 551700, China
2Guizhou Tianditong Technology Co., Ltd., Guiyang Guizhou, 550089, China
*Yong Lei: 546743737@qq.com

Abstract: Multi-conformity is an inevitable trend of urban construction and development. The appropriate coordinate system is chosen with side length projection calculation and treatment of deformation in the area of large deformation side length projection, relying on the surveying and mapping technology of natural resources department to perform conversion processing. Eliminating the differences between natural resources departments and urban and rural construction departments due to different coordinate systems is to meet the requirements of engineering construction accuracy, under the premise of ensuring the quality of engineering construction, to meet the requirements of the Ministry of natural resources.

1. Introduction
Surveying and mapping is the foundation of all kinds of engineering construction. China's various industries have put forward their own surveying specifications for surveying and mapping work in their respective industries according to their own needs, such as the national Code for Engineering Surveying, Code for the Water Conservancy and Hydropower Surveying of the water conservancy and hydropower industry, and Code for Urban Surveying of the urban construction industry. With the CGCS2000 coordinate system is put into use, the Ministry of Natural Resources, the competent department of surveying and mapping industry after the integration of land, surveying and mapping, urban and rural planning and other departments directly related to surveying and mapping, requires that the CGCS2000 coordinate system be fully used in the natural resource system from July 1, 2018. Surveying and mapping is an industry that directly serves for engineering construction. As the competent department of engineering construction, the Ministry of Housing and Urban Rural Development, influenced by the projection deformation of side length, is not required to adopt the national unified coordinate system.

2. Research significance
The integrated natural resources department, with a strong surveying and mapping technology, is a benchmark for the development of surveying and mapping industry. The full use of CGCS2000 coordinate system by the natural resources department will have a great impact on China's surveying and mapping industry. Lei Yong [1] put forward the transformation method of national coordinate system and independent coordinate system in a small range in 2009. Many scholars
such as Ou Chaomin, Zhang Xunhu, Zhou Junsong [2]-[4] and so on made a lot of research on the transformation of surveying and mapping results from different coordinate systems to CGCS2000 and responded to the requirements of the original National Geographic Information Bureau of Surveying and mapping, and put forward some feasible methods for the transformation of original results to CGCS2000. It is a good reference. He Lin [5] etc. proposed the mutual conversion relationship between CGCS2000 and 1954 Beijing Coordinate System and 1980 Xi'an Coordinate System. CGCS2000 Coordinate System is the latest national coordinate system, using the most reasonable CGCS2000 ellipsoid. Its promotion conforms to the reality of China and has strong practical significance. It lays a solid mapping foundation for the multi-conformity. The national coordinate system is discussed based on the national level. CGCS2000 Coordinate System plays an indisputable role as a large-scale research on the national level. But for the specific engineering construction and the small-scale engineering construction, in the area where the side length projection changes greatly, the side length projection deformation of CGCS2000 Coordinate System will restrict the engineering construction and may lead to the occurrence of engineering quality accidents.

3. Necessity of research
The central urban area of Bijie city is 964km2, it is close to the central meridian (105o) (15 ' - 30'), but its elevation is high. With CGCS2000 coordinate system, the projection deformation of side length will reach about 20cm/ km[6], far exceeding the requirements of Surveying and Mapping Law and Code for Urban Surveying. When it is used in the planning and real estate sectors, with the powerful surveying and mapping technical force of the natural resources sector, by means of calculation and processing, it can meet the needs of social and economic construction, it can meet the requirements of the national coordinate system and form a surveying and mapping benchmark with multiple conformity. Multi conformity is an inevitable trend of development, which is in line with China's economic interests. With the integration of national ministries and commissions, the planning function of the housing and construction department has been incorporated into the natural resources department, which provides convenient conditions for the national land use planning, urban and rural construction planning and other planning of multi-conformity. At the same time, it lays a solid mapping foundation for multi-conformity and promotes the implementation of it. However, for specific engineering projects, the design is based on the topographic map, all calculations are converted from the distance on the map to the actual distance. After the construction setting out, the side length of the building has a projection deformation error due to the influence of the projection deformation and the design side length, which has a negative impact on the project quality. In order to control the influence of the side length projection error, the Code for Urban Surveying has strict regulations on the side length projection deformation: the non conformity value of the side length projection deformation will not be greater than 2.5cm/km, if it exceeds this regulation, an independent coordinate system must be established to meet the needs of engineering construction. Therefore, the co-existence of CGCS2000 Coordinate System and independent coordinate system will not be changed. It inevitably requires solving the contradictions among different coordinate systems.

4. Feasibility of the research
Quality is the foundation of engineering construction. Construction coordinate system is the foundation of engineering construction quality and the basic guarantee of surveying and mapping service engineering construction. In order to meet the needs of engineering construction and ensure the quality of engineering construction, only the coordinate system that meets the needs of engineering construction can be used. The surveying and mapping technical force of the construction unit is still weak, but if the same coordinate system is used in the engineering design and construction, the surveying and mapping technical force of the engineering construction unit should be able to cope with it.
Under the condition that the projection deformation of the national CGCS2000 Coordinate System meets the requirements of engineering construction, it is the most reasonable choice to adopt the CGCS2000 coordinate system, which not only meets the needs of engineering construction precision, but also meets the requirements of the Ministry of Natural Resources.

In the area where the projection deformation of national CGCS2000 coordinate system does not meet the needs of engineering construction, in order to ensure the quality of engineering construction, local independent coordinate system that meets the requirements of engineering construction planning adopts the CGCS2000 Coordinate System, which leads to the inconsistency and contradiction of the coordinate system benchmark. As the competent department of Surveying and Mapping, the Ministry of Natural Resources has a strong surveying and mapping technical force, and it has sufficient professional knowledge to solve the difference of coordinate points and plot area between different coordinate systems. However, the surveying and mapping technical force of the engineering construction unit is relatively weak and relatively in a passive position, so it is unable to deal with these differences and contradictions. This requires the natural resources department should provide the converted mapping drawings, measurement control point coordinates and plot ratio for the construction unit.

5. Practical application

Guizhou is the only province without plain support. Bijie, as an old revolutionary area, is also a typical Karst topography. Within 964k m² of the central urban area planned by Bijie City, the elevation of the construction land is between 1200m and 1700m, and the projection deformation value of the side length is large, the mutual difference of the projection deformation is also large. In order to meet the requirements of Bijie City's engineering construction, in 2015, based on CGCS2000 ellipsoid, the independent urban coordinate system of Bijie City Center was established by ellipsoid expansion method. It could meet the needs of engineering construction side projection deformation. However, the 1980 Xi'an Coordinate System has been used from 2015 to 2018 by the Land and Resources Department of Bijie City. There are contradictions between the two sets of coordinate systems in terms of coordinate position and plot area. Due to the establishment of Surveying and Mapping Institute under the municipal Urban and Rural Planning Bureau, the planning department can understand the secondary differences, but how to calculate the plot ratio, greening rate and other indicators, the superior department and the superior surveying and mapping competent department have not made any clear official reply, which results in the hard planning approval.

With the integration of departments, Bijie Urban and Rural Planning Bureau and Bijie Land and Resources Bureau are integrated into the Municipal Natural Resources and Planning Bureau belonging to the natural resources system. According to the requirements of the Ministry of Natural Resources, CGCS2000 Coordinate System is used and the contradiction of surveying and mapping benchmark of urban and rural planning and land use planning is easily solved. However, the surveying and mapping data provided by the natural resources department are all got by CGCS2000 system, and the side length projection deformation value is far greater than the provisions of the code for urban construction, which can not meet the needs of engineering construction and cannot guarantee the quality of engineering construction.

In order to meet the needs of the project construction, Bijie Urban and Rural Planning and Mapping Institute, together with Guizhou University of Engineering Science, studies the ways of transforming the surveying and mapping data of CGCS2000 Coordinate System into the urban independent coordinate system of Bijie central city. The details are as follows:
5.1 Elevation of control points and topographic map
According to the state regulations, the existing surveying and mapping data are all based on the 1985 National Elevation Datum. Therefore, both CGCS2000 and Bijie urban independent coordinate system adopt it, and the elevation system is consistent, so it can be used directly.

5.2 Coordinate system conversion of control points
Relying on the technical force of the First Surveying and Mapping Institute of Guizhou Province, according to the 36 C-level GNSS control points established in the central and western urban areas of Bijie City and the results of geoid refinement, the coordinate transformation software suitable for the central urban area of Bijie City is compiled. Using the CORS System of Bijie city network, the GNSS C-level Observation is carried out, and the conversion results are tested. The conversion accuracy meets the engineering survey requirements. The inspection results are shown in Table 1.

Table 1 Comparison between coordinate conversion software and C-level observation coordinate

| spotting | X(m) | Y(m) | X(m) | Y(m) | Δ(mm) |
|----------|------|------|------|------|-------|
| GZBJ     | *.544 | *.830 | *.543 | *.830 | 1     |
| GZDF     | *.935 | *.497 | *.935 | *.498 | 1     |
| GZJC     | *.912 | *.789 | *.912 | *.788 | 1     |
| GZWX     | *.719 | *.795 | *.719 | *.795 | 0     |
| BJ01     | *.801 | *.578 | *.802 | *.576 | 2     |

5.3 Topographic map conversion
The topographic maps required for the project construction are all small-scale ones with small area (for example, circular plot with radius of 500m). They can be converted by using the South CASS software.

Method 1: The coordinates of two sets of coordinate systems of 36 C-level GNSS control points is used to calculate and convert seven parameters. Saving the conversion parameters and calling seven parameters for conversion each time the topographic map is converted. This method is relatively simple, but because the calculation of seven parameters is based on the C-level point, which covers 964km² of Bijie downtown area, the control point far away from the topographic map will also affect the topographic map conversion, the accuracy is relatively low. The specific inspection results are shown in Table 2.

Table 2 Comparison table of seven parameter conversion and measured coordinates of level C point calculation

| spotting | Converting coordinate | Measured coordinate | Δ(mm) |
|----------|-----------------------|---------------------|-------|
|          | X (m)                 | Y (m)               |       |
|          | X (m)                 | Y (m)               |       |
| 1        | *.568                 | *.731               | *.756 | *.631 | 213  |
| 2        | *.399                 | *.515               | *.588 | *.417 | 213  |
| 3        | *.496                 | *.146               | *.683 | *.049 | 211  |
| 4        | *.665                 | *.362               | *.851 | *.263 | 211  |

Method 2: Selecting 5 points from the East, West, North and South of the original topographic map, and transforming them into independent coordinate system through coordinate conversion software, calculating and transforming seven parameters according to the coordinates of these 5 points. Seven parameters are used to transform the topographic map. The second method is relatively complex, but the conversion accuracy is higher than that of the first method, so it is recommended to use. The specific inspection results are shown in Table 3.
Table 3: Comparison of seven parameter conversion and measured coordinates calculated by coordinate conversion software

| Spotting | Converting Coordinate | Measured Coordinate | Δ (mm) |
|----------|-----------------------|---------------------|--------|
|          | X (m) | Y (m) | X (m) | Y (m) |         |
| 1        | .755  | .632  | .756  | .631  | 1       |
| 2        | .588  | .417  | .588  | .417  | 0       |
| 3        | .683  | .049  | .683  | .049  | 0       |
| 4        | .850  | .263  | .851  | .263  | 1       |

5.4 Calculation of planning indicators

Due to the small scope of the project construction, the land area after the conversion is not changed so much. According to the market demand, Bijie Natural Resources Bureau controls the approved planning index, and the land area is calculated according to the land area calculated by the independent coordinate system after the conversion.

6. Conclusion

According to the application of Bijie city, the following conclusions are drawn:

1. The 1985 National elevation datum is adopted in the elevation system of engineering construction to meet the requirements of many aspects;
2. The CGCS2000 Coordinate System is used in multi-conformity to meet the requirements of the Ministry of Natural Resources;
3. The independent coordinate system meeting the code for urban construction shall be adopted to engineering construction to ensure the quality and safety of buildings. However, it is suggested that the independent coordinate system should be established by using CGCS2000 ellipsoid and ellipsoid expansion method, so as to be converted from CGCS2000 Coordinate System;
4. A certain number of high-level control points are used in coordinate system transformation of control points, they are transformed by strict transformation formula (delegating the units with strong surveying and mapping technology to compile transformation software within a certain scope of application based on geoid refinement is suggested);
5. The conversion of topographic map is based on the calculation and conversion of seven parameters of the surrounding and central points of the project construction land, and the conversion is completed by the Southern Software (or other mapping software);
6. Engineering survey, design, construction, completion and other works shall be carried out in the independent coordinate system.

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