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Article

Research on the Application of Mathematical Software in Concrete Data Analysis

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Abstract: Mathematical application software provides more efficient solutions for concrete construction and building quality management. In concrete quality management, numerous data calculation problems often arise, including data statistical analysis, prediction, and interpolation calculations. Without the assistance of mathematical application software, the volume of calculations is often substantial, and there is also the challenge of selecting outliers and performing repetitive calculations. Many mathematical problems have been transformed into programs using Matlab software, significantly simplifying the calculation workload. Therefore, the use of mathematical application software, such as Matlab, can resolve complex computational problems in concrete or structural calculations.

Keywords: mathematical application software; concrete data; data prediction; regression equation

1. Introduction

With the advancement of software technology and the development of construction techniques, the utilization of mathematical application software in construction engineering is becoming increasingly widespread. These software not only provide powerful technical support but also offer numerous ways to solve complex problems. It is believed that in the coming decades, computer-aided technology, network and information technology, and intelligent management will become the primary development directions of construction technology [1]. The use of mathematical application software will also be one of the mainstream directions. The use of Revit software for modeling and monitoring the quality of concrete, and Matlab and Excel software for data statistical analysis, ensures fast and accurate results in data processing. Particularly, Matlab software excels in handling regression equations, such as estimating the 28-day strength using the 3-day concrete strength, and regression equations of hydraulic jacks.

2. Overview of Mathematical Application Software

Mathematical application software is a tool specifically designed for mathematical calculations, data processing, and simulation. It can utilize mathematical methods, algorithms, and models to provide efficient solutions [2]. Common application software mainly includes Revit (BIM), Robot, GSA, Matlab, Python, and others. Revit (BIM) software is one of the most widely used application software in digital technology, enabling digital management of the entire process of building technology, including design, construction, maintenance, and other functions. This significantly improves design efficiency and accuracy, optimizes construction processes, and reduces costs. Matlab software provides an advanced numerical calculation and programming

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environment. It supports matrix operations and vectorization operations, efficiently handling large-scale numerical calculation tasks. Additionally, Matlab offers rich mathematical functions and symbol calculation tools, making it convenient for mathematical modeling and problem-solving. This article primarily uses Matlab software as an example to analyze some application techniques of mathematical application software in concrete quality management.

3. The Application of Mathematical Software in Concrete Data Processing

In Matlab software, the Curve Fitting Toolbox can be utilized for fitting curves. The Curve Fitting Tool provides graphical tools and functions for curve-fitting data, simplifying the usage of the toolbox for data analysis, outlier removal, selection of fitting models, and more. Next, I will use prestressed concrete engineering as an example to demonstrate the method of curve fitting using the regression equation of hydraulic jacks. In prestressed concrete engineering, due to the friction of the jack's piston, there exists a deviation between the theoretical and actual tension of the jack. Therefore, prior to use, calibration of the jack and oil pump is necessary, and the experimental data from the press and oil gauge must be organized for calculation using the regression equation:

$$Y = a + bX$$

Y: Reading of oil pump gauge (Mpa), X: Test machine reading (KN), b: Correction amount

Among them, the linear relationship data (a) and correction value (b) between oil pressure and tensioning force can be obtained through the calibration data of the jack. Using the regression equation, the tensioning force value (X) can be easily calculated. For instance, the force value of each steel strand. Based on the experimental data between X and Y, the following conclusions can be drawn:

$$\bar{b} = \frac{\sum_{i=1}^{n} x_i y_i - n\bar{x}\bar{y}}{\sum_{i=1}^{n} x_i^2 - n\bar{x}^2}$$

$$\bar{a} = \bar{y} - \bar{b}\bar{x}$$

However, when using this formula for calculation, the computational workload is often relatively large, and there are also issues with abnormal data, as well as insufficient data. If mathematical software is utilized, all these problems can be easily resolved. For instance, consider the calibration result of a specific jack. Now, the mathematical application software Matlab is used to calculate the regression equation (See Table 1).

Table 1. Calibration Data of Jacks.

Reading of Oil Pump Gauge Y (Mpa)	5	10	15	20	25	30	35	40	45	48
Test Machine Reading X (KN)	20	42	66	92	118	140	182	192	216	230

For such data processing problems, the first step is to use the plot (x, y,' r * ') command to draw a scatter plot to determine the approximate model of the regression equation. From the Figure 1, it can be seen that these points are roughly distributed around a straight line. Therefore, overall, it can be considered according to a linear equation of one variable, and the program developed is as follows:

```
x = [20 42 66 92 118 140 182 192 216 230];
y = [5 10 15 20 25 30 35 40 45 48];
n = 10;
X. = [ones(n,1), x'];
[b,bint,r,rint,s] = regress(y',X,0.05);
b,bint,s,
rcoplot(r,rint)
```

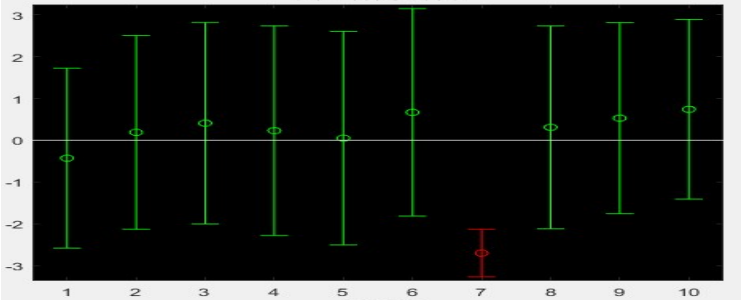

Figure 1. Residual Case Sequence Diagram.

From the sequence diagram above, it can be seen that in the calibration data of the jack, the seventh data is abnormal, so it needs to be removed and the remaining data needs to be reprocessed (see Table 2).

Table 2. Calibration Data of Jacks.

Reading of Oil Pump Gauge Y (Mpa)	5	10	15	20	25	30	35	40	45	48
Test Machine Reading X (KN)	20	42	66	92	118	140	182	192	216	230

There used to be a total of 10 data points, but due to discarding one abnormal data point, the remaining 9 data points have been reprogrammed (see Figure 2), and the results are as follows:

```
x = [20 42 66 92 118 140 192 216 230];
y = [5 10 15 20 25 30 40 45 48];
n = 9;
X. = [ones(n,1),x'];
[b,bint,r,rint,s] = regress(y',X,0.05);
b,bint,s,
rcoplot(r,rint)
```

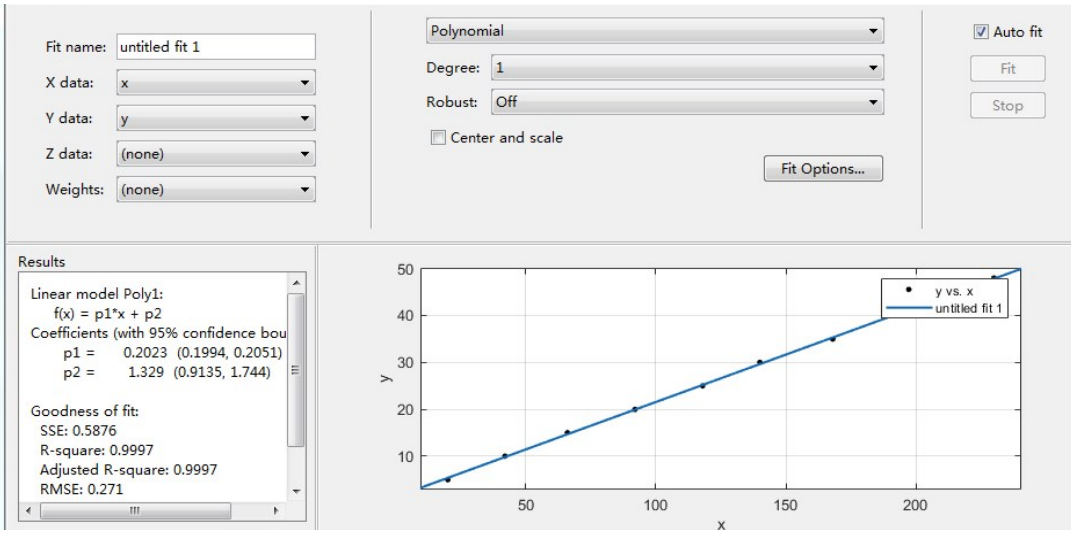

Figure 2. Running results of data processing.

The result of running this program is a = 0.2069 and b = 1.3269. Therefore, the regression equation obtained from running this program is:

$$Y = 0.2069x + 1.3269$$

From this regression equation, it can be seen that R-square = 0.9998, and the closer R-square is to 1, the stronger the explanatory power of the variables in the equation for Y. If this equation is used to calculate the tensile force of prestressed concrete reinforcement, if a certain prestressed reinforcement requires a tensile force

of 187.7 KN, the oil gauge reading can be calculated using this regression equation. The calculation results are shown in the Table 3.

Table 3. Calculation results of oil pump gauge readings.

Tensioning Stress	Reading of Oil Pump Gauge (Mpa)	Tensile Value (KN)
$10\%\sigma_K$	5.1	18.8
$20\%\sigma_K$	8.9	37.6
$100\%\sigma_K$	39.2	187.7

4. Conclusions

Mathematical application software possesses powerful computing capabilities and data statistics functions, enabling us to solve numerous complex engineering problems [3]. Additionally, many data application software have rich function libraries and toolkits. By dedicating efforts to learning these software, we can significantly improve the efficiency of quality management work. Therefore, the application prospects of mathematical software in engineering are extensive, and the role of mathematical software in engineering will continue to be increasingly important. Of course, to effectively utilize these mathematical application software, one needs not only a strong mathematical foundation but also a certain level of programming ability. When used in concrete or construction engineering, one must possess specific professional skills, presenting an important challenge in the development of mathematical application software.

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Data Availability Statement

The original contributions presented in the study are included in the article, further inquiries can be directed to the author.

Conflicts of Interest

The author declares no conflict of interest.

References

1 Xu, W. Research on Quality Management of G Building Projects Based on Building Information Modeling, Master's Thesis, Qingdao University, Qingdao, China, 2023; pp. 12–13.

2 Li M.; Chen W.; Wang S.; Li J.; Tian Z. Review of 3D Reconstruction Methods for Visual Deep Learning. *Comput. Sci. Explor.* 2023, **2**(**17**), 279–302.

3 Dai C.; Liang B.; Cheng K.; Zou M.; Liu Q. Research on Dynamic Scheduling of Prefabricated Building Construction Process Based on Digital Twin. *J. Build. Sci. Eng*. 2023, **5**, 33–35