The Research on Continuous Rigid Frame Bridge Girder Design Parameters impact Based On Orthogonal experiment

Wei Zhongchen[1] Wu Zeng[1] Ning Xiaojun[1] Lu Yao[2]

(1. Faculty of Civil Engineering and Mechanics, Kunming University of Science and Technology. Kunming China.650500 2. School of Civil Engineering, Central South University. Changsha China.410075.)

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Abstract: The design parameters, central beam high-span ratio, high-span ratio at root of the beam and beam bottom parabola, on continuous rigid frame bridge girder were valued in an appropriate range. Based on orthogonal experiment and numerical simulation, the effects of above parameters to the comprehensive performance index on the basis of stress, deflection and concrete volume were studied by the parameters combinations and the calculation of the text models. The research shows that the central beam high-span ratio has the greatest impact on the comprehensive performance Index, the beam bottom parabola have less influence， when the high-span ratio at root of the beam. Especially, the impact of the beam bottom parabola is larger than the high-span ratio at root of the beam.

Select the main beam parameters

The selection of Engineering background is come from concrete continuous rigid frame bridge on a highway in Yunnan Province, the bridge with a main span in the form of a 103m+190m+103m, where composed of two T, the total length of the main bridge is being 396m. Cross profile using single box single room girder cross-section.

Some literature Pointed out: For the small span continuous rigid frame bridge beam bottom should be used larger parabola, but for the the long span continuous rigid frame bridge beam bottom should be used smaller parabola. During the analysis of the domestic part of the bridge girder beam bottom parabola parameter ,we can found that the beam bottom parabola in the range from 1.5 to 2.0. This article respectively selects 1.5 times, 1.67 times, 1.83 times and 2.0 times for analysis.

Take into the some of section bridge ,that has been completed ,we found that continuous rigid frame bridge high-span ratio distributed from 0.05 to 0.065.Some literature points out, the h/L of root of the beam distributed between 1/16 ~ 1/20. the $h_{中}$/L of central beam distributed between 0.02～0.03. therefore considered the engineering examples and related literature,the height of girder at root of the beam respectively for the 11.2m、11.6m、12.0m、12.4m。the height of girder at central beam respectively for the 3.4m、3.6m、3.8m、4.0m。

Finite element model of orthogonal test parameter combinations

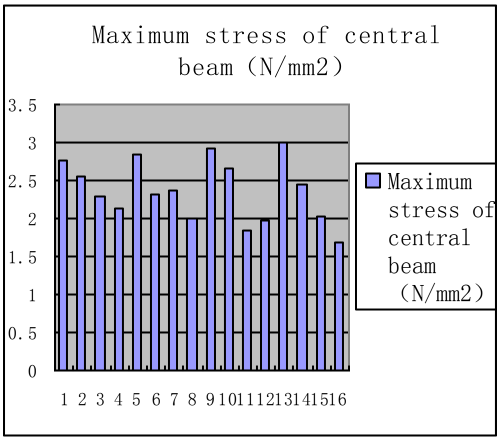
According to the assembly of factors orthogonal table, A represent the height of girder at root of the beam. B represent the height of girder at central beam, C represent parabola of beam bottom. A_1 value of 11.2m, A_2 value of 11.6m, A_3 value of 12.0m, A_4 value of 12.4m; B_1 value of 3.4m,B_2 value of 3.6m, B_3 value of 3.8m, B_4 value of 4.0m; C_1 value of 1.5 times, C_2 value of 1.67 times, C_3 value of 1.83 times, C_4 value of 2.0 times.the model of 16 finite element are combine of parameter.

Determining the optimal indicators

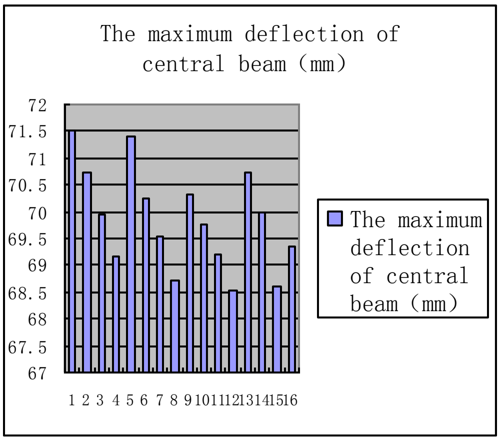
This article select the Strength, deflection and the amount of concrete of main beam central girder section as the goal, set up the different finite element models of combinations of parameters, Respectively calculation the maximum stress of central beam, the maximum deflection of central beam and the amount of concrete under the most unfavorable load combination, and select the results as the analysis evaluation criteria. By calculation, the results of each index were receive, as shown in Table1.

Table 1 Calculation results of different combinations of parameters

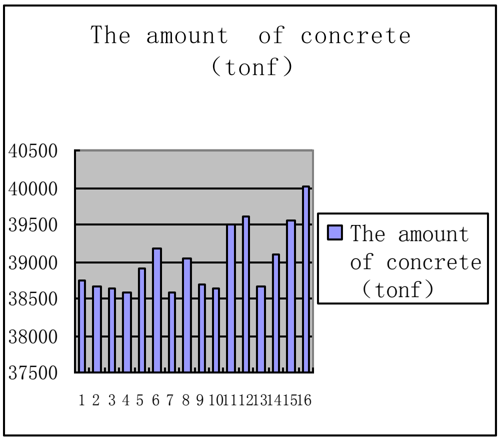
Test No.	Combination	Maximum stress of central beam （N/mm2）	The maximum deflection of central beam （mm）	The amount of concrete （tonf）
1	$A_1B_1C_1$	2.76	71.527	38746.4
2	$A_1B_2C_2$	2.54	70.73	38665.73
3	$A_1B_3C_3$	2.30	69.947	38631.78
4	$A_1B_4C_4$	2.13	69.16	38580.96
5	$A_2B_1C_2$	2.83	71.413	38899.17
6	$A_2B_2C_1$	2.32	70.245	39171.93
7	$A_2B_3C_4$	2.36	69.549	38570.64
8	$A_2B_4C_3$	1.99	68.714	39028.99
9	$A_3B_1C_3$	2.91	70.315	38690.04
10	$A_3B_2C_4$	2.65	69.759	38637.83
11	$A_3B_4C_2$	1.84	69.217	39508.5
12	$A_3B_3C_1$	1.97	68.531	39597.46
13	$A_4B_1C_4$	2.99	70.735	38666.28
14	$A_4B_2C_3$	2.46	69.967	39107.56
15	$A_4B_3C_2$	2.03	68.614	39559.39
16	$A_4B_4C_1$	1.68	69.368	40023



（a）



（b）



（c）

Figure 1 （a）The Maximum stress distribution of central beam;
（b）The maximum deflection distribution of central beam;
（c）The amount of distribution concrete.

In order to the evaluation and judgment synthetic characteristics of the main beam becomes more reasonable and intuitive,the multiple evaluating index issues are need to be converted to the single evaluating index.Used the formula scoring method to make the appropriate respectively conversion.

$$K_2 = \frac{\sigma}{f_{tk}} + \frac{f}{[f]} + \frac{F}{G} \qquad (3.6)$$

Among them:

K_2——the comprehensive indicators of main beam;

σ——The maximum stress of central beam under the most detrimental load combination;

f_{tk}——C55 Tensile strength of concrete standard values, f_{tk}=2.74MPa;

f——the maximum deflection of central beam under the most unfavorable of load combination;

$[f]$——long-term and medium-term deflection limits of main span, $[f]$=1/1600L=11.875cm;

F——Structure concrete using quantitative index, the total mass of the model of bridge.

G ——The total mass of the actual bridge project.

Based on Single index of the results , get the comprehensive test table 2 about performance of main beam by Orthogonal.

Table 2 The analysis results of comprehensive index of different parameters combination

Combination	No. 1 $A_1B_1C_1$	No.2 $A_1B_2C_2$	No.3 $A_1B_3C_3$	No. 4 $A_1B_4C_4$	No. 5 $A_2B_1C_2$	No. 6 $A_2B_2C_1$	No.7 $A_2B_3C_4$	No.8 $A_2B_4C_3$
K2	2.654	2.565	2.470	2.400	2.683	2.495	2.487	2.357
Combination	No.9 $A_3B_1C_3$	No.10 $A_3B_2C_4$	No.11 $A_3B_4C_2$	No. 12 $A_3B_3C_1$	No. 13 $A_4B_1C_4$	No.14 $A_4B_2C_3$	No.15 $A_4B_3C_2$	No. 16 $A_4B_4C_1$
K2	2.701	2.598	2.314	2.371	2.726	2.540	2.391	2.269

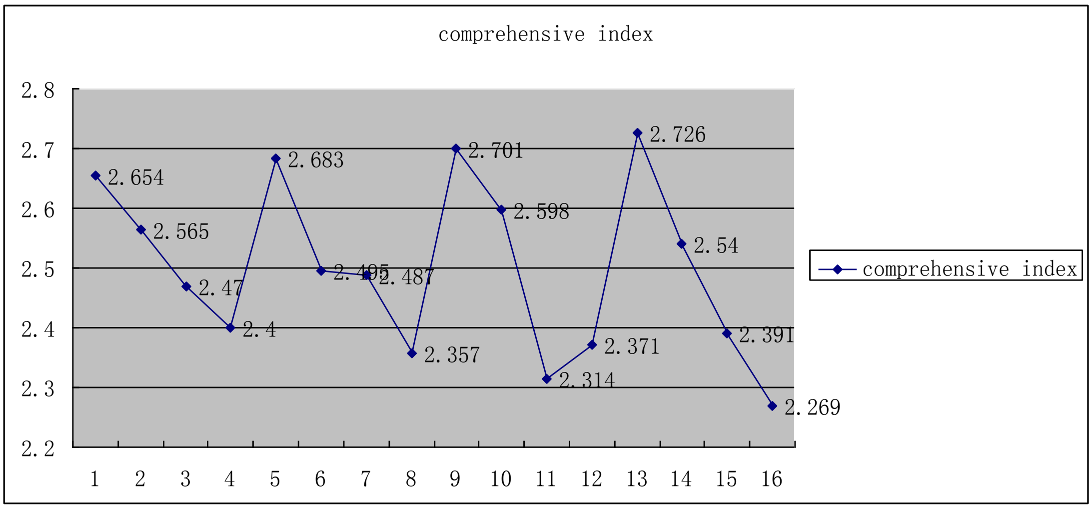


Figure 2 The comprehensive evaluation index distribution

According to the calculation results table 2 and figure 2 Shown, the comprehensive index on the 16th experiment is minimum, for the better parameter combinations results in orthogonal experiment; the comprehensive index on the 13th experiment is maximum, for the worst parameter combinations result in orthogonal experiment.

In order to determine the level of impact on level factors for the test results, need to analysis of the comprehensive test index, range analysis reflects influence level of the impact factor levels in the test index.

Table 3 Range analysis of comprehensive index

index/factor	high-span ratio at root of the beam A	central beam high-span ratio B	beam bottom parabola C
K1	10.090	10.765	9.789
K2	10.022	10.198	9.954
K3	9.985	9.719	10.068
K4	9.926	9.342	10.212
k1	3.363	3.588	3.263
k2	3.341	3.399	3.318
k3	3.328	3.240	3.356
k4	3.309	3.114	3.404
range R	0.054	0.474	0.141

Summary

The result of range analysis shows that the central beam high-span ratio has the greatest impact on the comprehensive performance Index, nevertheless the high-span ratio at root of the beam and the beam bottom parabola will have less influence. Among the impact of the beam bottom parabola is larger than the high-span ratio at root of the beam.

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