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Monitoring of Maslenica Bridge during Construction

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Summary

The analysis of Maslenica concrete bridge monitoring has been carried out. The bridge was finished in 1997. The main girders of the superstructure and the arch were analysed during different construction phases. It appears that there was a considerable shrinkage of concrete in girders after their pouring because of a relatively small moisture level at summer time when the measurements were undertaken. This caused compression in the reinforcement. The stiffness of girders was determined by means of the modulus of elasticity, by measuring their natural frequencies, and by means of concrete compression strength. By measuring stresses and displacements during construction and by comparing it with the values obtained by means of NELIN program which includes the material and geometrical non-linearity, a solid qualitative correspondence between theoretical and experimental research results has been established.

Keywords: monitoring, non-linear analysis, modulus of elasticity, stresses, displacements

1. Introduction

The new Maslenica bridge was built approximately 1,5 km west from the old destroyed bridge, over Zdrelac strait near Maslenica. The bridge completely satisfies all the requirements of a normal highway cross section. The main structure of the bridge is a concrete arch with a span of 200 meters and a rise of 65 meters. This paper includes the analysis of stress conditions, deflections and the stiffness of superstructure main girders as well as the conditions of arch stresses and displacements.

2. Monitoring of prestressed girders

Figure 1 shows the changes of stresses, the temperature of the girders' reinforcement and the temperature of the environment immediately after the assembly of a reinforcement cage and during casting and prestressing of superstructure main girders. Before the casting of girders, compression in the reinforcement increases with the fall of the air and reinforcement temperature. Within that period of time, the changes of the reinforcement temperature follow the changes of the environmental temperature. Because of the intensive process of concrete hardening during casting, the relief of thermal energy occurs in a relatively short period of time, which causes a quick rise of the concrete and reinforcement temperature. In the presented case, the reinforcement temperature gradient was approximately 15°C degrees, which caused the increase of compression in the reinforcement for approximately 55 MPa. These stresses return to the starting condition with cooling down of concrete after the hardening process. After the concrete hardening process with the fall of extreme air temperatures, compression in the reinforcement increases. In

Dalmatia, relatively high environmental temperatures often appear already in May with regularly less than 50% moisture, which causes a considerable shrinkage of concrete. This process of concrete shrinkage and the phenomenon of compression in the reinforcement have been registered from the course of stressing after girders' casting and the concrete hardening process. From the function of built-in stresses that is shown bellow, one can notice that about 15% of the allowable stresses were registered before prestressing. The analysis of air temperature gradients and the hardened concrete temperature gradient shows that there are considerably smaller daily temperature changes of the reinforced concrete structure because of slow warming up and cooling down of concrete. Therefore, for example, on 16 May 1996, the measured air temperature differed from 18 to 27°C degrees (ΔT_{air}=9°C), and the concrete temperature from 20,5 to 24,5 C ($\Delta T_{concrete}$= 4°C).

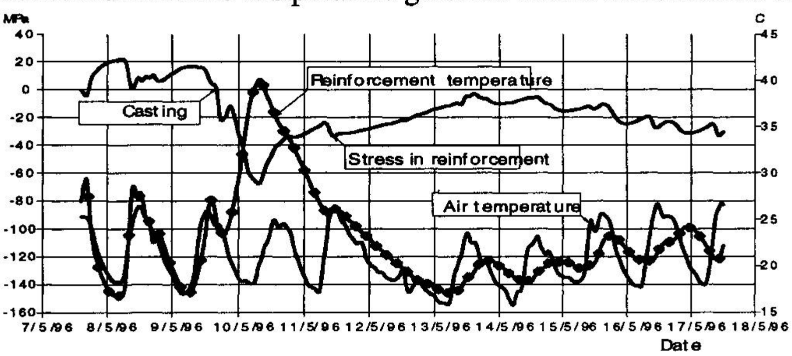

Figure 1. Changes of stresses, girders reinforcement temperature and environmental temperature from the assembling of the cage to the prestressing of girders

This paper contains the analysis of the stiffness of superstructure main girders. The bending stiffness of main girders can be determined by means of the dynamic modulus of elasticity. This modulus was obtained by measuring the frequencies (f) of simple spanned girders from the following equation:

$$E_d = \frac{4f^2qL^4}{\Pi^2 Ig} \qquad (1)$$

The dynamic modulus of elasticity was compared with the tangent modulus which was determined on the basis of the tested and designed concrete strength.

3. Arch displacements

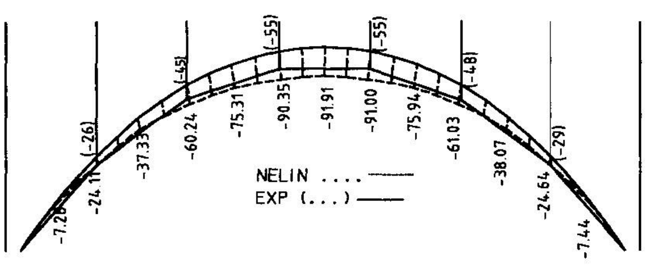

Figure 2 shows differences in displacements between the completed arch and the end of the bridge construction. The displacement difference is determined geodetically and by NELIN program. Comparing experimental and theoretical values of displacements at the all places of the pier and arch junction, averagely 28% higher theoretical valueas have been obtained.

Figure 2. Arch displacements between the completed arch and the end of bridge construction, determined geodetically and by means of NELIN program

4. Conclusion

By measuring displacements and stresses during construction and by comparing the values with the ones that were obtained by means of NELIN program, a solid qualitative correspondence between theoretical and experimental research results has been established. When comparing experimental and theoretical values, one should take into consideration that the theoretical calculations were not completely following all the construction stages of the arch.