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Measurements of Creep, Shrinkage and Temperature Changes in Prestressed Concrete Bridges

Mesures du fluage, du retrait et de la température dans des ponts en béton précontraint

Kriech-, Schwind- und Temperaturmessungen an Spannbetonbrücken

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Observations made over a period of several years at the Research Institute of Civil Engineering in Bratislava /Czechoslovakia/ by akustical resonance string strain gauges,and geodetical methods,in 10 prestressed concrete bridges.The strain gauges were concreted directly into the structures.The following types of highway and railway bridges were measured:

- bridges with simple and continuous precast girders,
- with monolytical (cast in place) concreted framework structures,
- monolytical concreted cantilever bridges,
- cantilever bridges or precast elements and
- footbridge of prestressed lightweight concrete girders.

The process of change of deformations stabilized in the bridges constructed with good quality of concrete (Youngs Modulus E= 350 000 kp/cm^2) after three years.The total strain (creep and shrinkage) measured after 10 years was - 200 x 10^{-6} in a monolytical concreted framework prestressed concrete structure (Highway bridge "K" - Kotešová, span 63.40 m , Fig.No.1). The maximum deflection after 10 years was 5.57 cm at the center of the span. 4.87 cm of the above was found after the first three months the bridge was in use.After 3 years the deformations oscilated only due to temperature changes.The strains at the centre of the span are shown in Fig.No.2.

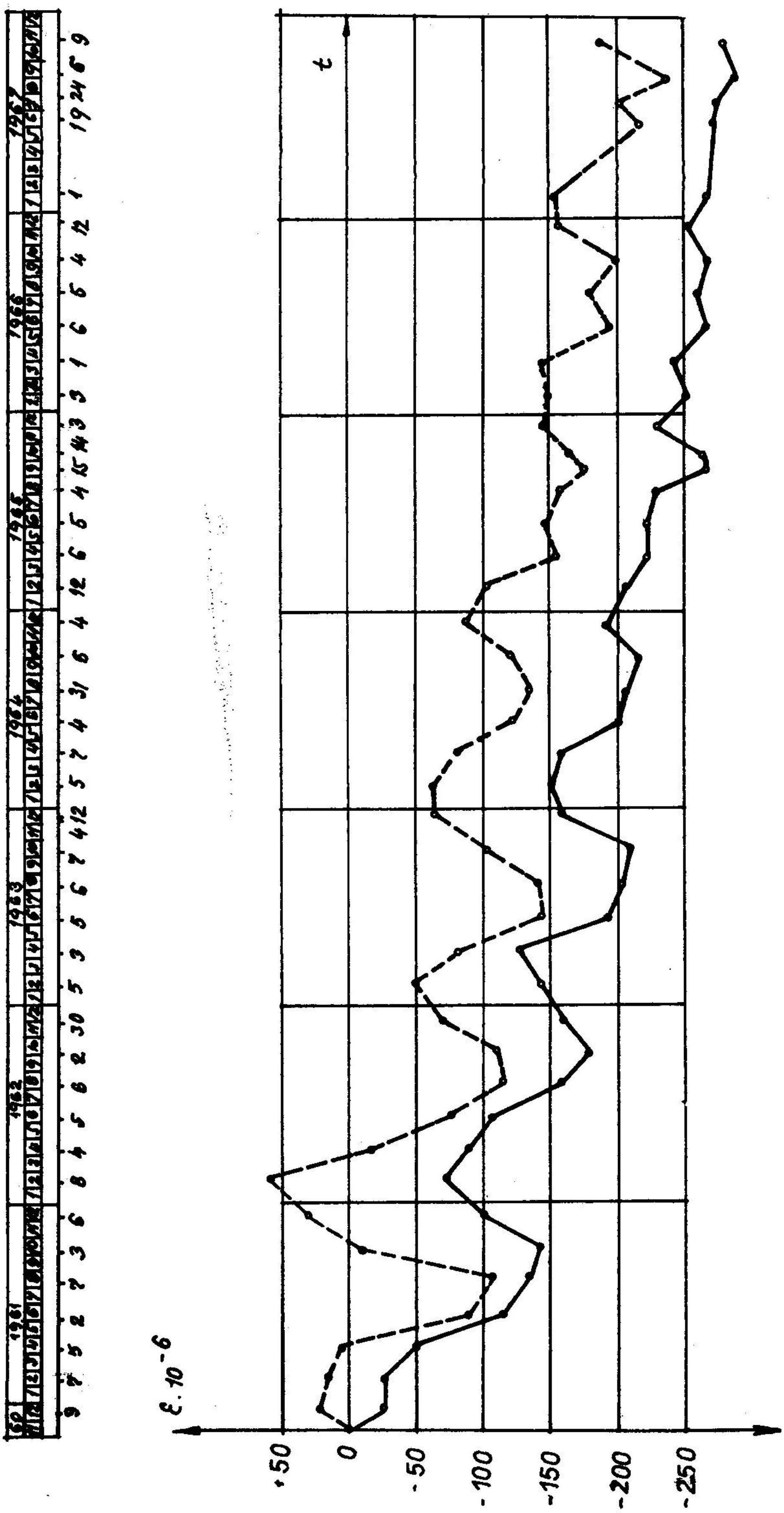

Fig. No. 2.: The strains in a monolytical concreted framework prestressed concrete highway bridge "K".

Fig.No.1.:The monolytical concreted framework prestressed concrete highway bridge " K " - Kotešová.

In the second framework structure (Highway bridge " B " -Bytča with the same span of 63.40 m) but of worse quality of concrete (Youngs Modulus E = 250 000 kp/cm^2) the maximum deflection was 11.77 cm after three years and is not stabilized. 8.5 cm of the 11.77 cm was found after the first 6 months of traffic on the bridge.The influence of temperature change between summer and winter on the deflection oscilations was $\pm$ 1 cm. However it is possible that these large deformations were partially caused by foundation movements and therefore recomandations were made to connect the bottom of the foundations with prestressed concrete bars in this type of structure.

The cantilever bridges with prestressed precast concrete elements had already larger deformations during prestressing in comparison with the monolytical concreted cantilever bridges.However one has to note,that the desired prestress in the highway bridge " S " (Sirník, span 60.00 m, Fig.No.3.) was - 147.3 kp/cm^2 (the measured prestress - 130.7 kp/cm^2) and in the monolytical bridge " N " (Nové Mesto, span 70.00 m) was - 83.0 kp/cm^2 (the measured -84.9 kp/cm^2) , which is smaller as in the bridge with precast elements " S " . From the measured results of the monolytical bridge " N " constructed with the inferior quality of concrete it was observed that maximum deflection at the center of the span was 31.18 cm,

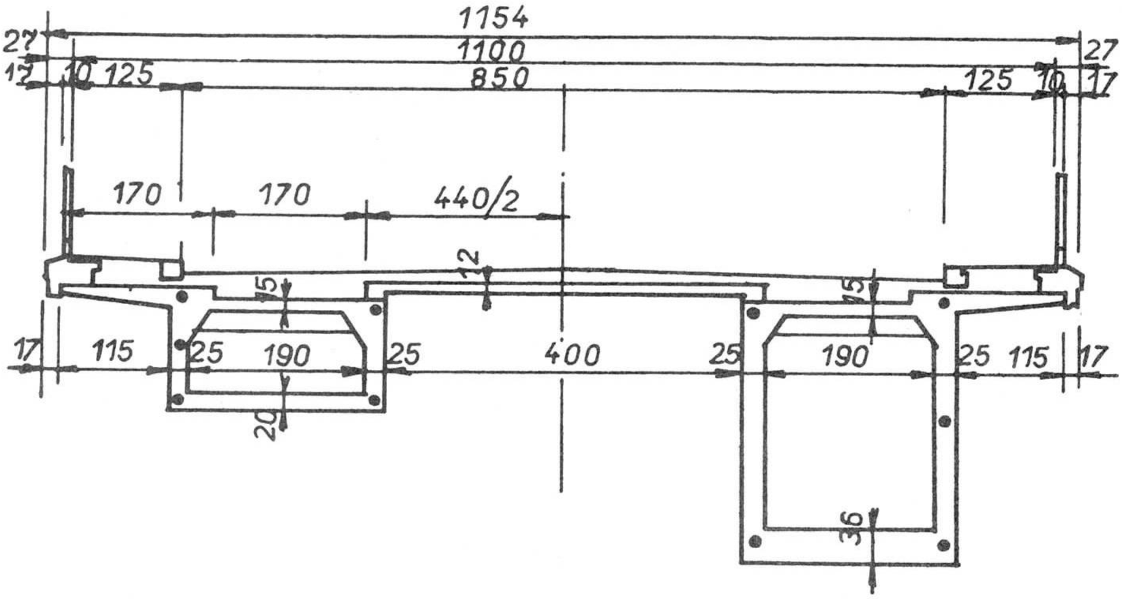

Fig.No.3.:The cross section of the cantilever highway bridge with prestressed precast concrete elements.

but the increase of the deflection in the last 3.5 years was only 6.95cm. In comparison,the monolytical concreted bridge "KO" (Kolárovo,span 61.61 m, Fig.No.4.) made with the better quality of concrete,the maximum deflection in 4 years was only 4.5 cm , and the strains,measured using akustical strain gauges, was 25 to 30 % smaller as in bridge " N ".In the bridge " KO " the advantage of the metal yoint was observed comparing it with the reinforced concrete joint in the center of the span in bridge " N " . The measured stresses during prestressing and after the first year after prestressing is shown in Fig.No.5.

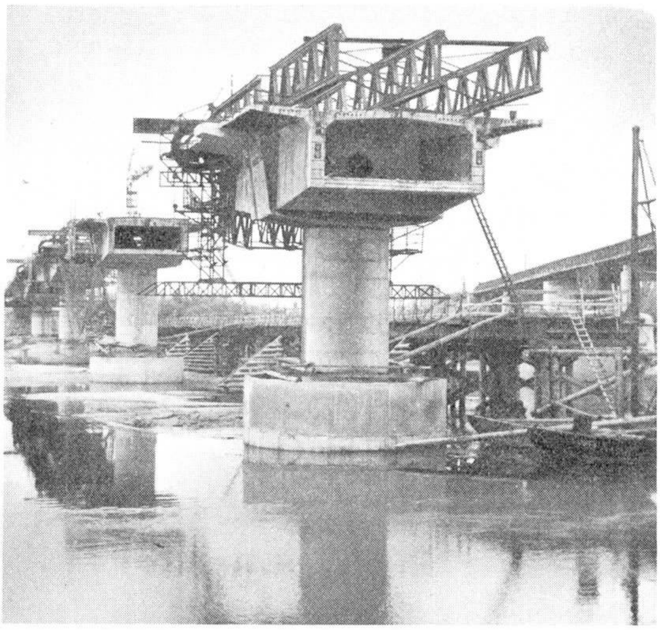

Fig.No.4.:The monolytical concreted cantilever prestressed bridge "KO".

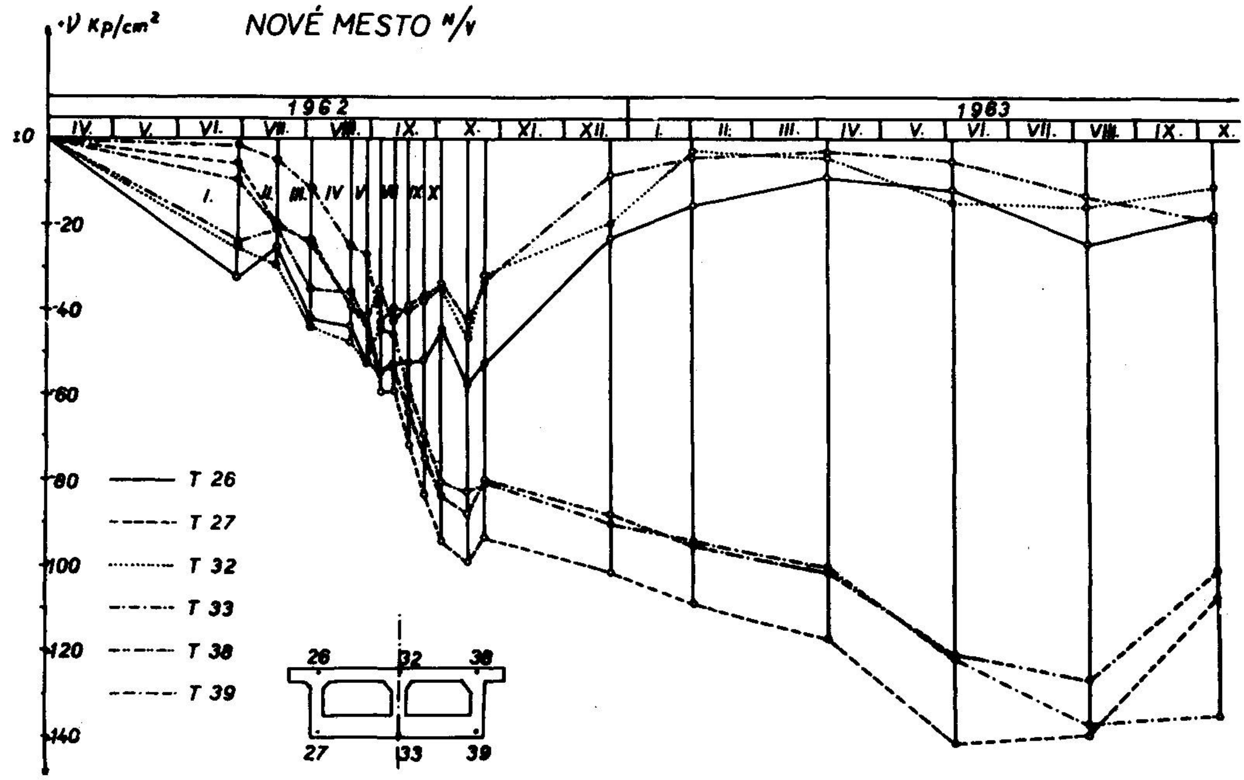

Fig.No.5.: The stresses in the cross section at the fixed end of the monolytical concreted cantilever prestressed concrete highway bridge " N " during prestressing and during the first year after prestressing.

An other interesting observation was that in the cantilever highway bridge " S " with precast elements,the strains after three years were 100 % higher (Fig.No.6.) as in the cantilever monolytical concreted bridge " KO ". The deformations in bridge " S " also stabilized in 3 years,since the quality of the concrete is not bed.The deflection increas was 45 mm in 1966, 13 mm in 1967 and 8 mm in 1968. In the cantilever bridge " S " the maximum strain was $- 850 \times 10^{-6}$ after 3 years, in the cantilever railway bridge " M " (Margecany,same span,Fig.No.7.) the maximum strain was $- 800 \times 10^{-6}$ after 2.5 years (50 % of the later is shrinkage).

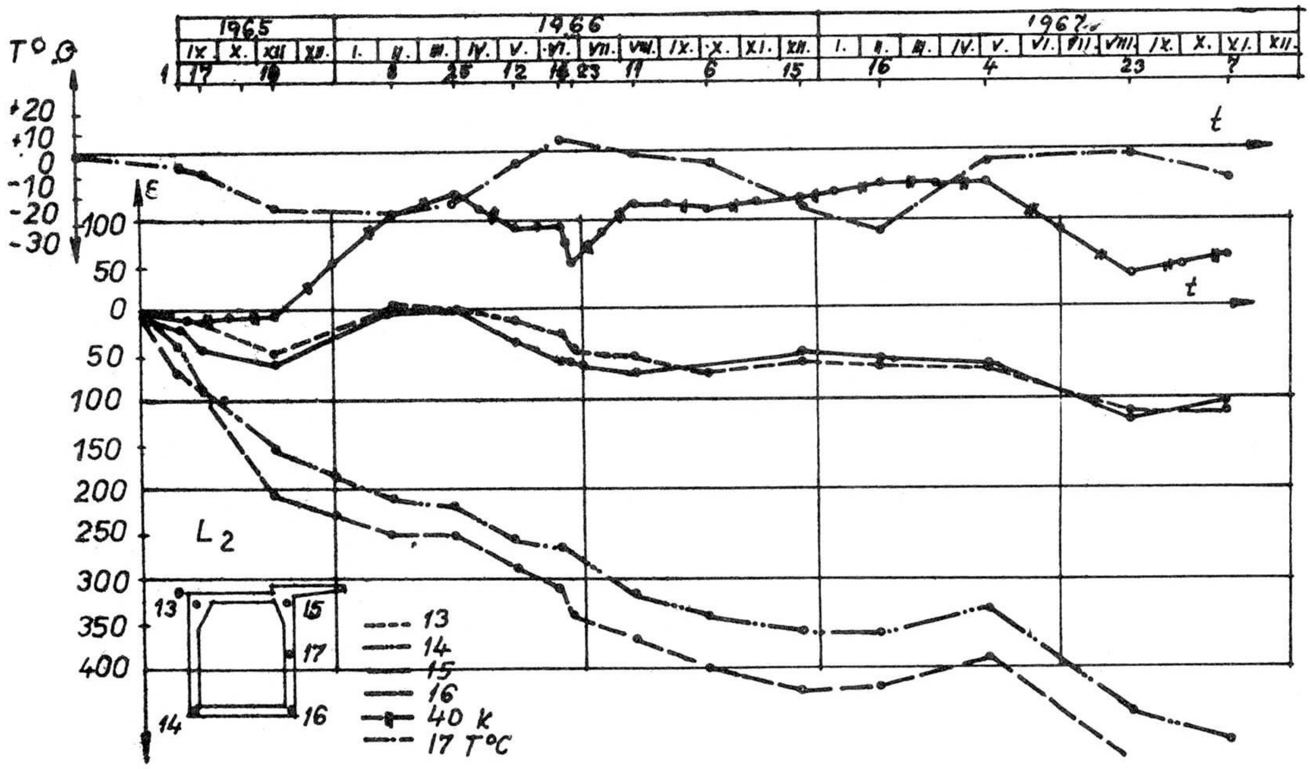

Fig.No.6.: The strains ε x 10^{-6} in the cross section at the fixed end (first precast element) of the cantilever highway bridge " S " with prestressed concrete precast elements during the first 2 years.

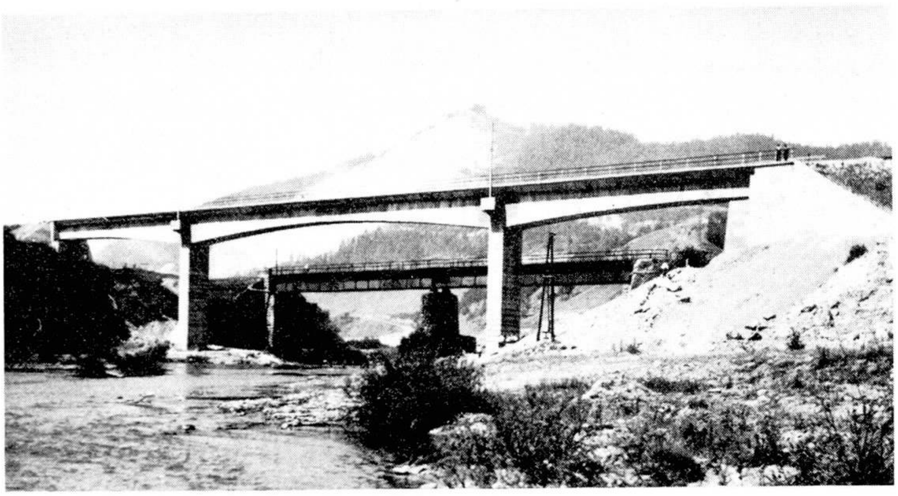

Fig.No.7.:The cantilever prestressed concrete railway bridge " M " with precast elements.

The process of deformation change in prestressed concrete bridges with simple and continuous girders had also stabilized after 3 years. In the railway bridge "KR" (Kramáre, span 24.00 m) the maximum strain was -180×10^{-6} after 4 years. In the footbridge " V " (Velim, span 11.20 m) after 3 years the deformation oscillation due to the deformation changes were $\pm 50 \times 10^{-6}$. In the highway bridge " NZ " (Nové Zámky , span 22.00 + 28.00 + 22.00 m), Fig.No.8., with continuous girders after 10 years the deformation oscilation due to the deformation changes were $\pm 10 \times 10^{-6}$.

Fig.No.8.: The highway bridge " NZ " with continuous precast prestressed concrete girders during construction.

According to our measurements we may conclude that between our results and the designe values from the chechoslovakian code No.732 004 , p.108 (the code formulas based on the classical Dischinger theory of creep and shrinkage) the difference is small in the cantilever concrete bridges even where the deformations are relatively large. The creep coefficient for the highway bridge " S " is 2.07 from the code (from the measurements 1.78) and for railway bridge " M " is 2.06 (from measurements 2.07). The safety factor for the other bridges is much larger.

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SUMMARY

The paper gives an analysis of the measurements of creep, shrinkage and temperature changes in various 10 prestressed concrete highway and railway bridges. Observations were made over a period of 3 to 10 years at the Research Institute of Civil Engineering in Bratislava by acoustical resonance string gauges and geodetical methods. It is concluded that between the results of the observations and the design values by the classical Dishinger theory of creep and shrinkage the difference is small in the cantilever prestressed concrete bridges and the safety factor for the other bridges is much larger.

RESUME

Cet article décrit les mesures de l'influence du fluage, du retrait et de la température sur 10 ponts-routes ou ponts-rails. Ces observations ont été exécutées au moyen d'extensomètres acoustiques et par des méthodes géodésiques pendant des durées de 3 à 10 ans par l'Institut de Recherches du Génie Civil à Bratislava. On peut en déduire que la différence, entre les résultats des mesures et la théorie de Dischinger pour le fluage et le retrait, est petite dans le cas des ponts en béton précontraint construits en encorbellement et que le facteur de sécurité des autres ponts est encore plus élevé.

ZUSAMMENFASSUNG

In diesem Aufsatz werden Kriech-, Schwind- und Temperaturmessungen an 10 verschiedenen Strassen- und Eisenbahnbrücken aus Spannbeton gegeben. Die Beobachtungen wurden während einer Dauer von 3 bis 10 Jahren am Forschungsinstitut für Ingenieurbauten in Bratislava (Pressburg) mittels Saitendehnungsmesser und geodätischer Methoden durchgeführt. Es zeigte sich, dass die Differenz aus Messergebnissen und den klassischen Dischinger-Werten der Kriech- und Schwindtheorie für Freivorbaubrücken sehr gering und dass der Sicherheitswert der anderen Brücken noch grösser ist.

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