

Experimental testing of beam girder on generally layered soil

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The paper describes model testing of girders and results of using the transversely loaded flexible beam girder on appropriately prepared layered soil. The settlement and bending moment (relative girder deformities) are measured along the girder in order to produce necessary results. The procedures and results of testing are then compared and final results commented on. Keywords: Foundation girder, generally layered soil, experiment, settlement, bending moment, comparisons.

Introduction

Some unknown reaction pressure is found to be loading girders laying on the ground, as a reaction to the known external load and the weight of the girder itself. Finding the distribution of reaction pressures is the primary task aimed at discovering the solution to the so-called contact problem of girders on a continual base. Distribution of reaction pressures must fulfil the conditions of balance and those of compatibility of settlement of girders and the ground below them. Those programmes which are presently accessible and most used adopt certain limitations concerning the possibility of system deformations (plane deformations or axially-symmetrical problems), meaning the realistic width of the girder is not being used. For that reason, it is beneficial to have as many test results as possible, especially when the ground is layered (with variable thickness of layers and variable thickness of compressible layers below the loaded girder).

Model testing

Model testing was performed using the prepared primary basin of the test model with various thickness of "artificial soil" forming the base for

monitoring loaded beam girders. The primary basin of the test model as a construction for laying artificial soil of various thickness was constructed from concrete in three different heights shown on Figs. 1 a, b, c. The artificial soil contained the mixture of sand, bentonite, concrete and water.

Several prepared samples with various component ratios were tested in the laboratory, and the one, for which we believed would suit the test run the best, was chosen: a mixture containing 87% sand, 10% bentonite, 3% cement and water amounting to 400% of the bentonite mass.

The mixture was chosen based on the assessment of accomplishing certain strength levels when tested. The chosen mixture was kept 20 days after mixing, i.e. after having been poured in a liquid state. Fig. 1c shows the test basin filled with artificial soil and steel construction (which will be used as support for the counter-weight).

Samples were taken from the test basin and its characteristics tested right before the testing/ observation of the loaded girder, i.e. 20 days after laying the floor in the basin. Compressibility characteristics were determined using the oedometer test and through measurements using the testing round plate 15 and 30 cm in diameter, as shown on Fig. 1d. The average compressibility module from oedometer and testing performed using the round plate was estimated to be $M_s=6500 \text{ kN/m}^2$.

Strength parameters were also tested on the artificial soil and bore the same results as the average ones: cohesion $c=20 \text{ kN/m}^2$ and the friction angle of $\phi=33^\circ$. Undrained strength was tested as well, using the vane, and amounted to approximately $c_u=140 \text{ kN/m}^2$. In the end, as will be shown later in the text, it was shown that this type of artificial soil with these components and basin laying is quite suitable for these and similar model experiments.

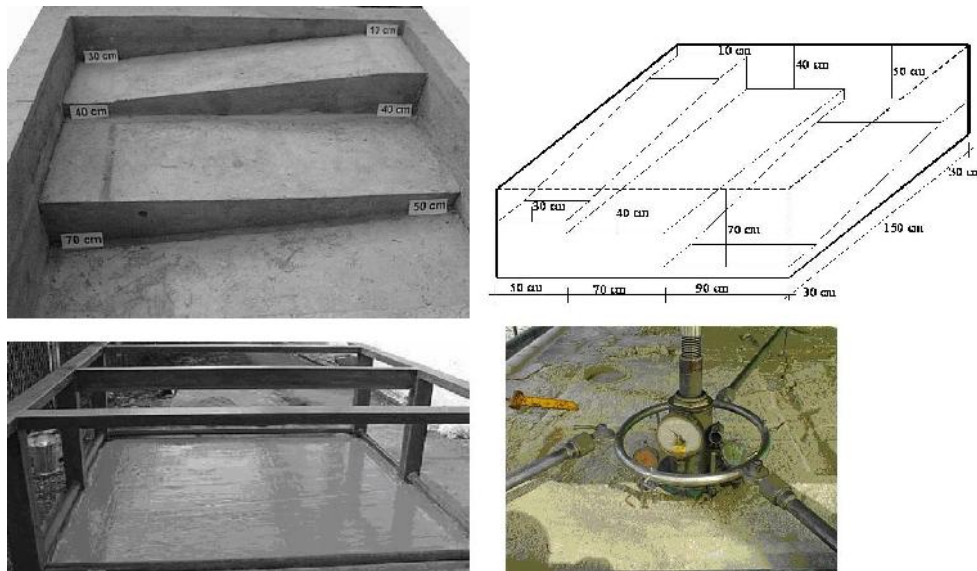


Figure 1. Model testing: a) Testing model basin, b) Test basin dimensions, c) Test basin filled with artificial soil and the steel support construction (for load support), d) Testing the soil using the testing plate

A steel girder of length $L=1.5$ m and cross-section $b=0.085$ m and $h=0.050$ m was chosen. The value of the elasticity module was tested according to Fig. 2 a and the calculation from the expression for the deflection of the girder on two supports when the force is acting on the centre:

$$w_{max} = \frac{Q \cdot L^3}{48 \cdot EI} \quad [\text{m}] \quad (1)$$

where: Q - force [kN], L - girder length [m], E - girder elasticity module [kN/m²], I - inertia moment $I = (b \cdot h^3) / 12$ for the rectangular section. Calculated value of the steel girder elasticity module used in the calculation of the bending moment is $E = 1.85 \times 10^8$ kN/m².

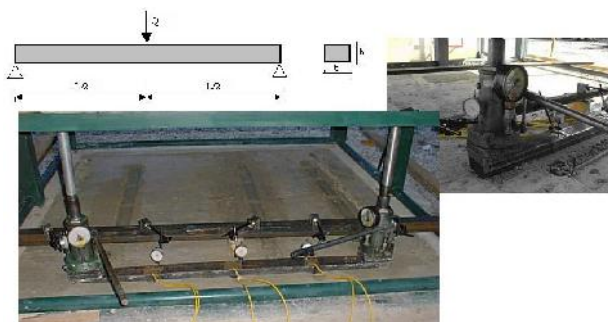


Figure 2. Primary girder: a) testing the girder on two supports with concentrated force, b) girder load detail, c) detail of girder being tested

Concrete blocks were used as counter-support for presses. Forces were applied to edges of girders (see 2b and 2c). Hydraulic presses with measurement area up to 60 kN and exactness of 5 kN were used. Force was applied in increments of 5 kN up to 35 kN.

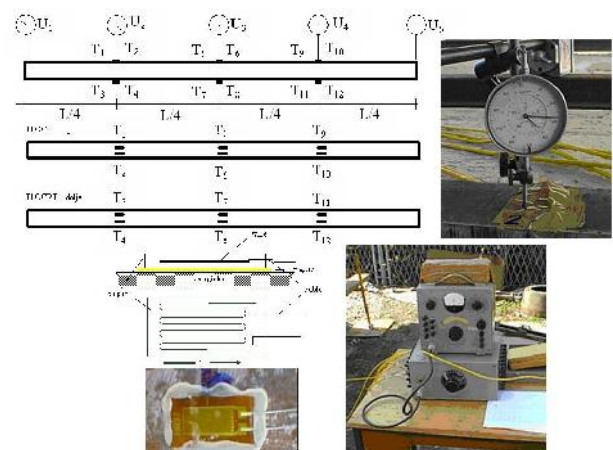


Fig. 3. Monitoring girder settlement and distortions: a) diagram of setting up the micro-gauge and tensometer along the girder, b) micro-gauges on the girder, c) attached (glued) electrically resistant tensometer on the girder, d) The Wheatston bridge

Micro-gauges for measuring settling were set-up on five points along the girder, as shown on Fig. 3a. Electrically resistant tensometers for measuring longitudinal deformities on the girder (manufacturer's code: 1-LY13-10/120), having a measuring base of 10 mm and resistance 120 Ω

(HBM, 1999, 1), were glued in three profiles x four tensometers (more tensometers = more reliable measurement of deformity in that point) along the girder ($L/4$, $L/2$ and $3/4L$). The Wheatstone bridge was used for measuring the change in resistance of the measuring tensometer (Fig. 3d)

Measuring electrically resistant tensometers, we achieved elastic relative distortion ε_{el} , and knowing the elasticity module of the steel girder E allows us to calculate the strain of fibers at the edges of the girder σ , and knowing the resistance of the cross-section of the girder W allows the calculation of the bending moment M .

Since the elasticity module of the steel girder is known ($E = 1.85 \times 10^8 \text{ kN/m}^2$), we can also calculate loaded girder stress using the following expression:

$$\sigma = E \cdot \varepsilon_{el} \quad (2)$$

After girder stress is calculated, and knowing the dimensions of the girder cross-section, we can calculate the bending moments. According to the theory of elasticity, the bending moment can be expressed as:

$$M = \sigma \cdot W \quad (3)$$

where W is the resistance moment of the girder cross-section $W = b \cdot h^2 / 6$, while σ is the stress on the edge strands of the girder.

Analysis of experimental test results

Soil profiles in model testing

Several girder tests with various soil profiles were performed on prepared bases; we will show you 3 characteristic variations - on Fig. 4a (Profiles A, B and C). The following is the overview of settling results and bending moments reached through experimental testing. The following experimental soil profiles were tested, see Fig. 4a: - Profile A is the linear change in thickness (10-30 cm) of the artificial soil layer - Profile B is the even thickness (40 cm) of the artificial soil layer - Profile C is the incremental change in thickness (20, 40, 60 cm) of the artificial soil

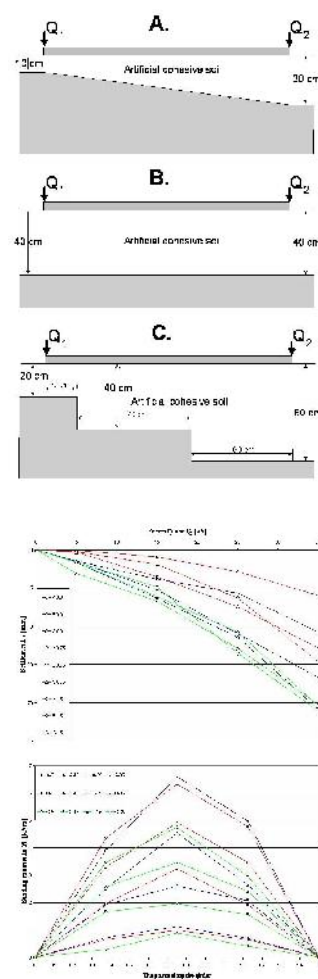


Figure 4. Measurement results: a) profiles A, B, C, profiles of bases beneath the girders, b) dependence of the forces on the girder and the settlement of the girder on soil profiles A, B and C, c) dependence of bending moments along the girder with various forces being applied on the girder using soil profiles A, B and C beneath the girder

Conclusion

When testing the soil of various thickness, the trend of increased settling with increased layer thickness was noticeable. Maximum bending moments with the same forces on the girder depend on the position of the layer beneath it, probably because certain breaks in the soil occurred. The differences in girder bending at higher loads on layer A with respect to layers B and C are possible due to various bearing capacities, which is tied to the relation of girder width and thickness of the layer along the girder. Results may be beneficial when calculating primary girders, specifically long primary girders, where the change in soil composition along the girder is common.

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Eksperimentalno testiranje grednih nosača na opće uslojenom tlu

SAŽETAK

Rad predstavlja model testiranja nosača i rezultate korištenja transversalno opterećenog fleksibilnog grednog nosača na adekvatno pripremljenom slojevitom tlu. Slijeganje i moment savijanja (relativna deformacija nosača) mjereni su duž nosača da bi se dobili rezultati. Postupak i rezultati testiranja su upoređivani i diskutovani.

Ključne riječi: temeljni nosač, opće uslojeno tlo, eksperiment, slijeganje, moment savijanja, komparacija.