Tuesday 3/14/2017

3–4:30 p.m.

Load Distribution on Buried Structures

Chairs: Fei Wang, Southeast University; Ryan Corey, RTE Technologies

The Effect of Soil Depth and Box Culvert Geometry on the Static Soil-Culvert Interaction

Osama Abuhajar, Tim Newson, and Hesham El Naggar, Western University

Soil arching is major factor that often controls the response of box culverts to static loads. The effect of relative stiffness between the culvert and the surrounding soil is critical in considering the complex soil-culvert interaction (SCI). In practice, box culverts can have different characteristic length scales in relation to vertical and horizontal soil stress changes. Therefore, the effect of box culvert size was investigated experimentally and numerically. In the present study, centrifuge tests were conducted to investigate the SCI considering the height of soil column and culvert geometry. The results were used to calibrate a numerical model to further investigate the response of the box culverts to static loads. The results have been evaluated for bending moment, soil pressure and soil culvert interaction factors. These results were then used to establish charts that may be employed to assess design values for box culverts.

Seismic Response of Shallow Buried Box Tunnels with Geofoam Side Cushions

Ozgur L. Ertugrul, Mersin University; Aurelian Trandafir, Fugro GeoConsulting Inc.

Seismic response of shallow buried box tunnels with geofoam side cushions was investigated through finite difference analyses with a numerical model that was validated against published experimental results from centrifuge tests. Analyses were carried out to investigate the effects of embedment depth, geofoam cushion properties and seismic excitation characteristics. Wall deformations as well as lateral dynamic earth pressures at various points on the embedded structures were monitored in the numerical analyses. Results were compared to those of a deformation based analytical approach. The study demonstrates that installation of EPS geofoam cushions may result in a reduction of the seismic earth force and sectional forces on the tunnel structure compared to the case of a structure without geofoam cushions. Structural rigidity of the embedded structure and embedment depth, as well as thickness ratio of the geofoam cushion, play an important role in the reduction of seismic earth forces and racking deformations.

Selection of Soil Stiffnesses for Load Rating of In-Service Culverts

S. Mehdi Mousavi, Priyantha W. Jayawickrama, Timothy Wood, and William D. Lawson, Texas Tech University

This paper presents findings from a critical review and an analytical study of soil stiffness values for the load rating of reinforced concrete box culverts. The responses of the soil-culvert system under dead and live loads were examined separately for a production-simplified, two-dimensional, linear elastic, soil-structure interaction model. First, soil-culvert systems were analyzed to determine dead-load-induced moments in the structure. The results were compared with moments obtained from an AASHTO policy-based structural-frame model and a calibrated value of static soil modulus, E = 10 ksi was selected as the optimum. A comprehensive literature review evaluated reasonable soil stiffnesses for live load analysis in culvert load rating. Typical resilient moduli of 12, 24 and 36 ksi for low, medium and high-quality culvert backfill soils were identified for live load predictions in the soil-structure interaction model.

Estimation of Coefficient of Lateral Stress Used in the Calculation of Loads on Buried Structures

Talia S. da Silva, Mohammed Z.E.B. Elshafie, and Gopal S.P. Madabhushi, University of Cambridge

The average vertical pressure on a buried structure can be calculated using the silo theory, which assumes the translation of a vertical prism of soil above the structure that is resisted by friction on the sides of the prism. One of the key assumptions made is the value of the coefficient of lateral stress, K. In this study, an assumption regarding the rotation of principal stresses in the yielding soil has been used to calculate the average coefficient of lateral stress acting at the side of a prism of yielding soil above the horizontal buried structure. The calculated value using the proposed method agrees well with experimental observation made in literature for the value of K, and is suggested for use in the estimation of loads on buried structures, where it is expected that the structure will yield relative to a stiff body of soil.

Modeling Factors Influencing Culvert Load Rating: A Parametric Analysis

Timothy Wood, Citadel; James G. Surles, S. Mehdi Mousavi, Priyantha Jayawickrama, Amir H. Javid, Hoyoung Seo, and William D. Lawson, Texas Tech University

This parametric analysis illustrates the relative influence of six parameters on reinforced concrete box culvert (RCBC) load rating using a production-simplified soil-structure interaction demand model. Frequently, field inspections show in-service RCBCs to perform adequately, but load rating per AASHTO guidance requires load posting. Parameters such as (1) the culvert design, (2) cover soil depth, and (3) soil stiffness are driven by the in-service culvert condition. The test matrix consists of three RCBC designs evaluated under three cover soil depths embedded in three soil stiffnesses. Load raters may implement less conservative, more accurate assumptions for (4) pavement stiffness, (5) effective moment of inertia, and (6) the top interior wall fixity, as appropriate. Cover soil depth and design showed significant impact on the culvert load rating, but are defined by the culvert condition. Less conservative assumptions for the effective moment of inertia had the greatest impact on the load rating, followed by the inclusion of pavement stiffness.

Full-Scale Burial Testing of Pipes and Storm Chambers

C. Joel Sprague and James Sprague, TRI/Environmental Inc.

A complex soil-structure interaction is involved when buried flexible plastic pipe or storm chamber systems are placed under load, and the stability of these buried systems must be demonstrated under “worst-case” live and/or dead load conditions. While it has become common place to demonstrate buried structure stability through analytical methods, including empirical equations or finite element modeling, full-scale burial tests have been recognized as necessary to, at least, calibrate these analytical methods. Two types of field tests have been used for this purpose: conventional excavation/backfill construction and compact burial chambers. This paper describes these full-scale burial testing facilities and procedures and how they have been used to develop deflection and strain data, along with a visual record, for use in correlating results of small-scale laboratory tests and calibrating design models. Included is an example of each type of field test – one evaluating storm chambers and another looking at corrugated pipe.