AHMED MAHGOUB
MASc (Civil Engineering), Cairo University, 2014

DEPARTMENT OF CIVIL AND RESOURCE ENGINEERING

TITLE OF THESIS:	INNOVATIVE APPLICATIONS OF TDA FOR BURIED PIPES AND CULVERTS
TIME/DATE:	11:00 am, Friday, September 20, 2019
PLACE:	Room 3107, The Mona Campbell Building, 1459 LeMarchant Street

EXAMINING COMMITTEE:

Dr. Nicholas Vlachopoulos, Department of Civil Engineering, Royal Military College of Canada (External Examiner)

Dr. John Newhook, Department of Civil and Resource Engineering, Dalhousie University (Reader)

Dr. Farid Taheri, Department of Mechanical Engineering, Dalhousie University (Reader)

Dr. Hany El Naggar, Department of Civil and Resource Engineering, Dalhousie University (Supervisor)

DEPARTMENTAL REPRESENTATIVE:	Dr. Fadi Oudah, Department of Civil and Resource Engineering, Dalhousie University
CHAIR:	Dr. Jeannette Janssen, PhD Defence Panel, Faculty of Graduate Studies

ABSTRACT

Social well being and economic prosperity are tied together in a mutually supportive and interdependent scheme. Achieving prosperity is highly related to the socio-economic well being and cannot be achieved without strong and supportive civil infrastructures. Soil-metal structures including buried bridges, culverts, and pipelines are key supporting pillars for the economic prosperity of developed communities.

In densely populated and congested urban centers, the interaction between surface structures and buried utilities are unavoidable. For instance, placing the pipe at a shallow depth attracts substantial additional earth pressures and loads causing overstressing and/or unacceptable deformations of the buried pipe. There are several alternatives that may be used to mitigate this situation. These alternatives include using induced trench construction, using lightweight fill material to reduce the imposed loads, and finally relocation of utilities which is the most expensive and less desirable alternative. The characteristics of the used backfill material control the pipe-soil interaction mechanism and sequentially the amount of exerted pressures. Using lightweight compressible materials above buried structures has long been investigated to reduce the stresses above buried pipes.

In this thesis innovative applications for using tire derived aggregates (TDA) as a lightweight backfill material to protect and improve the performance of buried structures under static and seismic loading conditions were investigated experimentally and numerically. Exploring useful uses for TDA (produced from recycled scrap tires) in civil engineering applications helps to reduce the environmental disasters that could be caused by disposing the tires in landfills which is becoming a scares resource by time. Full-scale field tests were carried to examine the feasibility of protecting pre-existing pipes, located underneath shallow foundations, by using TDA as an engineered stress-reduction fill above the pipes and underneath a concrete footing. Additionally, the study was extended to investigate the behaviour of rigid footings resting on a surface of conventional backfill materials overlying a TDA layer with different thicknesses. Furthermore, a comprehensive three-dimensional modelling exercise using the finite element (FE) code PLAXIS 3D was conducted to study the effect of changing various key parameters, i.e., the thickness of the TDA layer, the shape and configuration of the TDA cross-section, etc., on the performance of the system.

Another four full-scale tests were executed in the lab to investigate the feasibility of using TDA around corrugated steel culverts to enhance their performance under service loading. Afterward, 3D finite element models were developed of the different tested configurations to investigate crucial parameters affecting the culvert performance and to optimize the design of the proposed TDA system. In addition, a coupled TDA Geocell stress bridging system was developed utilizing three additional full-scale tests and a comprehensive 3D modelling component. The developed system uses a geocell reinforced top granular backfill layer over the TDA layer to induce a stress arching mechanism capable of reducing the imposed stresses on the underneath pipe and control the surface settlement.

Finally, the last part of this research focuses on evaluating the seismic design of open bottom large span metal arch culverts in the Canadian Highway Bridge Design Code (CHBDC) and developing an innovative system using TDA to mitigate the seismic hazards in high seismicity regions. Based on the results of the conducted study a set of recommendations for the analysis and design of buried structures were proposed.