Permeable Reactive Pavement for Controlling the Transport of Benzene, Toluene, Ethylbenzene, and Xylene (BTEX) Contaminants

Shengyi Huang (shengyi@smail.nchu.edu.tw) and Chenju Liang (cliang@nchu.edu.tw)
(National Chung Hsing University, Taichung, Taiwan)

Background/Objectives. Volatile organic compounds (VOCs) such as benzene, toluene, ethylbenzene, and xylenes (BTEX) are common pollutants from vehicle emissions detected in ambient air or precipitation. These hazardous substances from engine exhaust are called non-point source (NPS) pollution. NPS pollution is often more difficult to control than point source pollution. To take advantage of the pavement network where directly associated with NPS pollution from traffic, the asphalt pavement may be used as a media to control the NPS pollution. Therefore, the preparation of a permeable reactive pavement (PRP) (e.g., adsorptive) was initiated to explore the potential for reducing environmental BTEX pollution. The adsorbent (e.g., activated carbon [AC]) can be used as an additive ingredient when preparing porous pavement concrete (PAC), thereby enhancing the function of PAC by increasing its reactivity (i.e., PRP). The PRP could potentially adsorb the exhausted gas or particulates containing VOCs such as BTEX, and reduce contaminated water infiltration to the soil matrix. The objectives of this study were to (1) select a suitable activated carbon adsorbent as an additive aggregate for preparing PRP; (2) characterize the physicochemical properties of PRP with different amounts of AC additives, and confirm that the mechanical performance of PRP meets the regulated specifications of asphalt pavement; and (3) compare the adsorption capacity of PRP to conventional PAC using BTEX in aqueous phase as model contaminants to determine whether it is superior for controlling the fate and transport of environmental contaminants.

Approach/Activities. Laboratory-scale experiments were conducted under controlled conditions. In the 1st phase of this study, various adsorbents were screened for a suitable one to be an additive in the porous asphalt mixture. In the second phase, addition of the selected adsorbent was incorporated with the design of PAP to produce the PRP, which was subsequently tested for the potential of adsorbing aqueous BTEX as compared to the traditional porous pavement.

Results/Lessons Learned. Among various ACs evaluated, coconut shell AC (CSAC) demonstrated high surface area and thermal stability based on BET and TGA analytical results. Also, the results of both the analysis of adsorption kinetics thermal dynamics suggested CSAC as an additive for PRP preparation. The void space volumes of prepared PAC and PRP samples were approximately 20%, which met the specification for porous asphalt pavement. PRP08 and PRP16 samples (i.e., 0.8% and 1.6% wt. AC additions, respectively) met the physical performance specifications and exhibited higher loading strength (e.g., increases of 22-34% in Marshall stability; 12-20% in dynamic stability; 3-5% in retain strength; 13-24% in wet dynamic stability; 6-24% in indirect tensile strength), lower strain (decreases of 12-20% in Marshall flow; 12-7% in deformation rate; 12-19% in wet deformation rate) and higher permeability (increases of 57-93% in permeability.), as compared to conventional PAC. Additionally, the adsorption capacities of BTEX onto PRP08 and PRP16 increased by 33-46%, 36-51%, 20-22%, and 6-8%, respectively, as compared to PAC. These observations of physical performance and adsorption capability of PRPs demonstrated a great potential for PRPs being applied as a replacement of PAC for controlling the transport of NPS pollutants.