Development of Pervious Concrete Mix Designs and Specifications for Pavement Applications

Broad Areas

- Design and Development
- Habitation and Maintenance

Need for the Study in the Context of Future of Cities

In recent years, pervious concrete has become a popular strategy to mitigate a host of materials and environmental related issues such as storm water runoff, Urban Heat Island (UHI) effect, and tyre/pavement noise. Furthermore, pervious Portland cement concrete pavement type has been adjudged as an environmentally preferred alternative to conventional and impermeable pavement materials mainly since they provide night time minimum surface temperatures that are lower than impermeable pavement surfaces. Technically, pervious concrete is another type of concrete mix with a high porosity (30-40% by volume of the mix) prepared using large aggregates with little to no fine aggregates. Due to an increase in the impervious land cover mainly associated with urbanization, including roadways and the built-up environment, myriad consequences are bound to affect the local environment. Two major interactions have a predominating effect on the urban (impermeable) versus rural (permeable) setups: precipitation (rain) and solar radiation. In rural setup, the natural ground is permeable, which helps capture most of the rainfall, leaving insignificant amount as runoff. However, in the urban setup, a reverse trend is observed in that the impervious pavement surfaces and buildings do not allow rainfall to percolate leading to flooding and alteration in the hydrological cycle. Contemporaneously, the urban setup is also influenced by solar radiation very distinct from the rural systems. The built-up environment comprising of pavement and building materials are darker, denser, and dry unlike the rural vegetation which is green. This kind of a change results in a phenomenon called UHI effect, which is basically the imbalance in the surface energy flux between rural and urban areas that aids in the increase of night time near-surface air temperatures in urban areas in contrast to natural vegetation surrounding them. The UHI effect has been regarded as a global quality of life issue resulting in a significant impact on the overall energy, and human health. In the context of India as well, urbanization has created impervious surfaces using conventional pavements, and water logging in these areas have been causing drainage problems during rains and finally the failure of the pavement sections prior to their design lives. Past research studies have also indicated that pervious concrete mixes have provided enough structural support to withstand static loading and functional benefits such as reduction in the overall tyre/pavement noise affecting

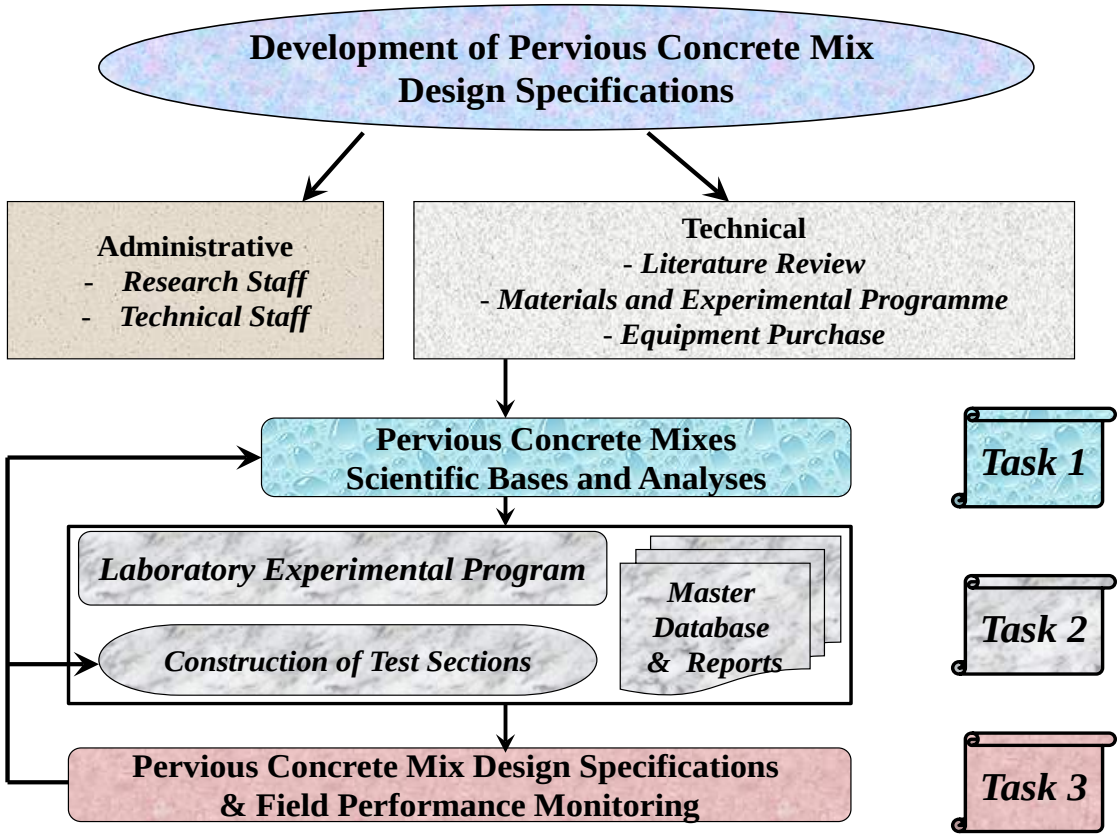
neighborhoods residing closer to the roadways (both low volume roads and local streets). Overall, there is an absolute need to use pervious concrete mixes in building greener roadway infrastructures and to reap the benefits of the materials in lowering the heat in the urban areas, enhancement in the pavement drainage capabilities through water replenishment, and reduction in the overall tyre/pavement noise; thus, targeting the many facets of the "quality of life" issues pertinent to "sustainable future cities".

Objective and Scope of Work

The major objective of the proposed study is to develop design specifications and standard practices of pervious concrete pavementsurfaces for use in different types of roads to alleviate night time surface temperatures, ameliorate drainage related problems, and investigate the effect of tyre/pavement noise damping characteristics. The scope of the effort includes:

- Review of the pervious concrete mix designs & standards currently being used worldwide
- Investigate mix design variants resulting in optimum job mix formula of pervious concrete
- Estimate material characterization (compressive & toughness) laboratory test parameters
- Obtain thermal properties such as thermal conductivity, specific heat capacity, and albedo
- Conduct permeability tests to investigate porous characteristics
- Perform acoustical tests to investigate noise damping characteristics
- Develop solar heat radiation, permeability and noise performance predictive models
- Design and formulate practices to provide heat retention basins and water recharge stations mainly to store heat and water, respectively, for future use
- Construct demonstration pilot test sections using pervious concrete mix designs in Kolkata, Kharagpur, and IIT campus to assess forthe field performance characteristics
- Study the economic feasibility and benefits of pervious concrete mix designs
- Organize workshops / short-term courses on pervious concrete pavement designs
- Recommend guidelines and best practices to incorporate pervious concrete mix designs
- Prepare draft standards of the pervious concrete mix designs for different classes of roads

Methodology



Outcomes/Deliverables

- Job mix formula design for optimum pervious concrete mix design with constituents: aggregate gradation, cement content, air voids (porosity), and modifiers
- Designs of heat retention basins and water recharge stations to be formulated as part of the pervious concrete pavement system
- Construction of pervious concrete demonstration pilot test sections in Kolkata, Kharagpur and IIT Kharagpur campus and long-term pavement performance monitoring
- Economic benefit indicators of pervious concrete mixes
- Workshops / short-term course on pervious concrete mix designs – annual / bi-annual
- Theses and dissertations, and articles in scholastic journals and international conferences

- Draft guidelines for the design of pervious concrete surfaces conforming to Standards

Team Composition

Principal Investigator	
Dr. Krishna Prapoorna Biligiri	Assistant Professor, Department of Civil Engineering, IIT Kharagpur
Co Investigators	
Dr. K. Sudhakar Reddy	Professor, Department of Civil Engineering, IIt Kharagpur
Dr. Swati Maitra	Scientist, Department of Civil Engineering, IIT Khargapur