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Reclaimed asphalt pavement (RAP): RAP is a removed/processed pavement material taken from the existing pavement after the completion of service life **(refer to Figure 3)**. The proper use of RAP materials provides greater economic and environmental benefits by reusing valuable non-renewable resources (aggregate and asphalt) and reducing the disposal and dumping of waste materials. Literature studies infer that the consumption of RAP up to 30% in the bituminous mixes led to a saving in cost up to 30% and a reduction in energy consumption and CO2 emission was observed to be around 16%.

Currently, the literature on the utilization of RAP in CGBM mainly focuses on micromechanical analysis. The possibility for the utilization of RAP material in the CGB mixes needed to be studied to understand the design, mechanical, and performance characteristics of CGB mixes containing RAP material. The current research work focuses on the design of porous asphalt mixture and the selection of suitable cementitious grouting material that provides full-depth penetration into the porous asphalt mixtures containing RAP material, mechanical properties, rutting, fatigue, moisture damage resistance, fuel, and abrasive resistance of CGBM containing RAP material. The outcome of the current study provides a detailed understanding of the performance characteristics of CGBM containing RAP and helps the industries and government bodies in moving forward with the construction of CGBM containing RAP material with higher confidence levels, which ultimately results in greater economic and environmental benefits.

(a) (b)

Figure 2 (a) Porous asphalt mixture containing 50% RAP material; (b) Cement grouted bituminous mixtures containing 50% RAP material

Figure-3: Milling of RAP material
(Source: dykespaving.com)

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The Future of Transportation: Revolutionizing Mobility through Vehicle Autonomy

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In today's transportation, smooth traffic flow and safer roads are the needs and desires of every individual. According to the World Health Organization (WHO), road crashes kill nearly 1.3 million people each year, and the majority of these crashes (around 90%) occur due to human errors. With the rapid advancements in the area of research in sensor devices, robotics, and intelligent transport systems, we can foresee autonomous vehicles (AV) taking over conventional, manually driven cars. Since these AVs are equipped with technology that helps them sense the road infrastructure and detect other vehicles around them with the least input from the human driver, they greatly reduce the cognitive burden and physical exhaustion of driving. AVs not only reduce human error but also contribute with other positives, such as allowing for work on-the-go, better fuel efficiency, improved road capacity, and mobility to the elderly and disabled. AVs are charaterized by varying levels of autonomy; the Society of Automotive Engineers (SAE) classifies AVs into levels 0 to 5. The Level-0 AVs are majorly limited to warning systems, with no significant control taken over by the vehicle itself.

Level-1 AVs integrate driving assistance systems that occasionally support the driver in lateral or longitudinal driving tasks. Level-2 AVs automatically provide multi-dimensional assistance. Level-3 AVs are empowered to autonomously handle acceleration, deceleration, and steering within specific environments. At Level-4, AVs operate autonomously under defined constraints, relieving the driver from driving duties unless a critical software malfunction occurs. Lastly, Level-5 entails complete AV autonomy across all environmental conditions, negating the need for driver intervention.

The Incorporation of AVs into the existing traffic environment comes with the need to overcome some prominent challenges.

The technological risks involved and the mandatory infrastructural requirement of AVs are among the major challenges to overcome (refer **to Figure 1**).

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Figure-1: Technological risks and mandatory infrastructure for AV inclusion in India

The technological risks that pose as major challenges to be addressed include safety testing, liability, insurance, privacy, cyber security, and industrial influence of AV inclusion on roads. Also, since the AVs require specially designed entities for their efficient functioning, the necessary infrastructural requirement for AV operation include specifically designed road infrastructure, digital communication systems, cloud storage facility, safe harbor area, service stations, and parking facilities.

Once we are able to resolve the various technological challenges and infrastructural demands that AV inclusion brings in, the next step ahead would be the safety testing of the AVs on simulated and real world like road conditions, before the AVs can actually be launched in real traffic. AV testing scenarios have been classified into 6 major categories which include a) Basic traffic manoeuvres, b) Navigation through varying road geometry, c) Interaction with surrounding vehicles, d) Interaction with vulnerable road user (VRU), e) Interaction with road signs and markings, and f) Crash prone/risky scenarios.

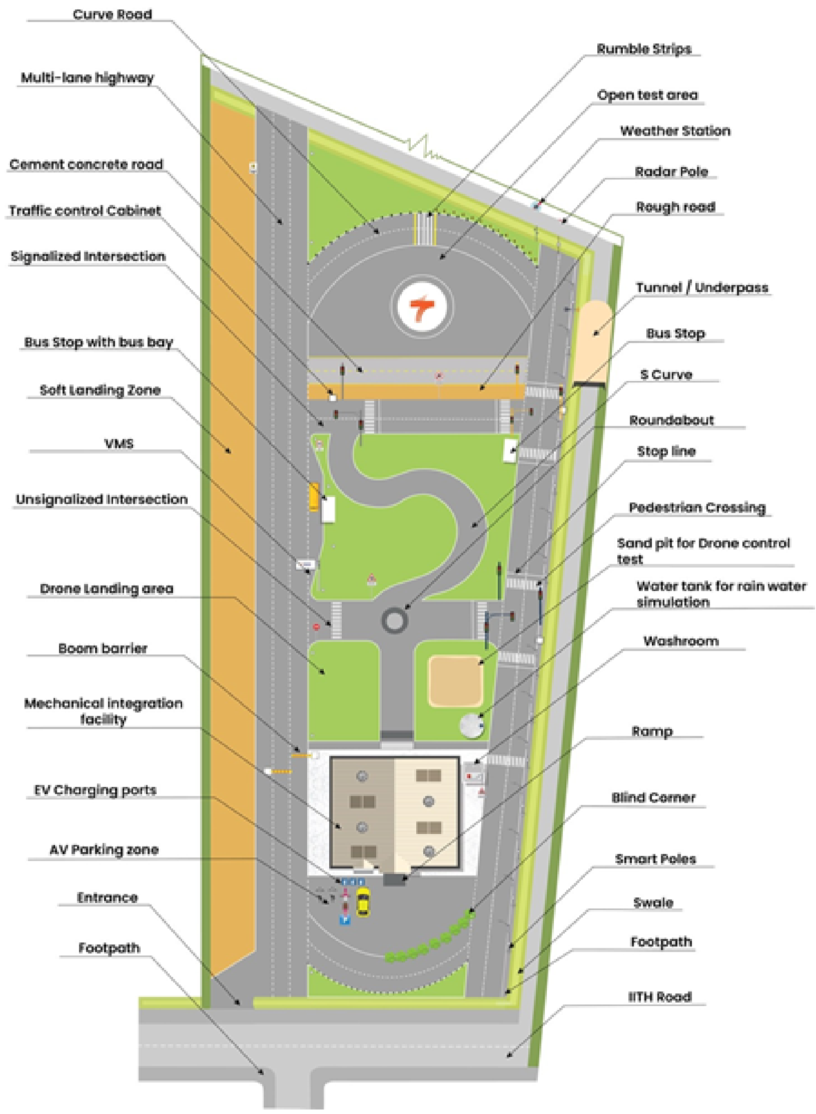

Figure-2: Plan of Connected Autonomous Vehicle Testbed at IITH

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Figure-3: AV testing procedure at CAV Testbed IITH

The TiHAN Connected Autonomous Vehicle (CAV) Testbed at the Indian Institute of Technology Hyderabad is one of its kind in India and can be effectively used for carrying out the designated safety test scenarios on AVs. **Figure 2 and 3**, illustrates the details of the CAV testbed facility at IITH. This CAV testbed facility is being effectively used by Researchers and development firms in India for conducting safety tests on AVs.

In July 2023, the Transportation Engineering Research Group at the Indian Institute of Technology Hyderabad (IITH), conducted a perception survey to gauge the public perceptions on the incorporation of AVs on public roads in India. The questionnaire was designed to capture the perception of the local public concerning the AV inclusion into mainstream traffic. The survey findings disclosed that 88% of the respondents believed that establishing a regulatory framework and guidelines for AV inclusion was necessary, before proceeding with AV testing on actual roadways. Furthermore, a clear inclination was observed towards intermediate autonomy levels in AVs (up to Level 3). In terms of the timeline, the responses indicated that the inclusion of AVs might extend until 2050, considering the existing conditions in India (refer **Figure 4**).

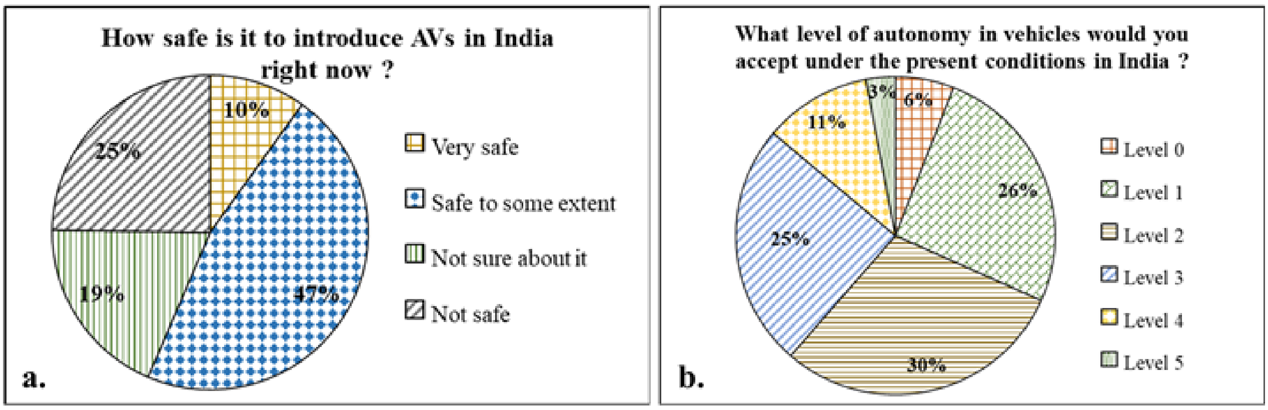

Figure-4: Perception of the public on a. Degree of safety of AV inclusion, b. Acceptable levels of autonomy in AVs

Conclusion:

The autonomy of vehicles holds great promise for the future but only with adequate preparation. With the AV industry seeing drastic advancements, our Transportation Research team at IITH is actively engaged in a collaborative effort to calibrate, improve, and safely induce AVs under Indian road conditions. **Currently, an AV shuttle facility has been deployed on IITH campus to help students reach the main gate from the main hostel blocks.** The ongoing research endeavors are dedicated to evaluating the efficacy of this deployed technology and understanding public perceptions on the adoption of AV technology.

AV Shuttle deployed on the IITH Campus

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