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Energy Generating Public Walkways

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***Abstract*— 'Walkable Cities,' although simple as a concept but have been a challenge that we have continued to fail on delivering to. India's population largely depends upon commuter rails and buses for making sure her workforce reaches work on time. For the ones who wish to walk to work, the infrastructure hardly exists. In places where it does, it is mostly encroached into, patchy and unsafe. Add to it the perils of harsh climate, piece meal planning of urban land, and poorly followed traffic rules, one of the most elementary forms of mobility seem like a distant and unsafe dream.**

Pedestrian zones are need of the hour. These zones however must offer a bit more than just being a public infrastructure. They need to have a distinct visual identity, utility that aligns with UN Sustainable Development Goals, ease of construction and scalability. These walkways will also have energy generating tiles which by virtue of pedestrian movement would power up their own lighting and even contribute back to the grid. Shading would be of built-in photo voltaic panels and some of these shade tops will double up as belts of urban farming with sit-out spaces. Careful planning and technological intervention could change the way we look at walkability in cities, add to its biodiversity, social landscape and generate energy as soon as someone steps on it.

***Index Terms*— Kinetic floor tiles, Piezoelectricity, Sustainability**

I. INTRODUCTION

India is a growing economy and home to 17.7% of global population, which is the most after China. Like every developing nation, India is largely dependent on its human resource for economic growth. Such a population needs mega public infrastructure for transportation, which is why India has the second largest road network in the world. This road network transports 64.5% of all goods in the country and *90% of India's total passenger traffic uses road network to commute*.

Roads in Indian metropolises are overcrowded with vehicles. In the hustle bustle of such a work culture where reaching to work on time seems to be a challenge even by fastest means of transport, the humblest way of travelling is forgotten [1].

It is rare to see walk-ways by the Indian roads. This discourages the people who wish to walk to work and compels them to opt for a private or public mode of transportation. The absence of walk-ways from Indian roads is due to many reasons; harsh climate, scarcity of urban land, dusty roads, improper implementation of traffic rules, poor infrastructure, illegal construction, piece meal urban planning, among others. All these factors contribute towards absence of useable walkways on Indian roads. But these factors also present an opportunity to think of lanes that respond to the Indian conditions and also act as points of interaction.

Roads in Indian metropolitan cities are jammed during rush hours and people have to drive at dangerously close distances. This is why with just 1% of the world's vehicles, India accounts for 11% of the global death in road accidents. This is the highest in world, according to a report by the World Bank. Yet not much is done to mitigate this issue [2].

One of the ways to scatter traffic and increase some breathing space on Indian roads is by creating more roads in the form of flyovers or bridges, which is the prevailing solution to traffic problems in India, and probably not the most sustainable way of addressing it.

Creating walkways and encouraging people to use them shall pull away some vehicles from the road and make them safer. This will not only decongest the roads but also ease the strain on fossil fuel consumption and pollution caused by their consumption. Two people shifting onto walkways is approximately one car less on the roads. However, for more people to make such a shift, these walkways need redefining to suit Indian conditions of climate and safety.

After the pandemic of COVID-19, people might be reluctant to use public transport as social distancing is greatly compromised in such systems making them an unsafe option to commute. This has engendered an opportunity of introducing walkways in Indian cities that respond to the native conditions, people and administration; an approach that is certainly better than replicating a system successful elsewhere.

II. Concerns With Walkways On Indian Roads?

A. Indian Climate

Climatically India is a tropical country. The sun is harsh for most part of the year in most parts of the country. Also, there is air pollution in the form of particulate matter or dust which causes compromised visibility and discomfort in breathing. This dust when mixed with precipitated water makes the roads marshy, slippery and dangerous [3].

If we want to encourage people to use walkways and quit motor vehicles, *ensuring their protection from elements of nature is of paramount importance*.

One way of protecting the walkways is by shading them. The traditional approach towards this will be to plant trees and counting on their foliage to provide shade. That will also help

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enhance the bio-diversity in the city. While there are benefits to shading a walkway with trees, there are some challenges and threats too. The branches from the trees would usually fall off without any warning; naturally or due to extreme weather conditions and can cause accidents and tripping hazard. Alternatively, to prevent such hazards, resources to trim and maintain trees should be invested into by the city[4],[5].

B. Road Traffic

The congestion on Indian metropolitan roads is worrisome. India's road networks have grown by around 30% over the past decade, whereas vehicle registrations have risen by almost three times. Driving on such congested roads is dangerous. These roads become deadlier as most of the population in the country travels on two wheelers without using appropriate safety gear [6],[7]. Also, economically weaker sections ride bicycles on these roads or even walk to work in such dangerous conditions. Putting vehicle users, pedestrians and cyclists together with all of them aiming to reach their destination on time causes chaos and unwanted exertion.

Fig. 1. Typical traffic jam in an Indian metropolis

III. How To Address These Concerns?

A. Indian Climate

Instead of shading these walkways from trees, which also takes years to come to its foliage, industrial products like steel floor decking plates could be used. Steel floor decking plates are profiled sheets that have ribbed pattern for greater strength. Using of this roof would create two levels; a road level for pedestrians and a top level for both, pedestrian movement, cafes and sit-outs. To mitigate the issue of rapidly heating floor plates, the roof over walkways could be covered by vegetation which in turn would provide insulation. Built in photovoltaics (BIPV) can also replace the vegetation and would generate power to light these walkways up towards evenings. Having large patches of such built in photovoltaic panels could also help local bodies to generate revenue by selling electricity produced back to the power grid, renting out spaces for urban farming hence encouraging setting up of more such infrastructure.

Fig. 2. Proposed walkway design with PV panels on top.

To generate additional revenue, roof top spaces could be rented out to vendors, newspaper agents, cafeteria operators, street performers and more. All these in turn would make these roof top spaces of social interaction. Activity atop the roofs would also prevent them from falling into state of disrepair and disuse [8].

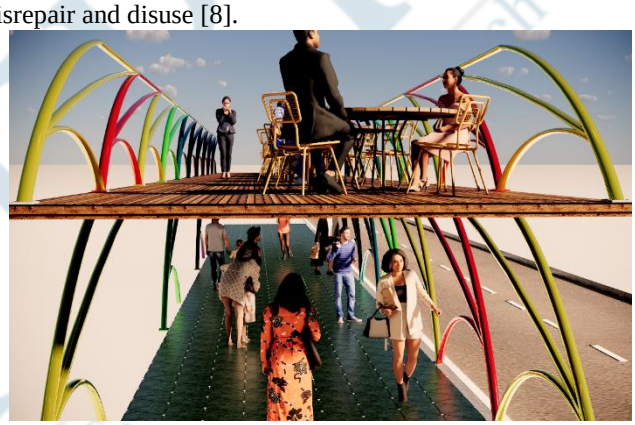

Fig. 3. Proposed walkway design with café seating on top.

B. Human Vehicle Conflict

While preparing town plans and road schemes, provision for such walkways can be earmarked. This could replace existing pavements and be a new build where pavements are non-existent. Making cities walkable also aligns with the 'Smart City program'.

These walkways could prevent human-vehicle conflict making their use much safer than current systems. For protection on upper levels, railings and street furniture can be added. Vegetation atop them can add to physical edge of the walkways making them easily identifiable as a part of public infrastructure. On lower levels, a height difference from road or Armco barrier can physically separate it and make its use safer.

IV. Energy Generation

The proposed design aims to make energy generating walkways, plausible energy belts that would generate energy every time someone steps on them. To do so kinetic floor tiles need to be installed. These tiles function on the principle of Piezoelectricity. Electric energy generated so can be stored, used or reverse metered to the power grid. They could also be used as charging points for electric vehicles (EVs).

After the economies of scale are matched, these tiles would

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prove as a better replacement for existing cement tiles. Once the tiles have paid their cost back to the city, they will generate significant amount of revenue with minimum carbon footprint. These tiles can produce 2 to 4 joules, or around 5 watts of power of off-grid electrical energy per step.
Installation of canopy as discussed above, over these kinetic tiled walkways would complement each other by providing a safe, social, sustainable infrastructure to users and the city.
Having vegetation atop the roof would unleash an opportunity to use this space as a public realm where urban farmers, vendors, cafeteria could generate revenue and footfall would make it a space for social interaction. Further, these rooftops could also act as seating or waiting areas to road side vendors, clearing the space that their customers would occupy on road otherwise. Renting of such rooftop spaces could add to revenue to the city, adding up to its case of business model.

V. Challenges

Cost model and monetary dynamics are the biggest challenge in any new infrastructure project and it can be expected for this proposal as well.
Kinetic floor tiles are a recent technology and hence they are expensive. Approximate cost of such tiles in the year 2020 was ₹8000/- per square foot. This translates to approximately 109 U.S. dollars. Also, these tiles need improvement in terms of durability so that they prove to be feasible and do not need frequent replacements. Currently, the life span of such tiles is considered to be five years.
Rampant vandalism in urban areas could also pose a threat to any new system. There have been examples of damage to and theft of public property in various instances. Being a unique product; these tiles may be at risk of freeloaders damaging them for selling in the grey market.
Apart from physical challenges, this system also might take time to get culturally accepted as this proposes a public realm that does not have great width, not as much as in existing public realms like gardens, but successful in many walkability promoting countries.

VI. Way Forward

An integration of kinetic tiles with Built in photovoltaics (BIPV), landscape elements, urban farming and street vendors might seem challenging, but has its merits. Local bodies (city) should look at it as a long-term investment with low to nil operational expense. To add to the economic benefits this system can generate multiple streams of revenue. This in turn, would not only make the proposition profitable but would also align it with multiple Sustainable Development Goals (SDGs) as identified by the United Nations (UN) and India's 'Smart cities' mission.

Fig. 4. Proposed walkway design view from roadside.

VII. Conclusion

India is undergoing transformation at a rapid rate with respect to building new cities and infrastructure. Walkability however often stays over looked. Inclusion of walking infrastructure within our cities that is safer and sustainable could change the paradigm of urban transportation as we know it. Amidst rising fuel prices and loss of health due to sedentary lifestyle, such walking infrastructure could be the right step towards setting an example globally.

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