INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: **Modelling of Pedestrian Walking Behaviour over Elevated Walkways**

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SHORT ABSTRACT

In a developing nation like India, where majority of the people walk approximately 1-2km per day, it is essential to construct well connected pedestrian facilities. However, pedestrian facilities, especially elevated walkways are neglected and poorly maintained. This discourages the pedestrians from using the elevated facilities and thus come in direct contact with vehicular traffic. Providing a safe, secure and comfortable walking experience over elevated walkways, could encourage pedestrians to avoid risky at-grade facilities and shift to a safer pedestrian elevated facilities. In the current study an attempt was made to understand the pedestrian movement behaviour characteristics over mid-block and vertical connectivity (stairway) sections of elevated walkways (FOBs: foot over bridges and skywalks).

To conduct the study, both videographic and questionnaire data were collected over seventeen FOB and seven skywalk locations across six different Indian cities. The extracted data was used for preliminary analysis related to demographic characteristics of pedestrians over mid-block and stairway sections of FOBs and skywalks. The young adult (21-40 years) male pedestrians were found to be the dominant users' across all locations. The percentage of mobile users varied between 8-15% (over mid-block sections) and 7-9% (over stairways sections). The pedestrians walking in groups of 3 or more pedestrians was observed to be more frequent across mid-block sections under moderate to heavy flow conditions.

For an overall estimate of the pedestrian flow characteristics (free flow speed, jam density, maximum flow rate, and flow rate) the fundamental diagrams were developed for both the mid-block and stairway sections of both the facilities. In case of both mid-block sections and stairway sections, a higher maximum flow rate was observed in case of skywalk facilities.

Subsequently, different walking behaviour models were developed using linear regression model based on individual (age, gender, luggage carrying conditions, mobile use and disability) and group (group size, lane formation, leader-

follower relationship, lane shifting, overtaking, squeezing effect and faster-is-slower effect) behavioural characteristics to study the impact of these factors on the walking speed over mid-block and stairways sections. The mean absolute percentage error (MAPE) and root mean square error (RMSE) evaluation metrics showed that all the developed models performed well.

Further, walking speed prediction models of pedestrians over elevated walkways were developed using different tree-based machine learning algorithms (Gradient Boosting Regressor, Light GBM Regressor, XGBoost, Adaboost, Random Forest, Extra Tree Regressor and Decision Tree) based on different pedestrian flow characteristics (individual and group) along with geometric parameters. The mean absolute error (MAE) was found to be less than 10% in case of both FOB and skywalk walking behaviour predictions.

To identify the most significant parameters affecting the preference of pedestrians towards using elevated walkways under the current existing conditions, stepwise binary logistic regression modelling approach and machine learning tools (GLM: Generalized Linear Model, RF: Random Forest and GBM: Gradient Boosting Machines) were used on the perception data.

Recently developed Indo-HCM (2018) provides guidelines for quantitative LOS across different FOB facilities. However, for skywalk facilities no such LOS standards are available. Using the quantitative and qualitative data, level of service (LOS) standards were developed in this study for skywalk and FOB locations across different cities.

This study also attempted to develop a global simulation model which can replicate walking behaviour over elevated walkways using commercially available software (PTV Viswalk). Sensitivity analysis was carried out to identify the most significant parameters which affect the walking behaviour and thereby calibration using genetic algorithm was carried out through COM interface in MATLAB. The model was validated using remaining 20% data set. The MAPE was found to be less than 20% across different locations.

A semi-manual technique for data extraction was also developed for extracting pedestrian position (subsequently speed and trajectory) data using front inclined camera angle as many times top-down angle is unavailable due to height restrictions (especially over elevated walkways). Vanishing point method was used to extract data for pedestrian body dimensions across vertical and pedestrian-specific trajectory planes. Using the trajectory and body dimension information, the spacing maintained between pedestrians were estimated. Subsequently, JUPedSim software was used for extracting the fundamental macroscopic properties (speed, flow and density) from the pedestrian position data, and the results were compared using classical and voronoi approaches.

The major outcomes of the study can be beneficial in different ways:

i. The capacity of elevated walkways (both for mid-block sections as well as stairway sections) can be estimated using the developed fundamental diagrams.

ii. In order to understand the walking behaviour of pedestrians over elevated walkways, the identification of individual and group behaviour characteristics would be extremely beneficial. Moreover, such behaviour can be incorporated into microscopic simulation models.

iii. The prediction of walking speeds would be beneficial to designers and planners in understanding the significant variables affecting the walking speed and thus constructing better elevated walkways.

iv. The perception usability models would be extremely helpful to understand the qualitative factors impacting the pedestrians' preference towards using the elevated walkways.

v. To estimate and understand the existing Level of Service (LOS) over elevated walkways, the developed LOS standards would be quite beneficial.

vi. Researchers who plan to study microscopic behaviour over elevated walkways using Viswalk software, can utilize the global simulated model and the estimated calibrated parameters for studying the microscopic behaviour of pedestrians.

vii. The developed semi-manual technique can be helpful in studying pedestrian gap maintaining behaviour and also establishment of different threshold levels for the crowd management where data collection using top down video is not possible and only frontal camera angle view is available. Such approach can be directly applied to CCTV footage (which mostly gives front inclined views of camera) to ensure the physical distancing in the current ongoing pandemic (COVID-19).