EVALUATING STATION FACILITIES THROUGH SIMULATION

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Presentation Overview

- Background
- Literature review
- Data collection
- Base Model development & Output
- Scenario development
- Findings and recommendations
BACKGROUND

Introduction
Research Objective
Scope & Limitations
Research Methodology
Introduction

- Rail based transit system are one of most Efficient and Economic, offers Shorter Travel Time and expected to enhance PT share.
- Attempts are to build passenger friendly stations
- Density, Walking Distance and Transfer Time as performance assessment tool
- Assessment through Manual Method and Simulation
- Simulation represents Effective Visualization and Detailed Analysis

Research Objectives

- Develop a methodology to assess transit station capacity using microsimulation model
- To demonstrate physical constraints of Maninagar railway station
Scope & Limitations

- The model created in PTV VISSIM is applicable to Maninagar railway station only. It is created for the paid areas of station only.

- It is not possible to visualise passengers travelling with luggage and with family or group with exact composition.

- The passengers waiting at station by occupying seating arrangements are not possible to visualise.

- The passengers in waiting area tend to move if and when congestion increases however the same is not true in the model.

- There are certain loop holes in infrastructure that can’t be incorporated in model.
Research Methodology

- Introduction
- Aim and Objective
- Scope and Limitation
- Literature study
- LOS identification
- Evaluation standards
- Case study
- Data needed
- Process
- Data collection
- Survey methodology
- Base model development
- Model calibration
- Scenario development
- Analysis
- Conclusion and recommendation

Evaluating Station Facilities through Simulation
LITERATURE REVIEW

Introduction to performance assessment
Summary of case study
Introduction to Performance Assessment

- A qualitative measure, **Level of Service** is generally used for the performance assessment.
- Density criteria by John J. Fruin in 1971

<table>
<thead>
<tr>
<th>LOS</th>
<th>Walkway ($P_{walk}$)</th>
<th>Queuing area/Platforms ($P_{queue}$)</th>
<th>Stairway ($P_{stair}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOS A</td>
<td>&lt;0.27</td>
<td>&lt;0.85</td>
<td>&lt;0.52</td>
</tr>
<tr>
<td>LOS B</td>
<td>0.27 to 0.43</td>
<td>0.85 to 1.11</td>
<td>0.52 to 0.71</td>
</tr>
<tr>
<td>LOS C</td>
<td>0.43 to 0.71</td>
<td>1.11 to 1.58</td>
<td>0.71 to 1.11</td>
</tr>
<tr>
<td>LOS D</td>
<td>0.71 to 1.07</td>
<td>1.58 to 3.70</td>
<td>1.11 to 1.42</td>
</tr>
<tr>
<td>LOS E</td>
<td>1.07 to 2.17</td>
<td>3.70 to 5.55</td>
<td>1.42 to 2.5</td>
</tr>
<tr>
<td>LOS F</td>
<td>&gt;2.17</td>
<td>&gt;5.55</td>
<td>&gt;2.5</td>
</tr>
</tbody>
</table>

Source: Pedestrian Planning and Design, J.J. Fruin, 1971

- The same criteria has been adopted by **HCM, TCQSM**.
- The Manual for standards and specifications for railway station by **Ministry of Railways, India** also follows the same criteria.
- The Manual suggest that operational LOS should be **LOS C** for all the infrastructure.
Introduction to Performance Assessment

**LOS A**
Free circulation, Ability to move in desired path

**LOS B**
Free circulation, occasional need to adjust path

**LOS C**
Slightly restricted circulation, Frequent need to adjust path

**LOS D**
Circulation without touching is impossible, overpassing slower pedestrian is restricted

**LOS E**
Restricted circulation for all pedestrians, Limited ability pass slower pedestrian

**LOS F**
Complete breakdown in circulation, Can’t pass slower pedestrian

Source: Author
Summary of case study

- Metrotown station, Burnaby
- Data needed for the study such as station layout, train schedule, passenger volume, speed has been identified
- Methodology has been finalised
DATA COLLECTION

Why Maninagar?
Introduction to Maninagar railway station
Data collection methodology
Observation from data collection
Why Maninagar?

- Train frequency from Ahmedabad railway station towards South direction is higher compared to North direction.
- Well connected by local service.
- Due to these characteristics, Maninagar Railway station has higher passenger load than Sabarmati Railway station.
Introduction to Maninagar railway station

PF 2 (Towards Mumbai)

PF 1 (Towards Ahmedabad)

AMTS Terminal

BRTS

AMTS
Data Collection Methodology

Data collection

Secondary data
- Station layout

Train schedule

Primary data

Defining peak period

Passenger count
- Classified In and out count at entrances and FOB

Speed survey
- Speed of pedestrian with respect to age, gender, Group, Luggage
Data Collection Methodology

Defining Peak

- 2 Local and 2 Express trains
- 3 Local and 3 Express trains

Daily trains

Time

00:00:00 01:00:00 02:00:00 03:00:00 04:00:00 05:00:00 06:00:00 07:00:00 08:00:00 09:00:00 10:00:00 11:00:00 12:00:00 13:00:00 14:00:00 15:00:00 16:00:00 17:00:00 18:00:00 19:00:00 20:00:00 21:00:00 22:00:00 23:00:00

Trains

0 1 2 3 4

Evaluating Station Facilities through Simulation
Data Collection Methodology

Speed Survey

- Speed varies with,
  - Group behaviour,
  - Luggage characteristics
  - Gender
  - Age

Videographic Survey Locations

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PF 2

PF 1
### Observation from survey

<table>
<thead>
<tr>
<th>Train Name</th>
<th>Platform number</th>
<th>Type of train</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surat Jamnagar Intercity Express Train</td>
<td>1</td>
<td>Express</td>
<td>Train is not schedule to stop but due to some reason stopped during survey period</td>
</tr>
<tr>
<td>Gujarat Queen Express</td>
<td>2</td>
<td>Express</td>
<td>This is special train which is scheduled to arrive at 5:20 p.m. but due to some reason it delayed and arrived during survey period.</td>
</tr>
<tr>
<td>Gorakhpur–Okha Express</td>
<td>1</td>
<td>Express</td>
<td>Train is not schedule to stop but due to some reason stopped during survey period</td>
</tr>
<tr>
<td>Ahmedabad Memu</td>
<td>1</td>
<td>Local</td>
<td></td>
</tr>
<tr>
<td>Navjivan Express</td>
<td>1</td>
<td>Express</td>
<td></td>
</tr>
<tr>
<td>Saurashtra Express</td>
<td>1</td>
<td>Express</td>
<td></td>
</tr>
<tr>
<td>Garibrath</td>
<td>1</td>
<td>Express</td>
<td></td>
</tr>
<tr>
<td>Anand Memu</td>
<td>2</td>
<td>Local</td>
<td></td>
</tr>
<tr>
<td>Gandhinagar Memu</td>
<td>1</td>
<td>Local</td>
<td></td>
</tr>
</tbody>
</table>
Observation from survey

Total passenger volume is 5483. Higher alighting volume than boarding volume.
Observation from survey

Gate 2 is predominant entry-exit point. The passengers are daily commuters.
BASE MODEL DEVELOPMENT AND OUTPUT

Introduction to Vissim
Methodology for Model Development
Model Calibration
Model Validation
Output
Introduction to Vissim

- The model has been developed using microsimulation tool **PTV Vissim**.
- Pedestrian behaviour is based on **Social Force Model** by Helbing and Molnar.
- The model considers pedestrian motion is subjected to forces and due to this forces, pedestrian move in certain direction.

$$\mathbf{F} = F_{\text{driving}} + F_{\text{Social}} + F_{\text{Obstacles}} + F_{\text{noise}}$$

Source: [http://futurict.blogspot.in/2014/12/social-forces-revealing-causes-of.html](http://futurict.blogspot.in/2014/12/social-forces-revealing-causes-of.html)
Methodology for Model Development

- Station layout
- Modelling PT infrastructure
- Passenger O-D and composition
- Modelling boarding passenger volume
- Train schedule
- Modelling alighting passenger volume
- Static potential, dynamic potential and partial routes
- Passenger routing decision
- Behavior parameters, GEH Statistics, Speed, Screen line check
- Calibration and validation
Model Calibration

- The calibration is a process by which one tries to **fit the accuracy of the model with existing situation**.

- Model calibrated by adjusting **behaviour parameters**.

- These parameters govern passengers characteristics such as reaction time, distance from obstacles and passengers, strength between passengers, directions, evading distance and random force.

- There is no study available for relationship between change in parameter value and change in behaviour.
## Model Calibration

<table>
<thead>
<tr>
<th>Walking behaviour parameter</th>
<th>Explanation</th>
<th>Change</th>
<th>Effect</th>
<th>Default value</th>
<th>Adjusted value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tau (τ)</td>
<td>Tau can be interpreted as reaction time which can be related to inertia or relaxation time. It relates the difference between desired speed and desired direction with current speed and direction. It can be consider as the driving force.</td>
<td>Increase</td>
<td>Increases pedestrian acceleration, decrease density at the bottleneck, increases radius near objects</td>
<td>0.4</td>
<td>0.6</td>
</tr>
<tr>
<td>React to n</td>
<td>Related to social force considered for the pedestrian movement. It determines the maximum number of pedestrians to be consider during calculation of social force</td>
<td>Decrease</td>
<td>It makes pedestrians more jitter and increase density at the bottleneck, leads to formation of the group</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Lambda mean (λ)</td>
<td>It considers the event and pedestrians behind a pedestrian do not affect the movement of pedestrian</td>
<td>Increase</td>
<td>Counter flow more efficient, flow through bottleneck depending on the size of jam, makes pedestrian push more</td>
<td>0.176</td>
<td>0.35</td>
</tr>
</tbody>
</table>
## Model Calibration

<table>
<thead>
<tr>
<th>Walking behaviour parameter</th>
<th>Explanation</th>
<th>Change</th>
<th>Effect</th>
<th>Default value</th>
<th>Adjusted value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A social Isotropic, A social Mean, B social Isotropic, B Social Mean</td>
<td>Governs the direction dependency force between two pedestrians</td>
<td>INCREASE</td>
<td>Counter flow is handled very smoothly, Lower density at the bottleneck, higher headway between passengers</td>
<td>2.720, 0.20, 0.4, 2.8</td>
<td>3.5, 0.3, 0.45, 3</td>
</tr>
<tr>
<td>VD</td>
<td>Decides when to evade opposite pedestrian</td>
<td>Increase</td>
<td>Increase distance for evade</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Noise</td>
<td>Parameter governs the random force</td>
<td>Increase</td>
<td>Prevents deadlocks</td>
<td>1.2</td>
<td>1.5</td>
</tr>
<tr>
<td>Grid size</td>
<td>The distance at which pedestrians have an effect on each other</td>
<td>Decrease</td>
<td>Reduce the maximum distance of the influence</td>
<td>0.5 m</td>
<td>0.5 m</td>
</tr>
</tbody>
</table>
Model Validation

- Validation is the process by which one **checks the accuracy of the model**.
- Model was validated by following parameters:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Satisfying Criteria</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEH Statistic</td>
<td>&lt;5</td>
<td>2.9 (Max)</td>
</tr>
<tr>
<td>Speed</td>
<td>&lt;15%</td>
<td>11% (Max)</td>
</tr>
<tr>
<td>Screen line accuracy</td>
<td>&lt;5%</td>
<td>1% (Max)</td>
</tr>
</tbody>
</table>

**Source:** Traffic Modelling Guidelines, Transport for London, 2010

- GEH statistic is generally used to check the goodness to fit of the model

\[
GEH = \sqrt{\frac{2(K-M)^2}{(K+M)}}
\]

Where K is observed flow
M is modelled flow

- GEH should be **less than 5 for more than 85%** cases of total run
Model Validation

GEH Statistics

GEH is less than 5 for all cases, hence model is accurate.
Model Validation

Speed by category

Average speed

Maximum variation is 10%
Model Validation

Speed by Characteristics

Maximum difference is 11%
Model Validation

Screen Line Accuracy

Model is 99% accurate for total screen line flow
Model Output

LOS on Platform

Average density

Density (Pax/m²)

Simulation seconds

0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

0 300 600 900 1200 1500 1800 2100 2400 2700 3000 3300 3600 3900 4200 4500 4800 5100 5400 5700 6000 6300 6600 6900 7200 7500 7800 8100 8400

Trains on PF1
Platform 1
Platform 2
Trains on PF2
Model Output

LOS on FOB

Average density on FOB

- LOS A
- LOS B
- LOS C
- LOS D

Simulation seconds:
- Density (ped/m²)
- Trains on PF1
- Average density
- Trains on PF2

Maximum LOS B for 3 minutes

Density (ped/m²)

0 0.2 0.4 0.6 0.8 1 1.2 1.4

Simulation seconds

300 600 900 1200 1500 1800 2100 2400 2700 3000 3300 3600 3900 4200 4500 4800 5100 5400 5700 6000 6300 6600 6900 7200 7500 7800 8100 8400

Trains on PF1  Average density  Trains on PF2
Evaluating Station Facilities through Simulation

Model Output

LOS on sections near gates

Average density near gates

Density (Pax/m²)

Simulation seconds

Trains on PF1
Gate 1
Gate 2
Gate 3
Trains on PF2

LOS A
LOS B
Model Output

Sections
Model Output

Sections

LOS A  LOS B
Summary

- Platforms operates at level of service A
- Foot over bridge operates at Level of Service B
- All the sections operates at LOS A

- Thus infrastructure is underutilised.
SCENARIO DEVELOPMENT

Ministry of Railways, India
Volume increased by 50%
Volume increased by 100%
Scenario Development

Scenario Development to check capacity

As per Manual for standards and specifications for station design by Ministry of Railways, India

50% increase in volume

100% increase in volume

Identifying Bottlenecks to check capacity
As per Ministry of Railways, India

Average Density on platforms

Average Density on FOB

Evaluating Station Facilities through Simulation
As per Ministry of Railways, India

LOS on section near gates

Maximum LOS D faced by 1% passengers

Average density near gates

Density (Pax/m²)

Simulation seconds

0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8
300 600 900 1200 1500 1800 2100 2400 2700 3000 3300 3600 3900 4200 4500 4800 5100 5400 5700 6000 6300 6600 6900 7200 7500 7800 8100 8400

Trains on PF1
Gate 1
Gate 2
Gate 3
Trains on PF2

LOS A
LOS B
LOS C
LOS D
As per Ministry of Railways, India

LOS on various section

% Passenger under LOS

LOS A  LOS B  LOS C  LOS D  LOS E  LOS F

Bottlenecks

LOS D faced by 1% passengers only...
Volume increased by 50%

LOS on platforms

Average density

Density (Pax/m²) vs Simulation seconds

- LOS A
- LOS B

Trains on PF1
Trains on PF2
Platform 1
Platform 2

LOS on FOB

Density (Pax/m²) vs Simulation seconds

- FOB
- LOS A
- LOS B
- LOS C
- LOS D

Maximum LOS D faced by 1% passengers

Trains on PF1
Average Density
Trains on PF2
Volume increased by 50%

LOS on section near gates

Average density near gates

Simulation seconds vs. Density (Pax/m²)

- LOS A
- LOS B
- LOS C
- LOS D

Density after Volume Increase:

- Gate 1
- Gate 2
- Gate 3

Train movements on PF1 and PF2
Volume increased by 50%

LOS on various section

% Passenger under LOS

LOS D faced by 1% passengers only..

Bottlenecks
Volume increased by 100%

LOS on platforms

Average density

Simulation seconds

Density (Pax/m²)

Trains on PF1  Platform 1  Platform 2  Trains on PF2

LOS A  LOS B

LOS on FOB

Average density

Simulation seconds

Density (Pax/m²)

Trains on PF1  Platform 1  Platform 2  Trains on PF2

LOS A  LOS B  LOS C  LOS D
Volume increased by 100%

LOS on section near gates

Maximum LOS D, when 2 trains arrives within 10 minutes time period
Volume increased by 100%

LOS on various section

% Passenger under LOS

21% passenger faces LOS D on section 31
FINDINGS & RECOMMENDATION

Findings
Recommendations
The worst case in all the scenario is when two train arrives on platform 1 within time period of 10 minutes.

<table>
<thead>
<tr>
<th>Scenario detail</th>
<th>Bottlenecks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base scenario</td>
<td>None</td>
</tr>
<tr>
<td>Scenario 1: Capacity check as per Ministry of Railways</td>
<td>Gate 2</td>
</tr>
<tr>
<td></td>
<td>Section besides FOB on PF 1</td>
</tr>
<tr>
<td>Scenario 2: Volume increased by 50%</td>
<td>Gate 2</td>
</tr>
<tr>
<td></td>
<td>FOB</td>
</tr>
<tr>
<td></td>
<td>Section beside FOB on PF1</td>
</tr>
<tr>
<td>Scenario 3: Volume increased by 100%</td>
<td>Gate 2</td>
</tr>
<tr>
<td></td>
<td>FOB</td>
</tr>
<tr>
<td></td>
<td>Section near FOB on PF1</td>
</tr>
<tr>
<td></td>
<td>Section beside FOB on PF 1</td>
</tr>
</tbody>
</table>
Recommendation

- As there is no issue of infrastructure in scenario 1, trains can be terminate at Maninagar railway station instead of Ahmedabad railway station.

- To improve Level of service at gate 2, it is recommended to provide alternative exit point.

- To improve level of service on FOB, it is recommended to increase width of FOB, to provide another FOB. Instead of steps, Escalators/lift can be tested for the level of service.

- The recommendation for increasing FOB width is considered as another scenario and analysis is carried out.

- By increasing width it is found that the level of service on the FOB has improved along with sections near FOB.
The scenario with increased width of FOB has been tested with volume increased by 100%.
Recommendation

% of Passengers on section near FOB on PF1

% of Passengers on section near FOB on PF2

LOS A  LOS B  LOS C  LOS D  LOS E  LOS F

Base scenario  Scenario 1  Scenario 2  Scenario 3  Recommendation scenario

LOS A  LOS B  LOS C  LOS D  LOS E  LOS F

Base scenario  Scenario 1  Scenario 2  Scenario 3  Recommendation scenario

Evaluating Station Facilities through Simulation
Thank you..
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