e-ISSN:2582-7219

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH IN SCIENCE, ENGINEERING AND TECHNOLOGY

Volume 6, Issue 7, July 2023

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 7.54

International Journal Of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.54||Monthly, Peer Reviewed & Referred Journal |

| Volume 6, Issue 7, July 2023 |

Pedestrian Flow and Density Simulation at Railway Station

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ABSTRACT: An enormous growth has been observed in number of passengers using railway transportation due to day-to-day urbanisation. It results into increase in number of passenger using railway station platform; usually this users are defined as pedestrian flow at platform. During arrivals and departure of trains at urban travel station, there is very high congestion due to pedestrian flow. Pedestrian flow goes to peak level with quick variation and brings about movement of pedestrian streams and may prompt to risky pedestrian facility. The analysis of this pedestrian flow in some circumstances in point of the gravity of situation turning unfavourable, subsequently for the proficiency layout and also compelling operations, modelling of pedestrian flow for such condition is important to increase pedestrian level of service. Simulation model of pedestrian network at Nagpur railway station was developed with the help of PTV Vissim 9 and analysis was carried out. The results show that ramp capacity is greater than maximum flow of pedestrian during peak hour and level of service is A.

KEYWORDS: Connectivity, Railway Transportation, Pedestrian.

I. INTRODUCTION

In India, Transportation web mostly four modes of transportations like as roadway, railways, waterways and airways, instead of that Airways and Waterways are developed mode and another roadways and Railways are developing conditions. Considering environmental aspect use of walking, cycling & public transport is very necessary in present, because of more traffic conjunction and accidents occurs on roads. Walking is also helps to reduce gas emission (pollution) which is depends on changing of climate, global warming & poor air quality. Walking improves speed of metabolism which is helpful for human good health. In both short distance and long-distance walking is property of travel to reach given goal. When trips are generated from origin to destination by different vehicles but in that pedestrian movement is also required to consider. Walking is an internal part of mode in transportation web. Pedestrian flow generally interactive with pedestrian and other facilities, so, it required well- planned/systematically should be done. It can be accomplished by executing system of walker stream. These models can be performed by solving different problems comes in under pedestrian behaviour and pedestrian accumulation. Presently present days Simulation study is extremely fundamental of pedestrian movement investigation in purpose of planning and outlines of open transport and also in private zone, Simulation tools beneficially shows vantage in conditions like heterogeneous traffic such as public transport (railway stations or bus stand), sports stadium, entertainment cinemas halls, marketplaces and different areas. Simulation model can be designed by three steps, like 1) Basic information of model for layouts drawing plans and O-D matrices of pedestrian trips, 2) Dynamic modelling for data standardisation and determination. 3) Analysis phase, simulation run show in 2D and 3D views and output gives in form of graphs, diagrams or charts etc.

In micro-simulation, we found many several software's which helps for checking behaviour of pedestrian traffic on railway stations. That software's is takes all characteristics as we depends and provides appropriate results in designing planning of new facility. There are some different values are required for pedestrian simulation framework such as walker flow, walker route Le. origin to destination path, pedestrian density as well as pedestrian speed which is undesirable on pedestrian category (Age, gender Sex er trip reasons) etc. Open transportation frameworks, generally passenger's pedestrian walks in horizontally, vertically or inclined direction on different infrastructure such as platform, ramps, escalators, elevators, stairways and passageways useful for to reach pedestrian on departure point. If we focus

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on vertical or inclined infrastructures, many conjunctions or queue formed due to heavy pedestrian traffic. So, it required to give sufficient infrastructure like perfect location of starting inclination, proper layouts or plans for planning or designing phases. Therefore, a main intension of this project is behaviour of pedestrian flow on passageway and stairway in peak hour time.

On this thesis work we will done by two phases. In the first phase, we study on walking behaviour of pedestrian with refers to different speeds and densities by using video- graphic camera which helps to plotting graphs for analysis of real-time pedestrian traffics in public transportation infrastructures. In second phase, by creating smaller scale reproduction display by utilising smaller scales recreation programming i.e. PTV Vissim. To get appropriate result we will observe on field study are analysis using simulation model. Main importance of this thesis is to gives guidelines of current facility and required facility for movement of pedestrian flow by environmentally. There are many simulation tools software's are developed for making models namely as Viswalk, Simwalk, Vissim, PedFlow, Simwalk Pro, NOMAD Model, LEGION, STEPS etc.

II. RELATED WORK

A highway pavement is a structure consisting of superimposed layers of processed materials above the natural soil subgrade, whose primary function is to distribute the applied vehicle loads to the sub-grade. The pavement structure should be able to provide a surface of acceptable riding quality, adequate skid resistance, favorable light-reflecting characteristics, and low noise pollution. The ultimate aim is to ensure that the transmitted stresses due to wheel load are sufficiently reduced so that they will not exceed the bearing capacity of the subgrade. Two types of pavements are generally recognized as serving this purpose, namely flexible pavements and rigid pavements. This chapter gives an overview of pavement types, layers, and their functions, and pavement failures. Improper design of pavements leads to early failure of pavements affecting the riding quality.
The development of a systematic and simplified method for evaluating pavement failures will help to ensure that even if the evaluation is carried out by inexperienced staff, there is a reasonable chance of success in diagnosing the problem and determining the best maintenance option. In addition, economic and practical factors involved in making a specific recommendation were discussed.

III. METHODOLOGY

According to goals and objectives, steps by step procedure adopted for this research work. Site selection, pedestrian traffic and model information comes in under this chapter.

1.Procedure:- According to the objectives and goals of the project work are done by conscientiously study of reappraisal of literatures. After study region is chooses in view of information/data required for further process. Data information with respect to inform of physical measurements of pedestrian facility, for example, length and width of path on passageways, height of passageway from ground, closeness of blockades/barricades, aggregate length of ramp, width, ramp inclination angle, its areas and transitional/intermediate landing etc. will watch and measure in proper dimensions. Similarly, required trap length is also will check. Video-graphic data gives information about pedestrian walker stream on railway infrastructures is gathered during peak hour Most of times peak hour of pedestrians is depend on arrival /departure of train in railway station. Railway station is fully busy during only peak hours. Pedestrian faces conjunction problems, walker flows and having large density amount, speed of pedestrian is slower so, less space openness and expected travel time required. From the video perception approach, the crucial parameters of walker development stream, like as, pedestrian stream rate, pedestrian density, mean walker walking speed will be analyze at specific interval of time.

2. Site Selection:-Indian Railways is the greatest method of transportation system in India. It has 64,000 km rail path on that 22 million passenger's daily travel by railways. There are 332 railway station located in India on 12 different zones. In Maharashtra state there are existing nearly 205 railway stations occurred. In the event that we concentrate on Nagpur railroad station in Maharashtra state almost 244 passenger trains arrivals and departure in one day. On these figure, 65 trains daily departure from Nagpur origin. Daily there are 106000 pedestrians arrivals/broad in Nagpur railway station. The railways in Nagpur are vital not just like say on the grounds that the city It is only one of the visitor put in India furthermore the second capital of the Maharashtra state likewise also by virtue of its prime zone. The Nagpur city is located at centre point of whole country, so all trains travelling on north zones to south zones, they trains stop in Nagpur railway station. Thus this railroad station is critical and hence is purposely key in the state and in addition in

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the entire subcontinent of India. So we can say this railway stations very biggest and busiest railway station in India. So, Nagpur railway station is selected for this research work.

After site selection will fix then data collection is done by in systematic manner so hence helpful for future extraction of data in easy manner. Mainly information gathering is done from two important sources such as, Manual dimension and video- graphic technique. In Manual dimension taken by measuring tape and video-graphic method is done by Cam coder. For selected site video camera was useful for pedestrian flow on passageway and ramp. Video camera is fixed in peak hour timing which is depending on arrivals or departure of trains. Video recording used to extract pedestrian stream, movement of pedestrians, also gives age, with luggage/without luggage, gender can be calculated which is helpful for calculation speed of walkers. Pedestrian speed is most of the part measured in meter per second. Density of pedestrian is also can be measured on passageway and ramp by video recording analysis which is depends on number of pedestrians per area. Pedestrian flow is also extracted by recording and value is taken by number of pedestrian per time required to complete that facility. On other hand, we taken different physical dimensions of passageways and ramp is helpful for making model in Vissim software. Dimensions like, Width, length, area of passageway and ramp, slope or angle of ramp etc. measured.

3.Software Tool:-

Planung Transport Verkehr is germane company organized different software's, for examples vissim, Vistro, Viswalk, Visum, Optima, Balance and Vistad etc. for micro and macro simulation purpose. Ptv Viswalk software gift us to done simulation and make model for walker behaviours. It is very effectively programming device for pedestrian stream required to done simulation and analysed be in home or outside of home.

This software is the very perfect solution for very one of the pedestrians who can consider the necessities of walkers in their tasks or studies, for examples, Transportation planning and organisation, consultant companies, planners of administrators of big buildings, large open spaces like market place, senior engineer or fire fighter engineers. PTV Vissim has many outcomes gives us like Area optimisation, planning for capacity, extraction and analysis, outline and optimize mass events, routing path and queuing analysis can be easily done.
There are very important advantages for such as, Easy to understand and utilise.

- Practical results
- Any number of pedestrians can be model
- 2D or 3D view help evolution of results

3.3Social Force Model:-
Social force model depends on Newtonian mechanics, where force is not directly said only pedestrian or person on foot but represents, measurements of pedestrian movements taken as individually. Here, Summation of all social force, physical force and psychological force is knows as social force model. The size, shapes and direction of forces are influenced by other pedestrians and other deterrents intention to rich their goals. This fundamental model for the motion of walkers in Vissim is the social force model developed by Helbin and Molner. The Social Force Model has been after extended by Helbing keeping in mind the end goal to be utilised as a part of Vissim. Vissim can likewise be utilised independently to reproduce pedestrian without vehicular movement.

IV. EXPERIMENTAL RESULTS

The purpose with the field studies was to collect pedestrian traffic data in a station environment. A conclusion from the literature survey was that video cameras are a common tool used for collecting pedestrian traffic data. An advantage is that video films can be analyzed for both manually and automatically movement of pedestrians Therefore, the pedestrian traffic data was collected by a video camera. Collected video films were later analyzed to extract walking speeds, pedestrian flow. During the field studies, the surroundings were studied in order to notice special events that could affect the behaviour of the pedestrians. Since the purpose of the study is to investigate walking speeds in a station environment, Station was visited in order to choose a location for the field studies.

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Possibilities for attachment of the video camera. The video camera should be attached perfectly perpendicular to the floor in a stable way in order to achieve video films of high quality. It is also important for the video camera to be attached high enough to cover a sufficiently large area.
2. Number of origins and destinations. The number of origins and destinations should be limited in order to clarify each pedestrian's origin and destination.
3. Pedestrian composition. The pedestrians walking through the study area should be a
Composition of different types with characteristics that easily can be identified from the
video films.
Major railway terminal Nagpur railway station of Maharashtra state is selected for the present study. Both the stations are equipped with the regular passageway and ramp facilities.

Table 4.1 Manual dimensions of selected facilities

Facility	Description	Railway Station
Passageway	Length(m)	25
	Width(m)	2.5
Ramp	Total Length(m)	16
	Inclined Trap Length(m)	22
	Width(m)	2.25
	Area	50
	Slope (Degree)	30
	Height(m)	10

Three basic parameters of pedestrian traffic flow, viz., flow, density, and speed, were extracted from recorded videos by manual counting. When pedestrian density is not high, the Video were played at normal speed to count the parameters. When the passenger flow density is very high it is very difficult to count the parameters by playing the videos at normal speed. A slow-speed playing of the videos was consequently adopted, and the time taken for pedestrians to cross a certain distance was calculated in milliseconds by playing the videos in windows media classic player. Data was extracted to get the pedestrian flow rate, density and walking speed values.

Pedestrian Flow

First, the number of pedestrians passing a line of sight across the width of pedestrian facilities in 60s was counted. As the passageway and ramp are two-way, the number counted was the total number of pedestrians in the two directions. Then, the number was divided by the width (m) of the facility to obtain the flow rate expressed as pedestrians per meter per minute (ped/m/min). Pedestrian flow rate

Number of pedestrians passing a point per unit of time, expressed as persons per minute, 15 minutes, or other time period; "point" refers to a line across the width of a walkway, stairway, or doorway, or through a pedestrian element such as an escalator or fare control gate.

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Figure 4.3 Pedestrian flows during peak hour

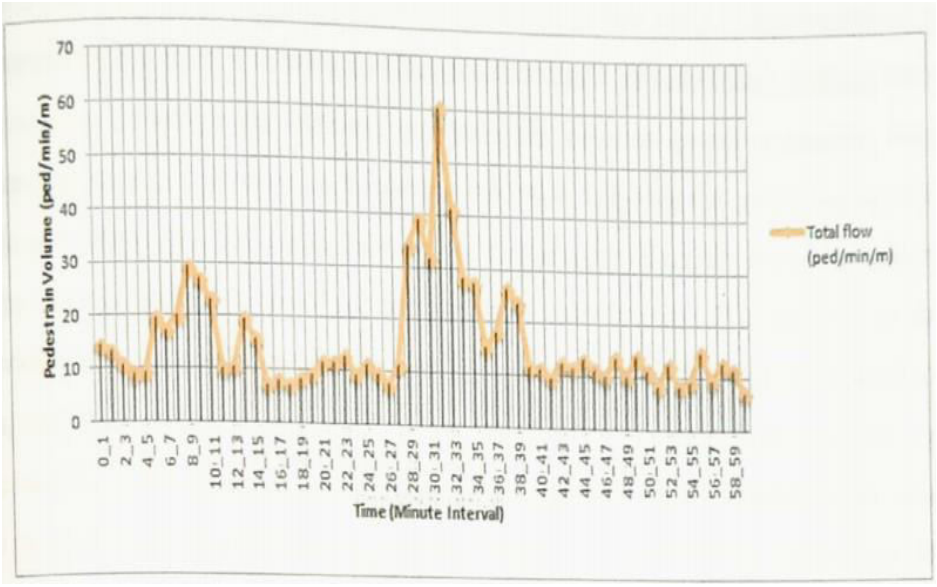

Table 4.2 Age distribution of selected types of pedestrians

Pedestrian Type	Age Distribution
Child	0 to 15
Youth	16 to 54
Senior citizen	Above 55

Passageway: Passageways should be designed to promote easy access, egress and circulation and offer good sightlines by avoiding recesses that could offer hiding places and litter traps. It may be one-way or two-way. The pedestrian flows inside a station are complicated, easily leading to many problems such as interweaving, conflicts in the main walking area, and imbalanced utilization of the facilities. Therefore the study of pedestrian movement is essential for better facility design inside rail transit stations. Entrances and passageways should be designed to promote easy access, egress and circulation and offer good sightlines by avoiding recesses and indentations that could offer hiding places and litter traps. It collects and disperses the pedestrian traffic within various platforms and is connected with the platform by ramp. It may be one-way or two-way, Pedestrian facilities such as lifts, ramps, stairways and escalators are normally used to facilitate level changes. Those vertical infrastructures are often bottlenecks of pedestrian traffic inside public transport facilities. Sufficient provision, proper location selection, and appropriate layouts of those vertical infrastructures are critical elements for designs of vertical circulations.

Ramp: Movement on ramps is more structured and restricted than walking because of the restraints imposed by the slope and the need to overcome gravity in ascending or to control it safely in descending. The use of ramp in the circulation pattern must be balanced against the real or potential needs of the handicapped the need to minimize travel distance and the geometric limitations of the site ramp may be ascending or descending in direction or bidirectional the total energy expended is a ascending stairs is 10 to 15 times greater than that used in walking a horizontal distance equal to the slope of ramp the energy expanded it descending is only one third greater than that used in walking a horizontal distance equal to the height of the ramp movement is most structured and restricted then walking on level surface because of the resistance imposed by the ramp slope and the need to overcome gravity in ascending or to control it safely in descending the use of ramp in the circulation pattern must balanced against the real potential need of the handicapped need to minimise travel distance and the geometric limitations of the site.

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Vissim Simulation: Planung Transport Verkehr is germane company organized different software's, for examples Vissim, Vissum, Viswalk etc. Ptv Vissim software gifts us to done micro- simulation and of all the pedestrian and vehicles as individually. Vissim has many outcomes gives us like Area optimization, pedestrian behaviour, extraction and analysis, outline and optimize mass event, routing path etc can be easily done.

PTV VISSIM is the software used for the both traffic and pedestrian simulation. Vissim is a microscopic, time discrete and the behaviour based simulate model. Vissim Simulates and analyses the walking behaviour of any number of pedestrians in a realistic and reliable manner. Based on the social force model it realistically and reliably models human walking behaviour it can be used for facility planning, event planning, evacuation analysis planning. railway station planning, urban planning, traffic & transport planning. The pedestrians on physical facilities for Nagpur railway station are being simulated in pedestrian simulation tool Vissim. The input for the vissim simulation tool includes speed(m/min) of a pedestrian, volume on the facility and density(Ped/m2) on the facility and corresponding flow (Ped/hr). The input for Nagpur railway station (passageway and ramp) for Vissim Simulation is shown in the following tables.

Table 4.3: Data required for micro simulation.

Facility	Flow (veh/hr)	Speed(km/hr)
Passageway	2379	1.05
Ramp	1922	2.92

For simulation the network is constructed in Vissim with parameters such as Pedestrian types, Pedestrian classes, Pedestrian inputs, Pedestrian composition, Routing, Measurement areas, Travel time measurement, Queuing areas. Input required for simulation is speed, flow, density, physical dimensions of the pedestrian facilities, space.

V. CONCLUSION

Ramp Results

Ramp of railway station includes Passageway For simulation of 3600 sec the results of ramp are speed (m/min) and density (ped'm). The values of speed and density are average values. Passengers are walking on slope area and are transported at the speed of walkers also increase the rate at which they are transported. The flow on the ramp will be from other passageway and other platform. Ramp input data includes volume in both the directions, speed of the pedestrian, angle of slope, width of ramp, landing trap width, height of balustrade. The use of ramp in the circulation pattern must be balanced against the real or potential needs of the handicapped, the need to minimize travel distances and the geometric limitations of the site. Ramp may be ascending or descending in direction or bidirectional. Passageway input data includes volume in both the directions, speed of the pedestrian, width of passageway. Passageways should be designed to promote easy access, egress and circulation and offer good sight-lines by avoiding recesses that could offer hiding places and litter traps. It may be one-way or two-way. The flow on the passageway may be from ramp, other connected platform. The ramp results are shown in table below.

Table 6.1 Ramp results of Nagpur Station

Ramp	Speed (km/hr)	Density(p/$m^{2)}$
Ramp No. 1	0.92	2.56
Ramp No.2	1.3	1.8

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2 Area results

Area of the network indicates start and destination of the pedestrian. Areas for vissim input include pedestrian input, pedestrian routing decision, travel time measurement and measurement areas. The results of the areas for pedestrian include speed (m/min) and density (ped/m2). Areas are given at the start of the ramps. Areas and ramps are accessible for pedestrians, Ramps can therefore be the generic term for construction elements, which connect areas of different levels with each other. Areas are defined as rectangles or polygons can import areas from AutoCAD. Ramps and stairways are defined as rectangles. Before accessible area data is transferred to the pedestrian model, Vissim combines areas that are directly adjacent or overlap into the largest possible, pedestrian accessible polygon. The original edges of these areas are not treated as obstacles. They are pedestrian accessible. So when an area is split during network editing, this does not affect pedestrian simulation in the network. Whereas links defined with the attribute Is pedestrian area (pedestrian area) are accessible elements, on which you can place signal heads, detectors or conflict areas. They are meant for modelling the interaction of pedestrians with vehicular traffic or other pedestrian flows. The area results are shown in table below

Table 6.2 Area results of railway station

Area	Speed (km/hr)	Density(p/m^2)
Area 1	1.02	1.33
Area 2	1.23	1.18

Areas may optionally include additional information for pedestrians, e.g. routing decisions. Areas have no direction. Construction elements are automatically connected where they are directly adjacent or overlap. Where accessible elements overlap, pedestrians may walk from one element into the next one. Pedestrians do not require any connectors.

Table 6.3 Pedestrian types

Name	LENVAR	WIDVAR	LGTVAR
Man	0.1	0.1	0.15
Women	0.1	0.1	0.15
Child	0.1	0.1	0.15

3 Comparison of Field and Simulated Data

The field data of the Nagpur railway station is compared with the simulated data of the Nagpur railway station after simulation in Viswalk simulation tool. The simulation output is compared with the input data for passageway and ramp.

1 Passageway

Passageway input data includes volume in both the directions, speed of the pedestrian, width of passageway. Passageways should be designed to promote easy access, egress and circulation.

Table 6.4: Comparison of simulated and field data of passageway

Parameter	Field study	Simulator study
Speed	1.05	0.81
Density	1.33	0.58

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2 Ramp

Stairway input data includes volume in both the directions, speed of the pedestrian, Number of steps, width of stairway, rise and tread of steps, landing width, height of balustrade.

Table 6.5 Comparison of simulated and field data of ramp

Parameter	Field study	Simulator study
Speed	0.92	0.86
Density	2.56	1.2

Fig 6.1: Micro Simulation of pedestrian flow

4 Charts

Charts are drawn for different attributes regarding network objects, attributes and time interval for different parameters of density, speed, time.
Network objects At least one object of the selected network object type, base data type or result data type. Can select an option to choose all objects of the selected network object type, base data type or result data type.
Attributes - At least one attribute for the selected object or objects. Simulation runs - the desired simulation runs to be used as data sources for the chosen objects and chosen attributes in the chart.
Time intervals - If time intervals are available, the intervals to be used as data sources for the chosen network objects and attributes in the chart.
Network Objects
The parameters for creating charts are area, ramp, walking behaviour, routing, pedestrian composition, pedestrian types for density, speed, time, routing, pedestrian types, and pedestrian classes.
Areas
Areas are accessible for pedestrians. Ramps can therefore be the generic term for construction elements, which connect areas of different levels with each other. Areas are defined as rectangles or polygons.

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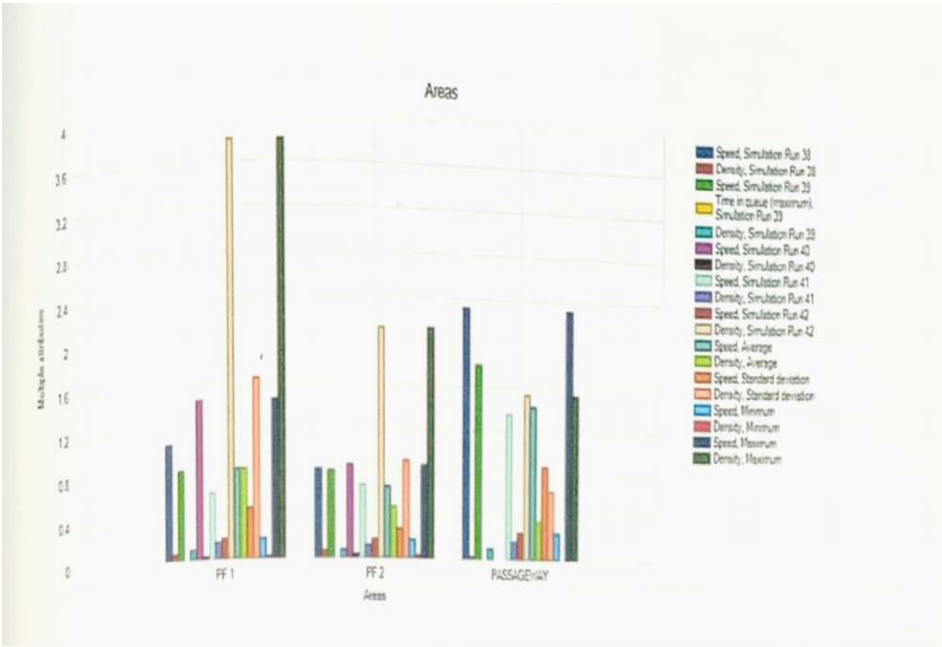
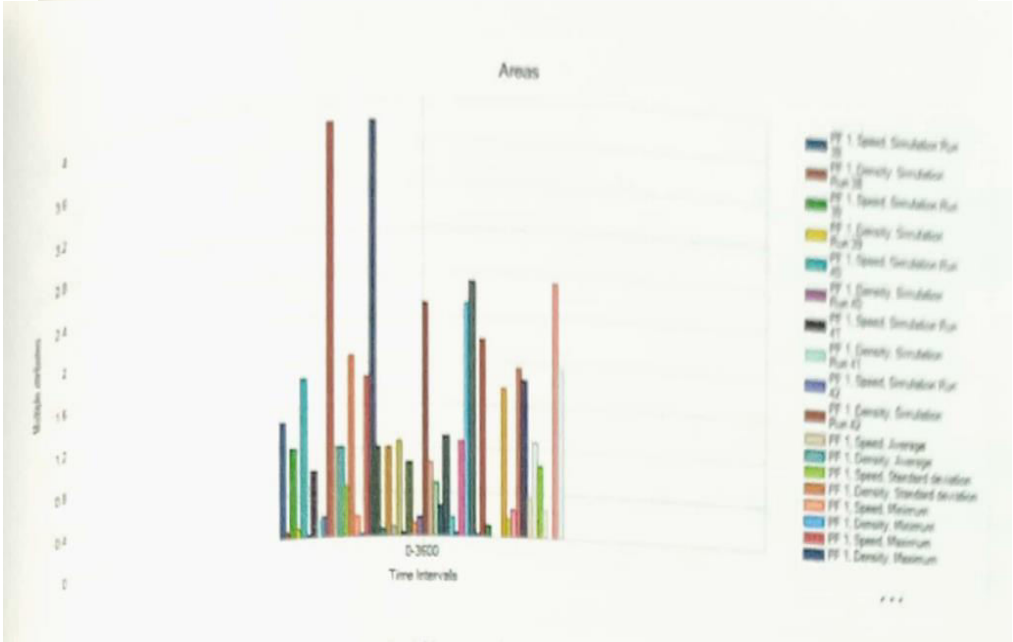
Figure 2 Chart for network object-area





For simulation run of 3600 sec the parameters are density, speed, number, pedestrian flow, routing.

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Fig 3: Chart for time interval-area

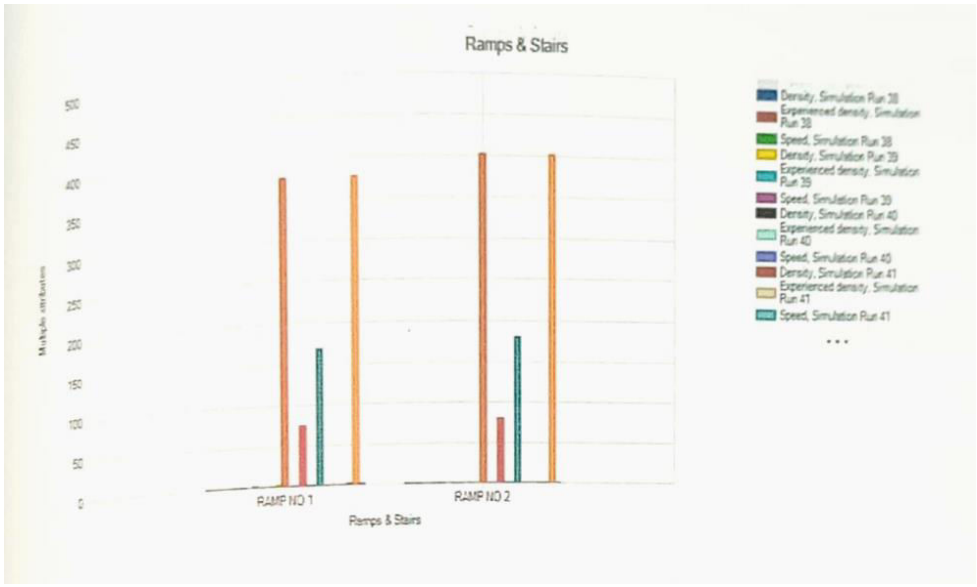

Fig 6.4: Chart for Network object Ramp

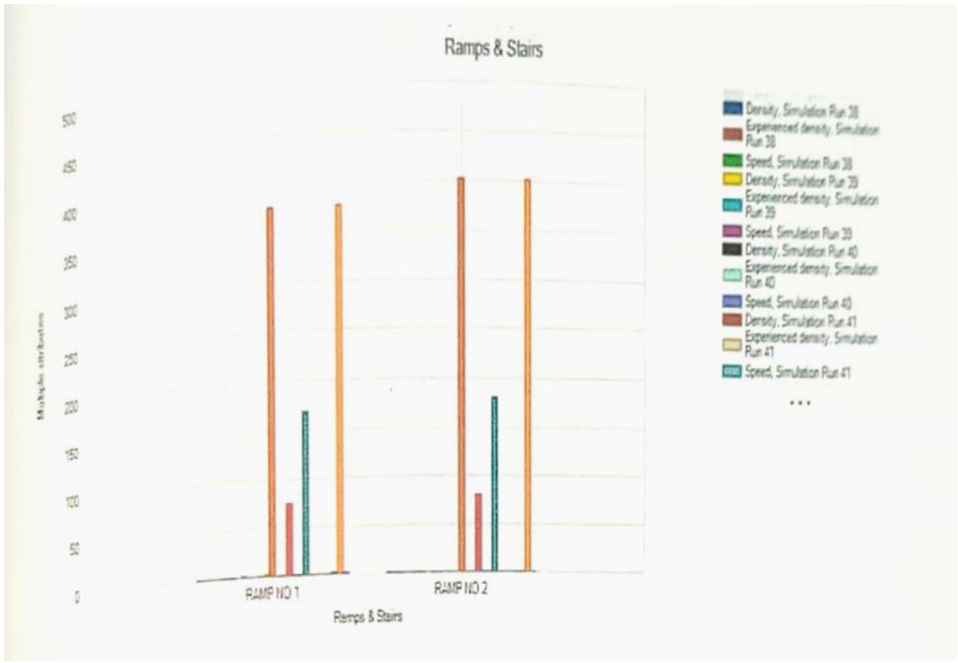

Fig 6.5: Chart for Time Interval Ramp

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Calculations

In stations where the platform area is grade-separated from the rest of the station and the adjacent outside area, ramps traditionally have been applied as the primary vertical pedestrian movement system.
Ramp width
The procedures to determine the required ramp width are based on maintaining a desirable Pedestrian LOS. For normal use, it is desirable for pedestrian flows to operate at or above LOS "C" or "D." However, in most modern terminals slope would be provided to accommodate pedestrians. Ramps, therefore, are typically provided as a supplement to the slope of ramp to be used when the ramps are over capacity or out of service due to a mechanical failure, maintenance outage, or power failure. Under these circumstances, maximum ramp capacity, or LOS "E" (17 p/ft/min or 51.8 p/m/min) may be assumed.
Consideration of pedestrian characteristics at a stair location is incorporated into the analysis

The following is a list of steps recommended for determining the required ramp width

- Maximum pedestrian flow rate (Based on LOS)

From field (Nagpur railway station) the average space (m^2/p) and flow (p/m/min) is taken

Avg. space 2.78 m/p Flow= 15 p/m/min

Level of Service A (field)

Directional peak 15-minute pedestrian demand from the data the peak 15 min flow

(ped/min) is computed

=158 p/15 min

- Design pedestrian flow (p/min)

Pedestrian flow-peak 15 min flow/15

=158/15

=11 p/min

- Required width of Ramp

=design pedestrian flow/max pedestrian flow rate

Max pedestrian flow rate for field LOS A

=16 p/m/min

The following are the conclusions for the present study;

The LOS of Ramp for Nagpur railway station from present study is A according 1 TCQSM (part7)-2nd edition.
.Ramp width obtained as per TCQSM for field data is Im and the Ramp width provided is 2.5m in the field,
Ramp capacity calculated as per transit capacity and quality service manual is 9000 phr and the maximum pedestrian flow is 2379 per. So the amp is effective in handling the passengers.

Pedestrian density increases at rump no due to high volume of polestar presented at platform no.1 so, our recommendation is to provide separate entry and exit ramp form platform no.1

.Based on analysis, pedestrian walking on passageway is average speed of pedestrian flow.

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.The charts were drawn for network, abates and ome interval for parameters of density, speed, time, number, geometry type, walking percentage, pedestrian flow, walking behaviour etc.

Simulation output (speed and density) are compared with the field study and the difference is 10%

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Impact Factor
7.54

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

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