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Research Study On Design And Assessment Of Fire, Life Safty Passive Meaures Of High Rise Mall Building

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Abstract

In recent years we come across the increased number of fire accidents in the society. To understand the current scenario of this fire behaviour towards the buildings context, a background study was started. The fire accidents numerical and its impacts were analysed. Five buildings affected by fire were selected. The fire influencing factors, the fire safety and life safety measures working conditions were studied. The fire accidents numerical data study was indicated that," The numbers of fire accidents are increasing in recent past years". The fire affected buildings study was indicated that," Few buildings were not provided with the fire safety measures and few buildings were provided with fire safety measures but they were not working at the time of fire accident. This background study results raised the question and the research problem was identified. The aim of the research was to "evaluate the heat resistance capability of building elements" The City area was selected as study area. The commercial category mall type buildings were selected as sample from this study area. study area documentation source was used for sample selection. Stratified sampling method was followed. These research elements and the research problem question gave a refined research problem statement as "Evaluation of Fire and Life Safety Passive Measures of Mall Buildings". This topic related information was referred from the available sources. The inadequate with missing information were found based on this topic. The hypothesis statement was framed based on the background study and the review of literature. The objectives of research were "To assure the full fledged implementation of fire safety measures, to assure the planning, structural stability efficiency of the measures, to assure to avoid the internal, external fire spread, to assure the evacuation within the time limit and to assure life safety, property safety of the people in side". All were deal with fire and life safety passive measures. The quantitative

applied research type was used for this research requirements preparation.

Keywords: Technology, Artificial Intelligence, Architecture, Architectural Design, and Fire Safety.

1. INTRODUCTION

The City infrastructures of transportations network, systemized communication system, well channelized water supply, uninterrupted electrical power supply, employment opportunities, health care facilities and education systems are providing the higher quality of life to citypeople. The Mall building concept is also incorporated to city infrastructures. These buildings are offering the quality house hold materials to city people. These buildings are providing variety of shops, indoor entertainment facilities, relaxations facilities, multi cuisine facilities, product launches, promotions, festivals and multi level parking facilities within the building premises. These facilities are attracting the younger generation in a grater way. They are using these buildings for their formal discussion and gathering. The easy accessibility of these buildings, internal air conditioning comfort and escalator facilities makes the people to spend their quantity time inside. In weekends and all festival times these buildings are used as public gathering entertainment buildings by all age group of people. HenceLife safety has become as paramount importance in these buildings. These multi vibrant activities, the multi storied height and the fixedglass construction for façade treatment of these buildings are required safety and security inside. It is the duty, responsibility of the architects and the construction industry professionals to assure fire safety and life safety to these buildings.

1. Fire Accidents Numerical Data Study and Analysis

The background study was carried out from numerical data and fire affected buildings. Numerical Data Study: The nineteen years (From 2001 to 2018) fire accidents, property loss and lives loss numerical data were collected and displayed in a table. From the display the highest values and minimum values were identified. The total values, average values were calculated.

Table1.1Fire Accidents Numerical Data Analysis (period From 2000 TO 2018)

Year	Numberoffire Accidents	Property loss in Crores	Humanlossin numbers
2000	16987	13.64	47
2001	17697	15.79	112
2002	18264	14.10	79
2003	16109	24.57	89

2004	16136	13.07Minimum value	249Highest value
2005	15093Minimum value	14.20	99
2006	17442	27.74	65
2007	21224	26.87	72
2008	17433	53.17	69
2009	21840	53.17	127
2010	18311	24.60	75
2011	22273	27.59	84
2012	32,273Highest Value	27.02	87
2013	25109	42.55	75
2014	24398	46.13	70
2015	19866	22.47	38
2016	25897	43.04	72
2017	21047	97.87Highest Value	67
2018	22601	58.83	36Minimum value
Total Values	3,90,000	646.42	1612
Average Values	20,526.32	34.02	84.84

OBJECTIVES OF RESEARCH

1. To Evaluate the Heat Resistance Adequacy of Passive Measures of Mall Buildings
2. To Assure the Full Fledged Implementation of Fire and Life Safety Passive Measures of Mall Buildings.
3. To Assure the Planning Efficiency, Structural Stability and Fire Rated Materials Adoption in Construction of Mall Buildings.
4. To Avoid the Internal and the External Fire Spread in Mall Buildings.
5. To Assure the Property Safety of the people from Fire Spread in Mall Buildings.

Figure shows fire accident

2. RELATED LITERATURE REVIEW

One of the major topics of the ire safety in high rise building and mall areas in city to support architectural design and optimization of building operations

In the view of Tadaoyoshida (1987): Explained about the fire, explosion of reactive chemical materials, energy hazard evaluation, fire and explosion properties. The evaluation of hazardous materials, hazard potential, safety measure adoption and smoke risks. Jain V. K. (1995 & 2010): Explained about the fire behavior, regulations importance, special care about design of escape routes, structural stability and fire rated materials usage.

Edgerley peter. G and Robinson peter. G (1989): Explained about the fire resist construction for the safety of the people and they recommended special features in buildings for disabled people.David Diamantee (1997): Explained about the passive 49 method of planning application, type of construction, resistance capacity of building elements, means of egress, hazardous management and all its fire related issues John Purkisses A (1996): Explained about the heat mass transfer knowledge between the steel structures. The structural members withstanding capacity, the structural members counter acting capacity. Properties and temperature limit of steel materials, B.S. 1881: Method of testing concrete, B. S.5268: Structural use of Timber, B.S.5588: Fire Precaution in the construction of buildings, B.S. 5628: Use of Masonry, B.S. 5950: Structural use of steel work in buildings, B.S. 8110: Structural use of Concrete & Part 2: Code of Practice for Shops. Edgerley peter. G and Robinson peter. G (1989): Explained about the fire resist construction for the safety of the people and they recommended special features in buildings for disabled people. They 48 recommended many international standard test results and safety design of the buildings. B.S. 5810: fire test for structure and materials, B.S.5395: Code of Practice for Stairs, Available Safe Egress Time (ASET), Required Safe Egress Time (RSET), NFPA- 1981 code details and American Society for testing & Materials (ASTM - 1980) are explained. Sheen P. A. D and Gray (1990): Explained about the thermal behavior of fire, its intensity, shapes, angles, metric units calculation of fire and various materials behaviothe architectural practice by optimizing resource allocation, automating repetitive tasks, and facilitating real-time collaboration among project stakeholders. (Meng et al., 2024.

3. RESEARCH METHODOLOGY

3.1. Research Design

The main focus of the study is discusses the research requirements derivation from code provisions, NBC elements application to key points, Design of major parameters, CMDA dimension application to design major parameters, sub

parameters, research requirements and its objectives explanation, flow diagrams details enclosing and check list preparation

3.2 Passive Measures Code Provisions Details.

The research requirements were derived from the following code book`s provisions recommendations.. National Building Code of India (1997, 2005 & 2016): From Part - 4, Title is, "Fire and lifesafety" About Passive Measures Provisions no from 2.00 to 4.17. International Building Code (2009): From all chapters: All recommendations relevant to fire and life safety passive measures

The Six Major Design Parameters are: (a) Site Planning Parameters, (b) Building Planning Parameters, (c) Occupancy Requirements Parameters, (d), Life Safety Elements in Escape Route Planning Parameters, (e) Structural Stability Parameters and (f) Fire rated recommended materials usage in construction Parameters The research requirements and its objectives explanation are as follows

(i) Site Planning Parameters:

Sub Parameters are: Road width, Gate width, Setbacks and External Stair Cases.

Main Objectives: To avoid the external fire spread. To facilitate the fire fighting operations and rescue operations.

Road width, Gate width Objective: The accessibility of the building by fire fighting vehicles.

Setbacks Objectives: To carry the adequate number of fire fighting vehicles around the building. To provide enough space to fire brigades to run around the building for fire fighting operations.

External Stair Case Objectives: To get entry of fire brigades through this staircase during fire. To use this staircase for ascendingand descending purpose during fire fighting operations.

Drawing References: Site planning parameters were referred from the site plan. External and fire escape stair cases were referred from ground and all floor plans.

(ii) Building Planning Parameters:

Sub parameters are: Space planning, Building dimension, Atrium designs, lighting and ventilation, core design, occupancy functional accommodation, open spaces, space for services provisions and compartmentation.

To achieve the main objectives in building planning, the following factors are to be considered. Well planning of adequate spaces for activities, Segregation of related activities, Allocation of floors for different activities in sequential order, Proper horizontal connectivity, vertical connectivity for

movement, required level of ventilation with smooth circulation were required in all floors
Main Objectives: To facilitate the occupants for systematic smooth and easy flow movement from one floor to other floor. It will also facilitate the people for quick evacuation operation. This evacuation operation should be done within two and a half minutes of time from all floors simultaneously at the time of fire emergency

(iii) Occupancy Requirements Parameters:
The Recommended Minimum functional requirements ofMall building are: Hyper Market, Anchor shop, Whole Sale Shop, Retail shop, Food court, Entertainment, Theater, Basement Parking, Surface Parking and Multilevel Parking
Regulations Application: The mall council functional requirements were applied
Drawing References: Occupancyfunctional details were referred from all floor plans

(iv) Life Safety Elements in Escape Routes Planning Parameters:
Life safety is one of the main components of Passive measures. It is one of the planning parameter. Due to the life safetyimportance the code books treat these requirements separately. It deals with the planning of safe escape routes from all floors to outside of the building.
Sub parameters are: Adequate number of driveways, adequate widths of single way Parking and two way parking. Adequate entry width, exit width, Pedestrian walk way width, Ramp width, slope width and other parking width in the parking area. Adequate Corridor width around various functions in all floors, the core design of lift size, stair case width and attached lobby area. The Main Door entry width, allot her functional door widths, services door widths.
Main Objectives: To assure quick safe evacuation of the building within two and a half minutes of time. To assure simultaneous evacuation in all floors at two and a half minute of time. To assure two hours internal fire ratings by the fire rated materials construction.
Drawing References: Life safety parameters were referred from all floor plans.

StructuralStabilityParameters:
Sub parameters are: Materials used for structural and non structural members construction, Cover thickness, plastering, Column size, column position, number of columns covering the built up area and its alignments. Wall, Beam, floor slab, joining position upon the column alignment. Structural Stability is obtained by: All structural members construction must assure the materials binding integrity, thecover thickness must

assures the insulation effect and the combination of materials binding integrity with insulation effect will assures the good structural stability to the building.

Main Objectives: To withstand the structural and non structural members up to 640 ^{0}C temperature. To assure four hours fire rating externally. The combined materials should not emit any smoke, fume and any toxic up to 640 ^{0}C temperature.(Building collapsible temperature is between 500 **^{0}C to 550 ^{0}C).**

3.4 Fire Rated Recommended Materials Usage in Construction parameter:

This is oneof the main parameter in Passive measures. As per the code recommendation, the entire building should be constructed by fire rated recommended materials.

Main Objectives: To assure two hours fire rating internally and four hours fire rating externally. The construction materials must with stand the temperature up to 640 ^{0}C without emitting heat, flame, smoke, fumes and toxic substance.

Drawing Reference: Fire rated recommended materials construction from foundation to terrace parapet were referredfrom the sectional elevation drawing.

4. Data Collection and Data Analysis

4.1 Data collection

Approved drawings were used for data collection. The length, breath, height and its construction materials data were collected in all directions. Thedimensional measurements and the materials details are given in the research report in qualitative description method. The relevant drawings were enclosed at required places. The Site plan, Basement Floor Plans, Ground Floor Plan with all Upper Floor Plans and Sectional Elevations are enclosed for references. The check list was used for identifying the measures and confirming the measures existence and non existence from the sample buildings.

4.2 Data Analysis

The analysis was carried out in a table the parameter name, the collected Physical dimensions of that parameter, the codes recommendations about that parameter, the comparison of thatparameter with codes recommendations and result of that measure were placed in adjacent columns of a table. All columns were correlated to relevant parameters. If the physical dimensions were equal or above the codes recommended dimensions, that parameter was considered as adequate measure. If the physical dimensions were less than the code recommended dimensions that parameter was considered as inadequate measure.

4.3 Site Planning Parameter:

Highway and Rail Accessibility Building Capability: A 40-meter-wide high road on the north side and a 30-meter-wide road on the west side provide access to the building. The major sections of the city are linked by these roadways. On the other two sides, you can see commercial buildings in the vicinity.

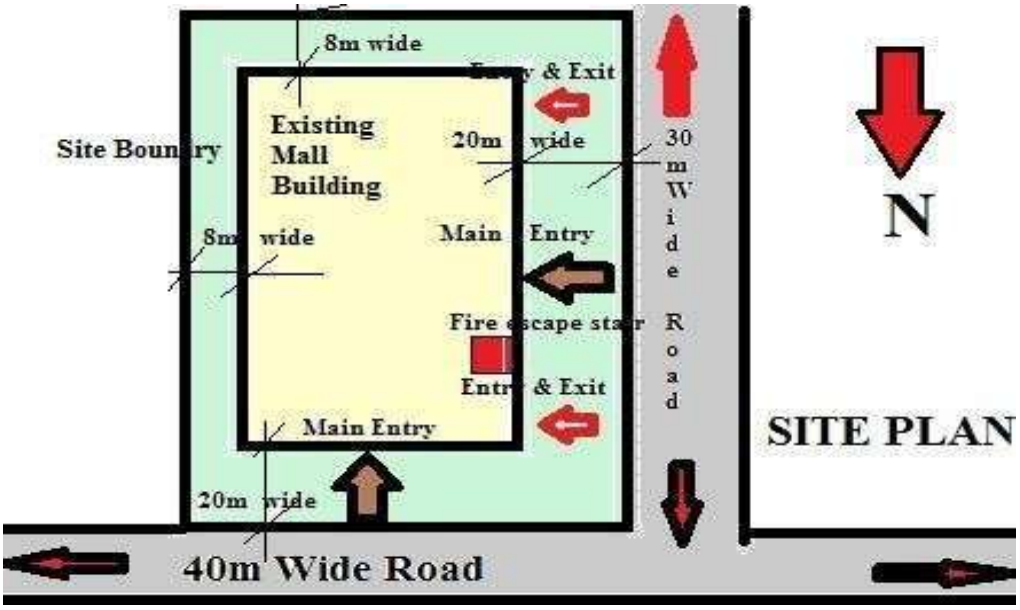

Figure4.1 Showing a Site Plan

The primary pedestrian entrance to the structure is a 12-meter-wide gate located on the north side. A big gate, 20 meters wide, is provided on the west side for vehicle ingress. The centre of the building is where you'll find both entrances. There are two access and exit gates on the west side, one at each end. At 7.6 meters wide,The building has setbacks that are 20 meters wide .borders open area on the west and north sides, as well as the reservation. On both the east and south sides of the structure, there is an 8-meter wide setback. One set of exterior stairs, designated as a fire escape stairway, is located closer to the building's North West corner.

Findings: This building is provided with good accessibility and reaches abilityfromits two sides' ofthe main roads. Two main entry gates and two numbers of entries cum exits gates are provided with adequate width. The fire fighting vehicle and ambulatory services can enter the building premises and exit smoothly.

Building Planning Parameters:

The land area is 12,460 square meters. Ground level built-up area is 3,599 sqm. On average, the building covers 40% of its

land. The index for floor space is 2.25. Layout of the space: The table below provides the details:

Table1. Details Space Planning

Floor	Built up area. Sqm	Ice area sq/m	Ing area sq/m	Four wheeler in nos	Two wheeler in nos
Second basement	88.00		6301	142	200
First basement	95.00	116	6178	138	200
Lower ground	3599.00	694	1372	30	300
Ground floor	3599.00		1372	30	100
First	4793.40	33	1372	30	-
Second	4135.31	33	1372	30	-
Mid level			1372	30	-
Third	4184.00	33	1372	30	-
Fourth	4314.47	76.76	1372	30	-
Fifth	2145	39.46	1372	30	-
Mid level			1372	30	-
Mezzanine	621.97	20.83	1372	30	-
Sixth	3868.19	127.51	1372	30	-
Terrace	94.00	4794		170	-
Total	27938.34	1373.56	30905	780	800

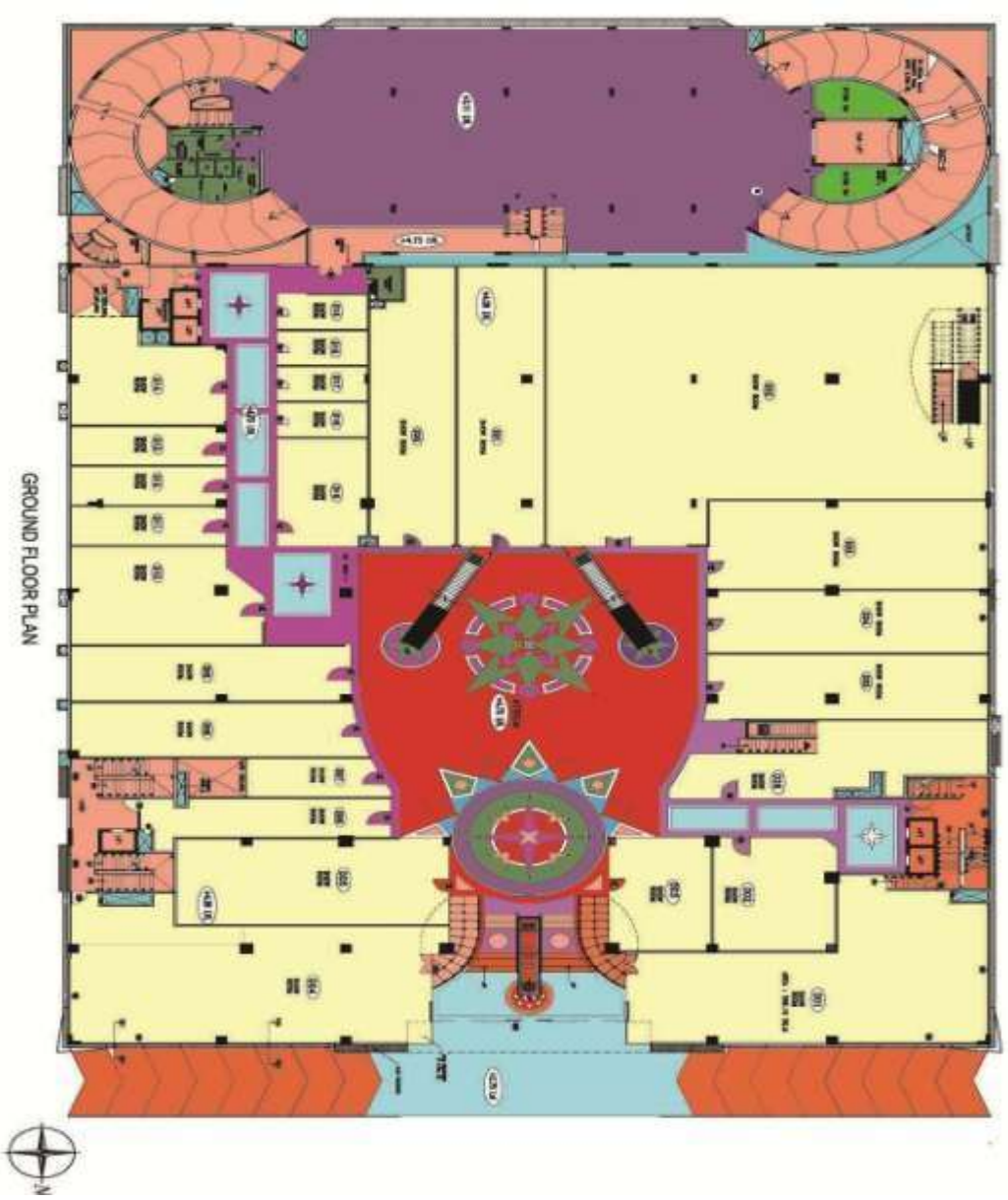

Figure 4.2Showing Ground Floor Plan.

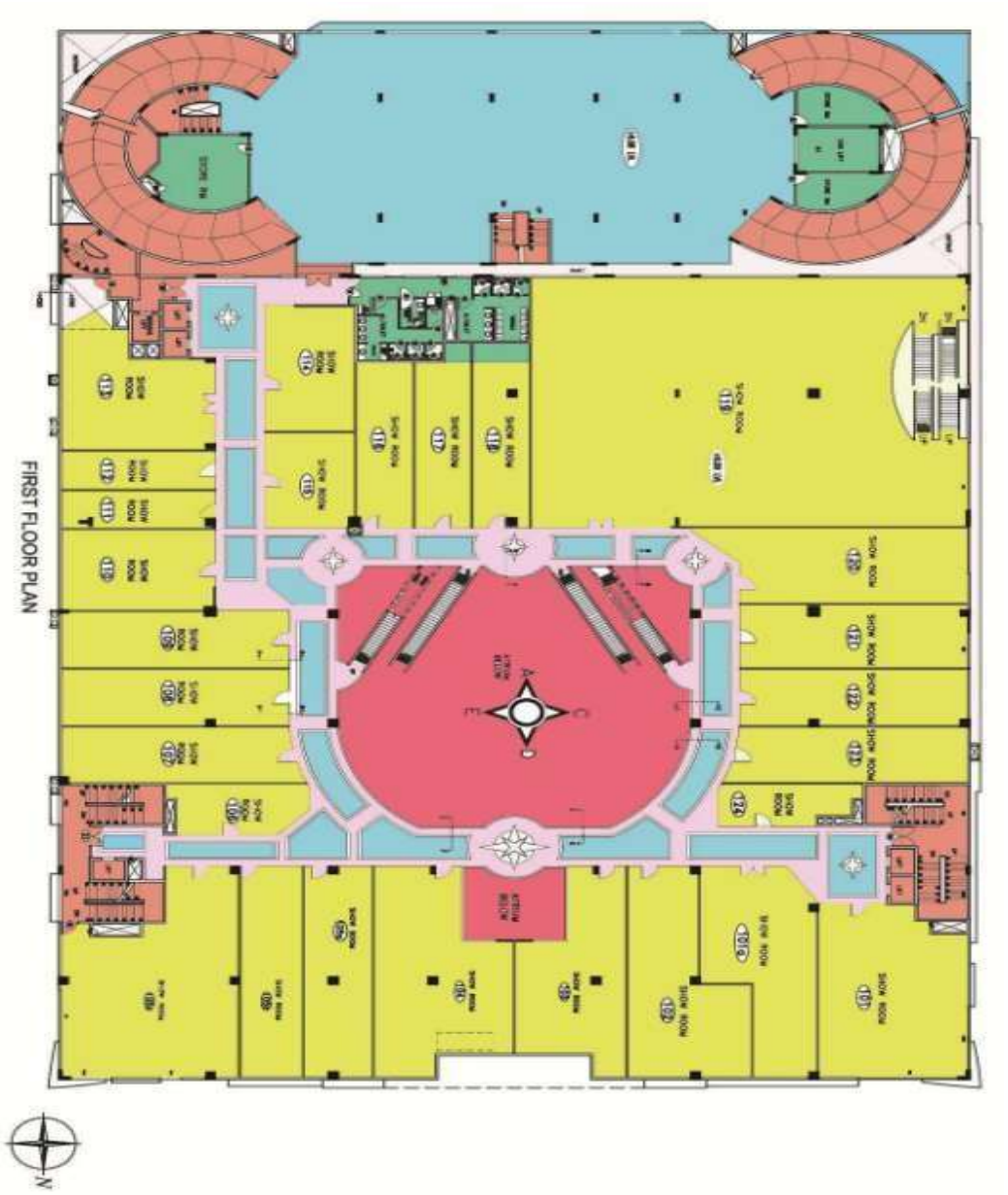

Figure.4.3 Showing First Floor Plan

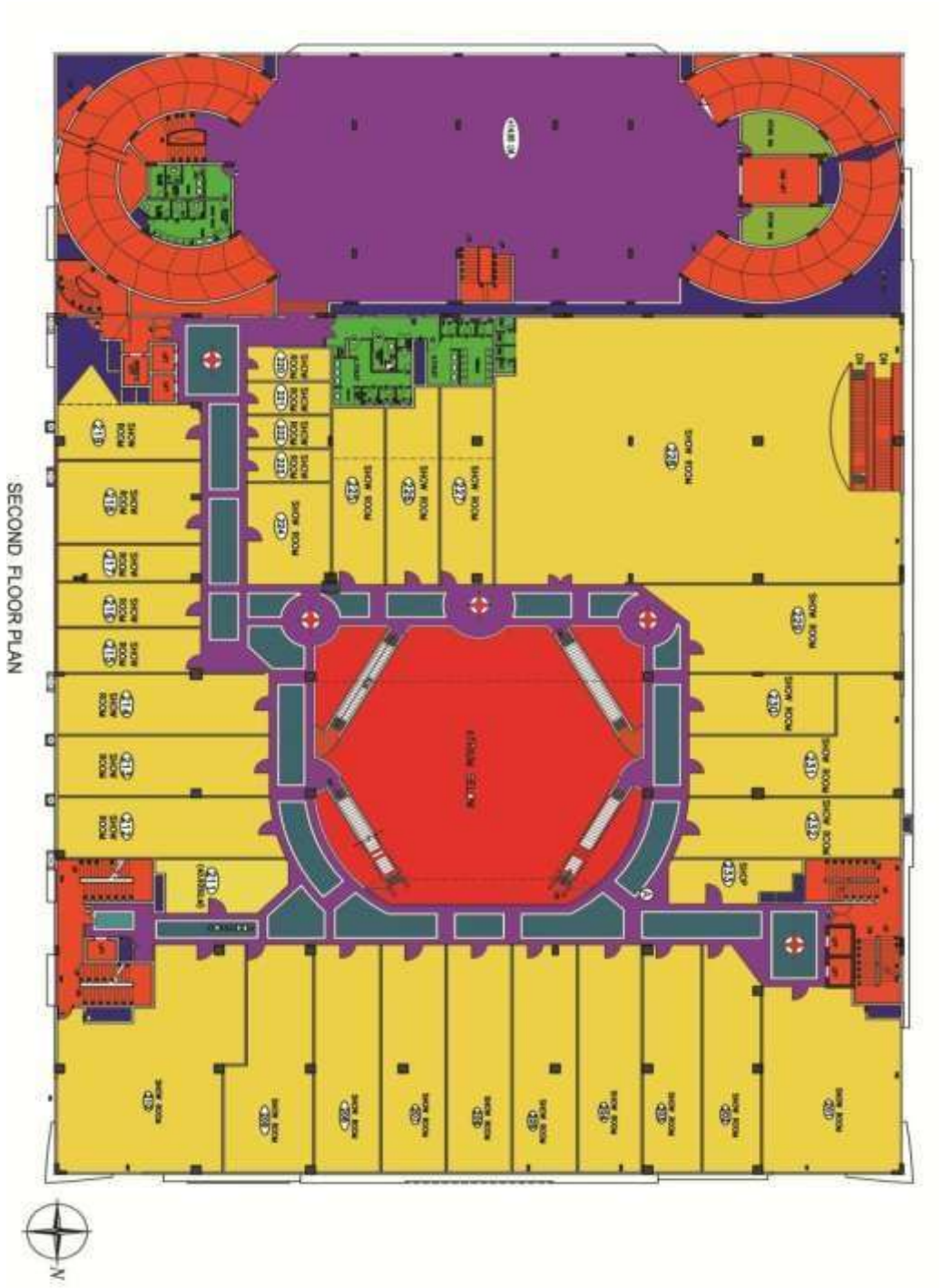

Figure4.4 Showing Second Floor Plan

Figure4.5 Showing Third Floor Plan

Figure4.6 Fourth Floor Plan

The location provides the building dimensions. Its dimensions are 143 meters on the west, 92 meters on the north, 194 meters on the east, and 127 meters on the south. The location on the east side is slanted and uneven. The whole size of the site is 12,460 square meters. The dimensions after the setback are 97 meters in length and 67 meters in breadth on the ground level. The building has a rectangular shape. From the cellar all

the way up to the terrace floor, it's just one unit. Two levels of basement space, one level below ground, one level above ground, five higher stories, a mezzanine, and a terrace make up the building. The heights of the basement and lower ground floors are 2.82 meters, 4.58 meters for the ground floor, 4.26 meters for the first, second and third floors, 5.55 meters for the fourth floor and 10.81 meters for the fifth story, which houses the theatre and includes the foyer, seats, mezzanine, projection room and false ceiling. The height of the lightning arrester is 6.4 meters, the height of the parking parapet is 3.65 meters, and the height of the lightning arrester tower is 2.38 meters above these. The basement floor is 5.64 meters high. From ground level to the tip of the lightning arrester, the building rises to a total height of 46.30 meters.

Atrium, Circulation and Ventilation: In the centre of the structure is the atrium, which is semicircular in design. Its total floor area, including hallways and stairwells, is 175 square meters. It serves as the building's primary emphasis. To let light in, a translucent material covers the atrium. This area alone draws the crowd. It separates the crowd and assigns different tasks to each floor. For efficient building circulation, the atrium encircles the corridor. With the exception of a small number of locations, the whole structure is air-conditioned.

Core design: The parking area is provided along with two ramps .The ramps are formality level car parking for up and down driving purpose. One ramp is provided around the lift car and staircase by a separate enclosure. The building's east side features two cores. A single set of fire escape stairs is located on the northwest side. The centre distance in between the core is 55m. Single lift without stair is provided for loading and unloading purpose on the south end. Individual single flight stairs are provided in side of the shops for mezzanine floors purposes in all floors.

Open Spaces: For the purpose of cabling, AHU, and other utilities, small shaft holes are supplied. Within the functional space that separates the car lift, parking, and other areas, there is a long, wider duct that collects sewage pipes from each floor. Located in the heart of the structure, there is no open space designated for interaction or ventilation purposes.

Compartmentation of Each Floor: The outer walls thickness is 0.23 m. provided with 0.025m thick Cement plastering is on both the sides. The inner walls are constructed with 0.15mthickness.The provision of compartmentation at every 750 sqm as per regulation is not provided in all floors.

Findings: Space allocation, grouping of activities, planning of each floor, circulation, ventilation and Atrium planning with population smooth movements are follows the planning

standards. Compartmentations provision is not provided in this building.

Occupancy Requirement parameter (Function of the Building): All four floors of the building's basement, the entire south wing, and the terrace level are reserved for four-wheeler parking. Hypermarket and surface-level parking are set up on the bottom floor. Four stories of the building are devoted to retail space. The food court and family entertainment activities are located on the fourth floor. The theatre and accompanying activities' designated fifth and mezzanine floors.

Findings; The occupancy features are as per the malls requirements.

Critical Safety Considerations for Evacuation Route Design:

Driveways and Parking Accessibility: The basement, lower ground, and ground level parking lots all have 7.2 m wide driveways, and the pedestrian walkway area is also 7.2 m wide. The primary egress points are located at 7.0 and 10 meters. The main entryway on the ground floor is 16.0 meters in length. There are two sets of ramps, one for going to the other. Wide at 3.7 meters and long at 72 meters, the ramp has a slope of 1:10.

Every Floor's Corridor Width: The shops are all linked by the hallways, which in turn link the stair and lift core for access to different floors. The circular, rectangle, and all shops have a 3.2-meter-wide corridor, while the elliptical atrium has a 4.2-meter-wide corridor. Starting from the atrium corridors, the service corridors are 2.5 meters wide. This width standard is adhered to across all levels.

Fire Rated Recommended Materials Construction Parameters:

The reinforcement materials are used in the following proportions: foundation, columns, beams, floors, ceiling, parapet wall, and stair cases, with the appropriate cover thickness of plain cement applied. Blocks of concrete: Brickwork measuring 0.23 meters thick and plastering one inch in a ratio of 1:2 on both sides make up the exterior walls. The floors are adorned with magnificent Grand Granite stone. Exteriors are completed with exposed aggregate, while interiors are painted with plastic emulsion. Gypsum board, plaster of parries, and stainless steel frames make up false ceilings. Full signage and display are achieved by treating the elevations with block work. Stainless steel components support the 12-millimeter-thick translucent fibre glass that covers the atriums.

Result Discussions, Interpretation and Conclusion

This chapter discusses the results summing up, results discussion with research requirements objectives, interpretation to compartmentation, type one construction,

comparison of objectives with findings, hypothesis statement conclusion, research conclusion and future scope of research recommendations.

- Site planning Parameters of all Samples: All components exist and their resistance capabilities were adequate.
- Building Planning Parameters of all Samples: The compartmentation and Type one construction does not exist. All other remaining components exist and their resistance capabilities were adequate.
- Occupancy Requirements of all samples: All functional requirements exist as per the mall council requirements.
- Life Safety Elements of escape routes Planning Parameters of all Samples: All components exist and their resistance capabilities were adequate.
- Structural Stability Parameters of all samples: All components exist and their resistance capabilities were adequate.

Fire rated recommended Materials construction of all samples Parameters: All components exist, and their resistance capabilities were adequate

Hypothesis Conclusion

As per the findings and the objectives failure of this research, the hypothesis statement is concluded here that "The Fire and Life Safety Passive Measures of Mall Buildings are Inadequate "hence hypothesis statement is proved.

5. CONCLUSION

This research finding reveals the passive measures condition of mall buildings in the study area. These buildings are existing with adequate measures and inadequate measures. The existing with adequate measures is recommended for future adoptability. The inadequate measures (not existing measures) construction should become mandatory for future upcoming buildings. In all sample buildings inadequate measures (not existing measures) are to be constructed and are to be incorporated with the existing adequate passive measures These full-fledged implementations of fire and life safety passive measures will meet the objectives in future in architectural design.

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