International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-8 Issue-3, September 2019

Fire Risk Mitigation at Urban Scale in Commercial Buildings of Kumbakonam Town

Ramesh Babu Natarajan, P.Jayasudha

Urban growth in old south Indian traditional towns results in overcrowded and chaotic developments which compromises occupant's safety especially from fire. The fire risk associated in built environment needs to be analyzed by understanding the changes in built form and built environment by a systematic procedure which can support fire mitigation strategies at urban scale. For the purpose of study, Kumbakonam which is a traditional south Indian town with rapid urbanization and change in urban fabric is identified as a case example. The methodology tries to identify problems in selected areas of kumbakonam town from the perspective of fire hazard by identifying commercial typologies in and around the core areas of old towns and analyzing them. This involves documentation of 4 commercial typology buildings selected in core area and analyzing for associated fire risk by comparing with norms outlined by NBC (2016). The purpose of the research is to highlight the presence of fire risks in commercial buildings of kumbakonam with minimum exit widths, increased occupancy load and maximum travel distance of means of egress. The findings can be a prologue to further research and decision making process for the safety of the occupants.

Keywords: Building Occupancy, Building Exit Capacity, Fire risk mitigation, Means of Egress.

I. INTRODUCTION

Old towns have gone through various stages of transition from historical to modern. They represent culture, tradition, rituals and identities which are in general subject to change in physical character. The Physical characteristics of streets and built form struggle to adopt the modern needs.

Increased density and change of activity in today's urbanization scenario is inevitable. Urban pressure in general has altered the geometry of land parcels and built environment to a greater extent which forces to have more compromise in fire safety aspects. The infamous Kumbakonam school fire tragedy on 16th July 2004 in which 94 children were charred to death is a typical example of failure of built environment during a fire emergency [8]. Trends of urbanization in core area due to unplanned urban development beyond thresholds need attention from the perspective of fire risk mitigation. [5]

In this context, few urban areas in the core area of Kumbakonam, a south Indian temple town with rich cultural history is taken for the study and commercial buildings were selected and analyzed for fire risks. The selections of commercial buildings in this study are based on parameters that compromise the safety of occupants from the aspect of fire risk namely exit widths and maximum travel distances.

Manuscript published on 30 September 2019
* Correspondence Author
Ramesh Babu Natarajan*, Department of Architecture, Periyar Maniammai Institute of Science and Technology, Thanjavur, India Email: rameshbabu@pmu.edu
Dr.P.Jayasudha, Department of Architecture, Periyar Maniammai Institute of Science and Technology, Thanjavur, India

II. REVIEW OF LITERATURE

The issues of the old urban centers from the perspective of the analysis and inventory of building's features will help to classify/ categorize the typology of buildings in terms of seismic vulnerability. In their study on the old city centre of Seixal, Portugal, Santos, C., et.al.(2013), parameters such as the building size, configuration and volume, number of floors, distribution systems and internal space organization, and building materials and the relative construction period were analyzed and assessed. The evaluation of seismic vulnerability is carried out with 14 parameters. Overall seismic vulnerability index with these 14 parameters ranged from 0 to 650 and they were normalized with a range of 0 to 100.The evaluation of global fire risk was done using the factors such as fire initiation, fire development and propagation, fire evacuation and fire combat. Fire vulnerability index thus arrived is mapped in ranges of 0 to 20, 20 to 40, 40-60, 60-80, 80-100.This identification of building typologies has supported a seismic and fire vulnerability assessment of the old building stock [2]. Similarly an attempt to classify buildings based on occupancy nature and accessibility parameters was done in this research paper to support fire risk mitigation.

Based on the character of occupancy, the buildings were classified as residential, educational, institutional, assembly, business, mercantile, industrial, storage and hazardous (NBC, 2016). The exit capacities or the number of people who can pass through an exit arrangement are expressed as capacities of means of egress. These capacity factors are expressed as width per person in mm for various occupancy groups. The maximum travel distance based on occupancy and construction type.

Vulnerability of fire risk in old urban areas depends on various factors. A simplified methodology of assessment of fire risk for large-scale assessment and spatial mapping of output using GIS tools of old city centre of Seixal by T.M.Ferreira, et.al.,(2016),is a valuable step towards risk mitigation at urban scale [1]. Phase one of the study focuses on identifying and collecting data relevant to fire risk vulnerability.

Phase two was on using the data as input for development and application of the new methodology to assess urban fire risk. This allows the City managers and regional authorities to intervene the issues more accurately and prepare comprehensive risk management strategies to support safety and emergency planning in the case of an urban fire.

Among the problems posed by movement of people in buildings are those dealt with by standards, codes and regulations mainly in relation to means of egress Pauls, J. Fire Technol (1984). Means of egress are often dealt with occupancy classification, occupant load and number of exits, types of egress facility, capacity and dimensional limits for individual means of egress, travel distance to exits, remoteness of alternative exit, illumination and marking, fire protection. Movement safety is considering to a lesser extent. Research suggests that stairs with larger treads, improved visibility, and better handrails can improve comfort and safety in normal, everyday use and reduce the risk posed by crowd conditions in emergency egress situations. [3]

The Criteria considered for Weighting and ranking of fire safety criteria for students housing facilities by M.A.Hassanain Kobes., et.al.(2017), are Building characteristics, fire safety systems, Management and maintenance. The results of the weights show that the ‘‘building characteristics” (weight 0.43) have the highest weight among the criteria, followed by the ‘‘fire safety systems” (weight 0.41) and then ‘‘management and maintenance” (weight 0.16). In the ‘‘building characteristics” criterion, the maximum travel distance, number of exits, and occupant load are ranked successively as the three most crucial attributes for the safety performance of the facility. [4]

III. METHODOLOGY

The research methodology carried out is as per the steps below

Reconnaissance survey

Step-1

Typology and sample selection

Criteria –commercial buildings with narrow width parcels

Step-2

Documentation

Preparation of measured drawings of plans, section of the selected samples

Step-3

Occupancy load calculation

Step-4

Minimum Building exit width capacity analysis

Based on occupancy load (NBC 2016)

Step-5

Maximum travel distance and travel distance shortage analysis based on documentation (NBC 2016)

Step-6

Findings and discussions

IV. PHYSICAL CHARACTERISTICS OF CORE TOWN OF KUMBAKONAM

Kumbakonam is a town in the southeast Indian state of Tamil Nadu. It was under the rule of Early Cholas, Pallavas, Medieval *Cholas*, Later *Cholas*, *Pandyas*, the Vijayanagar Empire, *Nayaks*, and the *Marathas*. It rose to be a prominent city between the 7th and 9th centuries AD, when it served as a capital of the Medieval *Cholas* [12].The town reached the zenith of its prosperity during the British rule when it was a prominent centre of European education and Hindu culture. The town has a population of 1,40,156 spread over an area of 12.58 km^2 with a density of 11,000/km^2 as per Indian Census 2011. [12]

The settlement characteristics of *Kumbakonam* town reflect the vernacular principles. The geometry of land parcels in congested urban areas of the town is predominantly rectilinear with minimum frontage. The widths of land parcels range as low as 20 feet and the depth reaches till 350 feet. The built forms in these vernacular settlements follow the plot geometry with certain prominent characteristics. Common characters are Narrow streets, wall to wall built up structures and courtyard as the tool for ventilation and lighting. These linear wall to wall constructions and narrow streets are highly effective in hot and humid climatic conditions.

V. MAIN CHANGES IN PHYSICAL CHARACTERISTICS OF CORE TOWN

The Physical characteristics of *Kumbakonam* town with heterogeneity of buildings reveal the overlap of various construction periods of buildings. Changes in land parcel boundaries and built form have occurred in these settlements due to increased densities in core areas as a result of increased commercial demand and land value. Various spaces especially the *thinnai* space in front are changed to accommodate commercial spaces or activities. These are strong reflections of adaptations of buildings to suit the growing urban demands. Once common, the charming, traditional row houses occupied by *brahmins* have fallen prey to urban realty development [7]. The developments can be categorized as below:

- Land parcel/ Building subdivision.
- Land parcel amalgamation (Two linear plots combined to single).
- Changes in building occupancies.
- Vertical developments with negligible setbacks.

A. Land parcel /Building subdivision

Traditional Vernacular settlements are often narrow land parcels with residential typology having the depth ranges from 100 feet to 350 feet. Narrow residences with wall to wall construction end with a service lane at the backyard.

Retrieval Number C4791098319/2019©BEIESP
DOI: 10.35940/ijrte.C4791.098319
Journal Website: www.ijrte.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

These backyards were once used by servants and for cattle movement. Morphology changes in these settlements have resulted in Land parcel bifurcation or subdivision where the service lanes have transformed to narrow streets which act as frontage for the bifurcated or subdivided lands.

B. Land parcel Amalgamation

Narrow plots with minimum frontage being ineffective for commercial development as in Fig.1.(a). Few developments have resulted in amalgamation of neighboring plots to increase the frontage width as in Fig.1.(b). Though front access is available they lack alternate escape routes.

Fig. 1.(a) & Fig.1.(b) . Narrow front Commercial buidings

C. Change in Building Occupancies

Change of Occupancies to accommodate essential amenities such as schools, shopping complex, hospitals are quite natural in the evolution of a town. Occupancy changes in Traditional building often result in modification of part or whole of existing built forms or demolition and construction of new structures [7]. Instances of marriage halls and schools functioning in residential buildings are a common scenario in *kumbakonam* town. This scenario quite often ends with built environment with increased number of occupants for which they are not designed.

D. Vertical development with negligible setbacks

Increased urban pressure has facilitated for vertical development with minimum or no setbacks. Means of egress are compromised to a greater degree where the occupants in upper level are at an increased risk.

In the Fig. 1(a) & (b), three storied buildings are constructed wall to wall where the vulnerability of fire spread from adjacent structures are more. Also the means of egress is complicated due to lack of setbacks.

VI. SITE AREA AND TYPOLOGY SELECTION

The study tries to identify problems in selected areas of an old urban town from the perspective of fire hazard by identifying typologies in its core area and categorizing them. The study area is delineated in the core area of kumbakonam town as in Fig.2 & Fig.3 based on commercialisation trend.

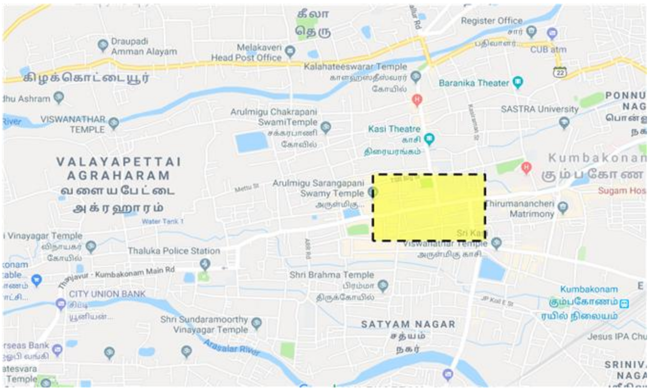


Fig. 2.Delineated study area – Kumbakonam Town Map

The study area consists of commercial developments on and either sides of *Nageswaran North street*. Within the study area built environments of Mercantile Occupancies are taken for detailed study, analysis and categorised in to typologies. Though various parameters such as building size and construction quality, occupancy configuration, number of floors, internal spatial arrangement and fire load determine the fire risk in an urban environment, a basic classification is essential to understand the built environment from the context of evacuation during a fire risk.

Fig. 3.Enlarged map of study area with sample location

Hence the primary focus in selection of building samples in commercial typologies is Geometry of Land parcels and usage which are related to spread of fire and evacuation during an emergency situation. The common physical characteristics adapted while selecting samples are Land parcels of Narrow front with varying depths and mercantile or commercial occupancies as in Table-I. Also the buildings selected were with no setbacks. The width of land parcels selected ranges from 7m to 10m against varying depths up to 5 times of their widths.

The acronym in classification were taken as T-Typology, C01- Commercial type related to departmental store, textile stores, C02- Commercial type related to showrooms, 01and 02 – Sample numbers. Two typologies T-C01 and T-C02 with 2 samples on each of these typologies were taken.

Retrieval Number C4791098319/2019©BEIESP
DOI: 10.35940/ijrte.C4791.098319
Journal Website: www.ijrte.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

Table- I: Samples in Commercial Typology

Description of Selected Sample			
Typology	***Physical Characteristics***	***Land parcel width to depth***	***Building usage***
T-C01-01	Narrow width, Very deep land parcels and newly constructed building.	7.6 m to 39.8 m	Departmental store
T-C01-02	Narrow width, Very deep land parcels and modified old building.	8.2 m to 44.4 m	Textile stores
T-C02-01	Narrow width, Medium deep land parcels and newly constructed building.	5.94 m to 28.8 m	Electronics showroom
T-C02-02	Narrow width, Medium deep land parcels and modified old building.	9.2 m to 24m	Electronics showroom

A. Typology T-C01-01

Urbanization in city centre has forced the change of occupancies resulting in commercial structures with increased floor heights and wall to wall construction. Facades constructed with modern building materials that follow the form of land parcels are taken for study. Typology T-C01-01 consists of deep land parcels with retail structures in core area. The general observations are the facade opening into main road which act as the only entry and exit for the entire building. The upper levels are accessed by stairs either located in the front or in the farthest rear end.

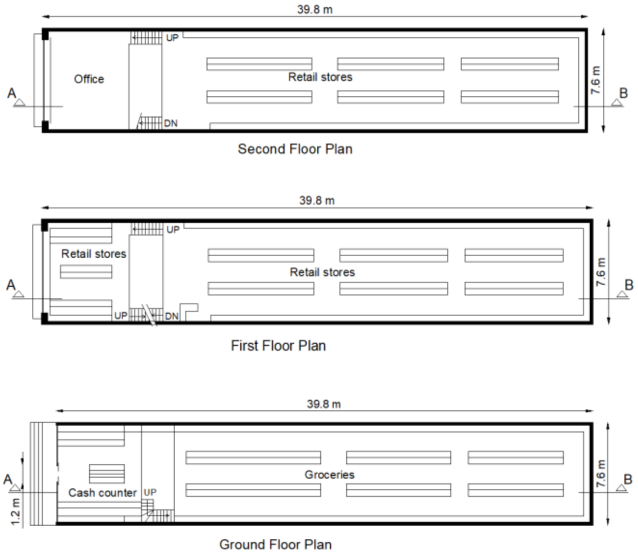


Fig. 4. Floor plans of T-C01-01 with exit width of 1.2m

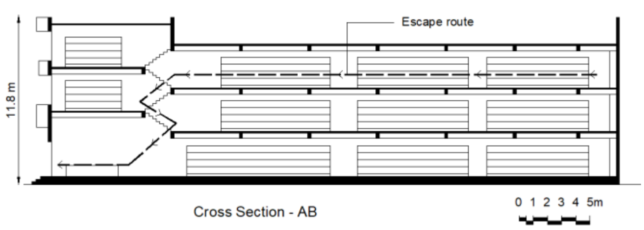
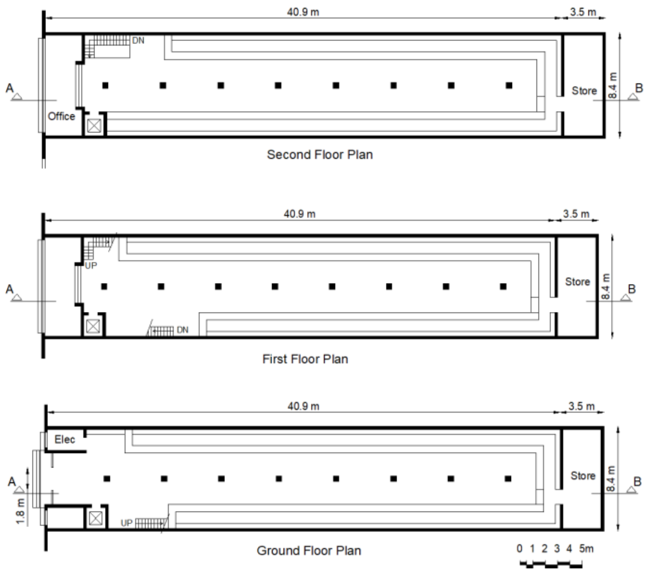


Fig. 5.Section of T-C01-01 with Escape route of 44.5m

A Retail departmental store taken for study is in *Nageswaran North street, Kumbakonam*. The Retail departmental store building is quite narrow 7.6m width against a depth of 39.8 m .The only access to the entire building is in the front side with an effective door opening of 1.2 m. The internal arrangement of display racks has reduced the width of the internal circulation space to 1.2 m wide as the displays are present on either side. High occupancy loads during peak business hours against insufficient exit widths presents the existing threat during an emergency evacuation. The plans of retail building documented as in Fig.4 & section as in Fig.5 are studied with respect to NBC norms. The findings reveal that the Maximum travel distance is 44.5 m as in Fig.5 against the norms of 30m resulting to a shortage in travel distance by 33%. The Occupancy load for mercantile building comes to 200 persons in this 841sq.m building. The insufficient exit width is 1.2m against the required width of 1.77 m and the non availability of alternate exit route is a threat during emergencies [6]. The possibility of providing alternate exit routes is not feasible as the structure is constructed wall to wall with no setbacks. The spread of fire to and from adjacent building is another underlying threat.

B. Typology T-C01-02

The Textile showroom building in *Nageswaran North street*, *Kumbakonam* as shown is constructed wall to wall with different construction materials. This building is an example of modified old building. The presence of series of newly constructed structural columns in the center of the aisle and drop in floor level of the front space as in Fig. 6. show a modification of 80% of the old structure. The width of the building is 8.2m and depth is 44.4 m. The entry and exit to the building are through a double door with an effective width of 1.8m. The available width of 8.2 m is further reduced by the presence of a row of columns in the centre due to retrofitting. A single flight of narrow stairs with their widths as minimum as 0.75 m are available at each floor. Due to lack of alternate exits these steps are the only access for the shoppers in the upper level quite often with increased occupancies. As the stairs are not fire stairs the Maximum travel distance is 56 m against the norms of 30m resulting to a shortage in travel distance by 46%. This is an example of continuing trend of modifying buildings to fit the commercial usages.



Retrieval Number C4791098319/2019©BEIESP
DOI: 10.35940/ijrte.C4791.098319
Journal Website: www.ijrte.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

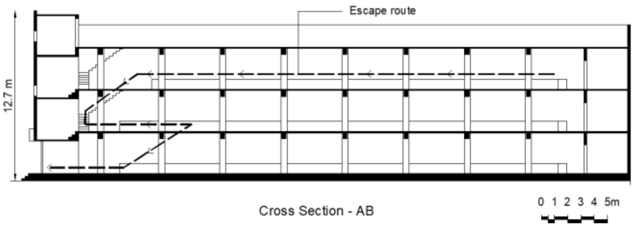


Fig. 6.Floor plans and Section of T-C01-02 with escape route

C. Typology T-C02-01

A reputed Electronics retail showroom in *Sarangapani East Sannathi street, Kumbakonam* is taken for study. The building measures 28.8m in length and a depth of 6 m and is a newly constructed building.

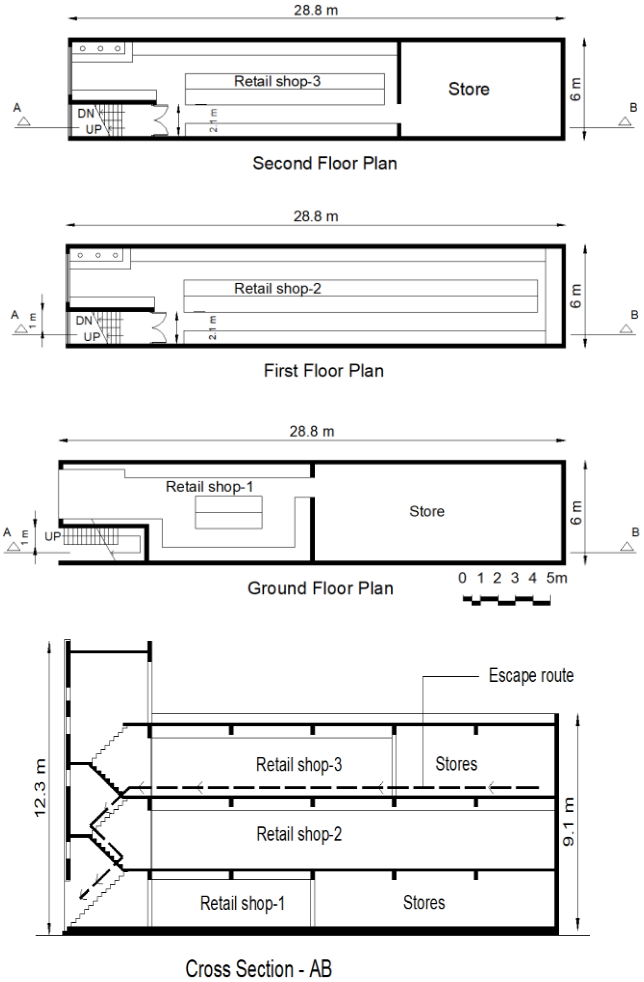


Fig. 7.Floor plans and Section of T-C02-01 with escape route of 56m

The Retail shop is 12.3 m in height Fig.8. (a) and the shops at ground floor are easily accessed from the road. Whereas the retail shops in the upper levels are accessed through a dog legged stair 1.07m wide. The entry and exit at each levels of building is through a double door with an effective width of 2.1 m as in Fig.7.

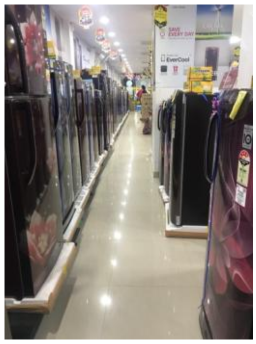


Fig. 8.(a) Exterior facade. Fig.8 (b) Interior displays

Though the retail shop has a wider entry, the passageway is reduced to 0.9 m due to display of equipments as in Fig.8 (b). The entry to the shop is through the staircase landing which also acts as a lobby. This area gets congested as there are movements of people to upper levels through this stairway landing area. As the stairs are not fire stairs the Maximum travel distance is 35 m against the norms of 30 m resulting to a shortage in travel distance by 14%.

D. Typology T-C02-02

This Electronics retail showroom in *Nageswaran South street, Kumbakonam* is an example of land parcel amalgamation in which the adjacent building is linked in to a single ownership as in Fig.9 and Fig.10. The old building measures a width of 8.8 m and depth of 13.2 m. This building is linked to the new building with a width of 9.22m and a depth of 24m. Though this linkage has been created for increase in space, it has created the possibility of accessing the building from the rear side of the road. Thereby an alternate exit route has been created which serves as an emergency exit.
The exit widths in the front side are 3.9m (1.2m +2.7m) and 2.7m in the rear side. Total exit widths in the building in 6.6m. The travel distance in an emergency is within 30m which is well within the norms.

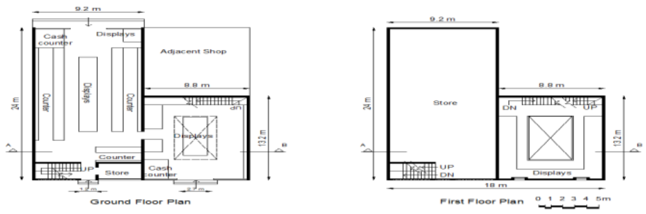


Fig. 9.Floor plans of two amalgamated buildings of T-C02-02.

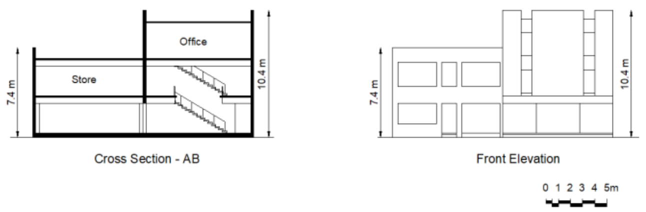


Fig. 10. Section and Elevation of T-C02-02.

VII. BUILDING EXIT CAPACITY ANALYSIS

The documented buildings in each Typologies were analyzed for exit capacities based on the norms of NBC 2016 part 4 -Life safety [11] for calculating the capacities of exits, occupant load for occupancy types are determined as in Table-II: Occupant load of NBC 2016 part 4.

Table- II: Occupant Load

Occupant Load as per NBC 2016	
Group of Occupancy	*Occupant load factor (sq.m/person)*
Group F:Mercantile	
a) Street floor and sales basement	3.00
b) Upper sales floor	6.00
c) Storage/ warehouse, receiving and the like	20.00

The below Table - III shows the calculated occupant load or number of occupants in the selected buildings.

Table- III: Building Occupancy Load Calculation

Occupant Load Calculation as per NBC 2016				
Typology	*Floor Level*	*Building Area in sq.m (A)*	*Occupant load (Floor Area in sq.m per Person) (B)*	*Total Number of Occupants (C) = (A/B)*
T-C01-01	Ground	303.55	3	101
	First	290.55	6	48
	Second	290.55	6	48
	Total			**197**
T-C01-02	Ground	372.37	3	124
	First	372.37	6	62
	Second	372.37	6	62
	Total			**248**
T-C02-01	Ground	171.48	3	57
	First	171.48	6	29
	Second	171.48	6	29
	Total			**115**
T-C02-02	Ground	336.72	3	112
	First	336.72	6	56
	Second	119.22	6	20
	Total			**188**

Though the above table gives a theoretical figure the actual occupants vary during peak hours of business as in Table –IV.

Table- IV: Building Occupancy Actual

Typology	*Total Number of Occupants Calculated as per NBC 2016 (C)*	*Actual Occupant[a] (D)*	*Increase (D-C)*	*Remarks on increased Occupants load*
T-C01-01	197	220	83	Demand
T-C01-02	248	267	19	Festival shopping
T-C02-01	115	163	48	Reputation/ offers
T-C02-02	188	192	4	Reputation/ offers

[a] The actual occupants are taken based on field studies conducted over a period of 1 week.

The capacity of exits or capacity factors for mercantile group is expressed as width per person in mm. The capacity factor mercantile group as per NBC 2016 is 10mm for stairways and 6.5mm for level components and ramps. [11]. The calculated minimum exit widths of all the typologies are as in Table –V.

Table- V: Minimum Exit Width Calculation

Minimum Exit width required as per NBC 2016			
Typology	*Actual Occupants (D)*	*Capacity factors –Exit Width by door/ stair per person in m as per NBC 2016 (E)*	*Minimum exit width required in m (D x E) (F)*
T-C01-01	124	0.0065	0.81
	56	0.0100	0.56
	40	0.0100	0.40
			1.77
T-C01-02	142	0.0065	0.92
	72	0.0100	0.72
	53	0.0100	0.53
			2.17
T-C02-01	65	0.0065	0.42
	54	0.0100	0.54
	44	0.0100	0.44
			0.98
T-C02-02	95	0.0065	0.62
	65	0.0100	0.65
	32	0.0100	0.32
			1.59

Table- VI: Building Exit Widths difference

Typology	*Minimum exit width required in m (F)*	*Actual exit width available in m (G)*	*Exit width difference in m (G -F)*	*Exit width difference in percentage*
T-C01-01	1.77	1.20	-0.57	32%
T-C01-02	2.17	1.80	-0.37	17%
T-C02-01	0.98	1.07	+0.09	Surplus 9%
T-C02-02	1.59	6.60	+5.01	Surplus 215%

Exit Width differences in Table-VI reflects shortages in two samples and surpluses in the other two samples.

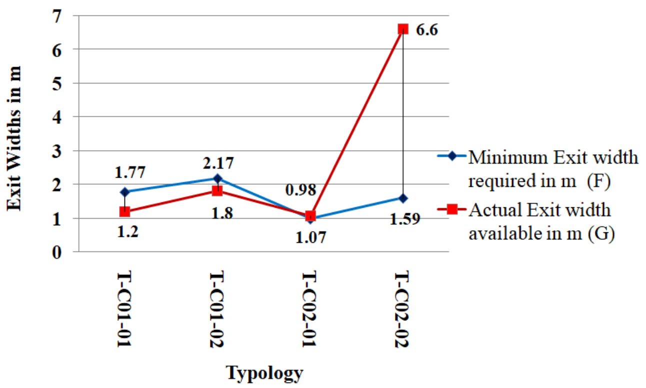


Fig. 11. Exit Widths analysis

Though exit widths analysis of two commercial buildings T-C01-01and T-C01-02 show a minimal shortage of 0.57m and 0.37m in Fig.11 they do not have alternate exit routes and fire stairs.

Retrieval Number C4791098319/2019©BEIESP
DOI: 10.35940/ijrte.C4791.098319
Journal Website: www.ijrte.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

The exit width shortages in percentages are 32% and17%. The commercial building T-C02-01 has surplus exit width in ground but upper levels lack fire stairs. Surplus exit widths are observed in T-C02-02 and the reason is due to amalgamation of two shops in T-C02-02. This has increased the number of exits and alternate routes which are safer egress and can perform better in an emergency situation.

VIII. MEANS OF EGRESS AND TRAVEL DISTANCE ANALYSIS

Means of Egress and Travel distance are important aspects of Building accessibility. Means of Egress is a continuous and unobstructed way of travel from any point in a building to a place of comparative safety. Travel distance is the distance to be travelled from any point in a building to a protected escape route or final exit. Travel distance for escape during a fire emergency is a challenge in buildings modified due to urbanization in old towns [10]. The Maximum travel distance for Type 1 and 2 constructions as per life safety norms of NBC 2016 for Educational, Institutional and Mercantile occupancy is 30m. [11] The difference in Travel distance between norms and actual distance are shown in Table VII.

Table- VII: Maximum Travel distance analysis

Required Travel distance analysis as per NBC 2016				
Typology	*Maximum travel distance in m as per NBC 2016 (H)*	*Actual travel distance in m (J)*	*Travel Distance shortages in m (J-H)*	*Travel Distance shortages in percentage*
T-C01-01	30	44.5	14.5	33%
T-C01-02	30	56	26	46%
T-C02-01	30	35	5	14%
T-C02-02	30	30	NIL	NIL

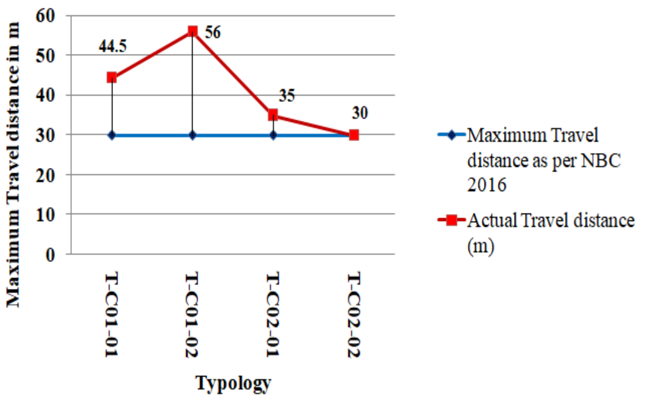


Fig. 12. Travel distance shortage analysis

A notable observation as in Fig.12 is that an increased travel distance is evident in all the selected commercial shops except T-C02-02. Also fire stairs are not present excepting T-C02-01where there is a possibility of converting an existing stair in to a fire stair as it is connecting all levels externally. Hence a shortage in exit width distances ranging from 14% to 46% in Table VII and lack of alternate exit routes are detrimental factors for the building failure during a fire emergency.

IX. BUILDING EGRESS RISK FACTORS

Based on reconnaissance survey and detailed documentation of five buildings in *Kumbakonam*, the commercial buildings have high combustible contents, obstructions in escape passages and risk of critical evacuation during peak business hours. Combustible contents in store rooms and warehouses of commercial spaces increase the fire load. The obstructions in escape routes decrease the effective widths. The continuously built commercial buildings are at an increased risk in the event of fire spread from adjacent buildings due to lack of setbacks.

The risk factors pertaining to building egress are shown in Table-VIII

Table-VIII: Building Egress Risk factors

Building / site Elements	*Identified issues*	*Risk Factors*
Exits and Stairs	• Entry and Exit routes in the building are same • Exit width of stairs do not comply with fire safety norms • Insufficient and improper distribution of stairs • Single stair for exit and lack of Alternate exits • Stairs are not Fire stairs	• Difficulty in evacuation • Delay in travel time • Congestion of occupants • Congestion of occupants
Setbacks	• Wall to wall construction • Narrow setbacks • Lack of ventilation	• Easy spread of fire to adjacent structures • Easy smoke engulfment • Narrow setbacks inappropriate for means of egress
Internal Circulation	• Insufficient circulation widths • Obstructive materials in escape route • Poor internal arrangement	• Congestion in an emergency

X. FINDINGS AND DISCUSSIONS

Based on the study carried out on commercial developments in core area of kumbakonam town, buildings with narrow width against medium to very deep depth were identified.

The geometry of the buildings followed the land parcels without setbacks. These buildings are partial modifications of traditional buildings or demolished and rebuilt with modern materials and needs. The natural lighting and ventilation in traditional buildings are replaced with artificial lighting and ventilation in the phases of modification. The need for increased luminance and comfort has changed the spatial characters Facades are rebuilt with modern materials and building heights are increased. An increased occupancy load is observed due to change in land use from residential to commercial use. These changes are process of urban evolution which are adaptations to growing demands in commercialization.

The critical aspects in these buildings were verified with the norms of NBC and presented. Study carried out in these buildings reveal the existence of insufficient exit widths, increased travel distance and ineffective means of egress which are related to evacuation risks during a fire event. An important observation for increased travel distance is lack of alternate exits as there are no setbacks. The feasibility of providing alternate routes or exits is a constraint as the traditional buildings were constructed wall to wall. Also the risk of fire transmission from neighboring buildings is on the higher side [9]. Majority of the buildings have a single entry that acts as the only exit also. In the unlikely event of a fire the evacuation time will be on the higher side due to single or insufficient exit capacities and obstructed escape routes. As a suggestive measure the development control regulations by statutory authorities shall focus on restricting high occupancy developments on minimum width to linear depth land parcels. The nominal width can be outlined in development control regulations for such high occupancy developments. Amalgamation of neighboring land parcels can be encouraged where alternate emergency exits are feasible. This favorable development is seen in the study sample T-C02-02. Advanced fire control technologies and mechanical installations can control fire spread and reduce fire risks.

XI. CONCLUSIONS

Based on the study carried out in the traditional town *Kumbakonam,* it is evident that an understanding of physical changes in built form is imperative. Old residential buildings are modified to suit the demands of growing urban built environment which compromises fire safety. Evolution of Buildings in linear land parcels into multiple occupancies that share common narrow lanes and high occupancy load buildings like showrooms with single or inadequate exits are ineffective in an emergency evacuation. The study identified higher occupancy commercial buildings with insufficient exit widths posing risk to the occupants in the event of an evacuation. Building accessibility risk factors related to means of egress in identified typologies are on the higher side as per fire safety norms. The conclusion of this research is that maximum travel distance and sufficient exit widths are important parameters in reducing evacuation risks for the occupants in continuously built buildings of core area of *Kumbakonam*. There are other parameters related to fire ignition like fire load, space between buildings, building condition and parameters related to fire propagation like fire compartmentalization, combat, fire detection, alarms that increase fire risk and can be taken up in further researches. Typology classification in traditional towns like kumbakonam can improve the perception of associated fire risk while preparing for fire risk mitigation at an urban scale. There is a scope for development of Innovative solutions to address the Fire risk in identified typologies of urban areas of traditional towns.

REFERENCES

1. Ferreira, T., Vicente, R., Raimundo Mendes da Silva, J., Varum, H., Costa, A. and Maio, R. (2016). Urban fire risk: Evaluation and emergency planning. *Journal of Cultural Heritage*, 20, pp.739-745.
2. Santos, C., Ferreira, T., Vicente, R. and Mendes da Silva, J. (2013). Building typologies identification to support risk mitigation at the urban scale – Case study of the old city centre of Seixal, Portugal. *Journal of Cultural Heritage*, 14(6), pp.449-463.
3. Pauls, J. Fire Technol (1984) 20: 27. https://doi.org/10.1007/BF02390046
4. Hassanain, M., Hafeez, M. and Sanni-Anibire, M. (2017). A ranking system for fire safety performance of student housing facilities. *Safety Science*, 92, pp.116-127.
5. Waheed, M. (2014). Approach to Fire-related Disaster Management in High Density Urban-area. *Procedia Engineering*, 77, pp.61-69.
6. Kobes, M., Helsloot, I., de Vries, B. and Post, J . (2010). Building safety and human behaviour in fire: A literature review. *Fire Safety Journal*, 45(1), pp.1-11.
7. The Hindu. (2011). *Chennai's vanishing agraharams*. [online] Available:https://www.thehindu.com/features/homes-and-gardens/chennais-vanishing-agraharams/article2518383.ece
8. Murali. P, M. and Vijayalakshmi, D. (2014). Fire Accidents in Buildings – Case Studies. *International Journal of Engineering Trends and Technology*, 11(4), pp.178-184.
9. Fire Safety Design in Buildings. (1996). Ottawa,Ontario,Canada, pp.73-74.
10. Biao, Z., Xiao-meng, Z. and Ming-yong, C. (2012). Fire protection of historic buildings: A case study of Group-living Yard in Tianjin. *Journal of Cultural Heritage*, 13(4), pp.389-396.
11. National building code of India, 2016. (2016). 2nd ed. New Delhi: Bureau of Indian Standards, p.Part 4.
12. En.wikipedia.org. (2018). *Kumbakonam*. [online] Available at: https://en.wikipedia.org/wiki/Kumbakonam.

AUTHORS PROFILE

Ramesh Babu Natarajan, B.Arch, M.T.P Associate Professor, Department of Architecture, Periyar Maniammai Institute of Science and Technology, Thanjavur, India

Publications:

1. N.Ramesh Babu, Changing quality of aesthetics of urban spaces: A case study of Traditional towns of south India, Thanima 2, “2nd International Conference on Design Pedagogy & Contextual Aesthetics 2017”, NIT Calicut, 19th-21st January 2017.
2. N.Ramesh Babu, Building Typologies for fire risk mitigation at urban scale ,“International Conference on Sustainable
3. Technologies in Building & Environment 2018”- Sathyabama Institute of Science and Technology, 23rd -25th January 2018.
4. N.Ramesh Babu, 2016“Infrastructure Management of Cities through Automation.”, International Journal of engineering sciences and research technology, 5 Issue 3 “March-2016” issue.

Dr.P.Jayasudha, M.Arch, PhD, Professor, Department of Architecture, Periyar Maniammai Institute of Science and Technology, Thanjavur, India

Papers Published:

1. Jayasudha, P, Dhanasekaran, M, Monsingh D Devadas & Ramachandran, N 2013, 'Study on Sustainable Design Principles of a Vernacular Dwelling in Thanjavur Region of Tamilandu, India', Indian Journal of Traditional Knowledge.
2. Jayasudha, P, Monsingh D Devadas & Ramachandran, N 2011'Proposing a rural cluster as a Sustainable Land use Model to assess the concept of Pura' in the Conference Proceedings'Green Cities: Design, Planning And Management –ICGCDPM'

Papers presented in Conference Proceedings:

3. Jayasudha, P 2005, 'Temple Fortress Technology' in the National Level STTP organized by Tamil University, Thanjavur.
4. Jayasudha, P 2007, 'Rural Tourism', National Conference on Tourism and Architecture, Thiyagarajar College of Engineering, Madurai, India.
5. Jayasudha, P, Monsingh D Devadas & Ramachandran, N 2011, 'Proposing a rural cluster as a Sustainable Land use Model to assess the concept of Pura' International Conference on Green Cities: Design, Planning And Management (ICGCDPM2011), MANIT, Bhopal, India.
6. Jayasudha, P 2012, 'Seismic Design Principles – Lessons from the Vernacular Architecture', National Programme on Capacity Building for Architects on Earthquake Risk Management (NPCBAERM), NIT, Trichy.
7. Jayasudha, P, Monsingh D Devadas & Ramachandran, N 2012, 'A study on Vernacular Settlements in Thanjavur District, Tamil Nadu, India and Assessing its Suitability in Modern Context', 5th International Congress on Environmental Research, UMT, Kuala Terengganu, Malaysia.
8. Jayasudha, P, Monsingh D Devadas & Ramachandran, N 2013, 'Understanding Sustainable Vernacular Design Principles As A Solution To Disaster Resistant Architecture', International Conference on Disaster Mitigation and Management towards Sustainable Development, Periyar Maniammai University, Vallam, Thanjavur, India.
9. Jayasudha, P, Dhanasekaran, M, 2014, 'Thermal Performance Assessment of a Vernacular Residence in Thanjavur Region' in the International Conference on Innovative Research and Solutions (ICIRS 2014) held at Pondicherry organized by JIRAS Journal and Bharath University, Chennai, April 12, 2014.

Retrieval Number C4791098319/2019©BEIESP
DOI: 10.35940/ijrte.C4791.098319
Journal Website: www.ijrte.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication