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"Navigating Live Loads in Building Design: Challenges and Considerations in Assessing Realistic Usage and Occupancy Scenarios"

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Abstract: *Residential terraces are essential components of many buildings and offer useful outside areas for gatherings, lounging and other various activities. Terraces are frequently crowded with items like planters, chairs, tools, and other gym equipment. It is essential to ensure their structural integrity and safety, especially when they are subjected to live loads from people, furniture, and equipment. This study examines the actual live loads on terraces and contrasts them with the statutory requirements given in various construction codes. The goal of the study is to give a thorough understanding of how well the current standards deal with live loads on terraces and to make adjustments where they are called for.*

Key Words**: Live Load, Terrace, Usage and Occupancy, Various codes**

1.INTRODUCTION

The utilization and occupancy of any building give rise to various live loads, encompassing forces generated by individuals using the space, furniture, non-fixed equipment, storage, construction and maintenance activities. These loads, which place a great deal of strain on floors, roofs, and supporting components during construction, are the result of scheduled activities, material stacking, mechanized operations, or propping. Additionally, dynamic loads from moving objects like people and planters, along with maintenance-induced loads from personal, tools and materials, impact regular-purpose roofs. Despite the critical importance of accurately assessing these live loads, there exists a lack of consensus within the architectural and engineering communities regarding the precise values that should be applied. This article delves into the complexities of live load analysis, exploring the challenges faced in determining realistic live loads for diverse building types and structures. By examining real-world usage scenarios, this study aims to shed light on the discrepancies and uncertainties in live load calculations, offering insights into the crucial considerations architects and engineers must weigh when ensuring the structural integrity and safety of buildings.

1.1 LITERATURE REVIEW

The existing literature predominantly delves into live loads concerning various building elements and constructions, yet there is a noticeable gap in research dedicated to terrace live loads. Although prevailing building codes like the International Building Code (IBC), Eurocode, and National Building Code of India (NBC) offer directives for computing live loads on terraces, their applicability to real-life scenarios is questionable. These codes, while serving as essential guidelines, might not consistently mirror the genuine loads encountered in practical situations. This disparity highlights the necessity for in-depth exploration and analysis specifically focused on terrace live loads, bridging the existing gap between theoretical standards and the authentic demands of terrace structures in urban environments.

2.METHODOLOGY

The roof slabs are designed to support a dead load (DL), a live load (LL), or an imposed load (IL). According to BIS 875 part 2, the live loads were calculated at 1.50 kN/m^2. In the current situation, roof slabs are being used for roof gardening without any notice being given during the design phase or after construction, which causes excessive deflection and water to pool on the slab. The loads for terrace finish and new construction techniques also differ, thus a study of the live load is necessary. To investigate realistic live loads on terraces, this study conducted field measurements in various settings, including residential buildings, commercial complexes, and recreational facilities. Monitoring occupancy patterns, furniture arrangement and terrace usage were all part of the data collection process. The elements that are placed on terrace includes Patio Furniture, planters and pots, umbrella or shade structures, outdoor appliances, gym equipment ,Air Conditioner and people. The values of minimum and maximum load of these elements are given in table 1

Table 1: Weight of various objects placed on terrace

Terrace Element	Minimum Load (kN)	Maximum Load (kN)
Patio Furniture		
Chair	0.5	2
Table	1	4
Lounge Chair	1	3
Planters and Pots		
Small Planter	0.5	2
Medium Planter	1	4
Large Planter	2	6
Umbrella or Shade Structure		
Small Umbrella	0.5	1
Large Umbrella	1	3
Shade Structure	2	6
Outdoor Appliances		
Grill	0.5	2
Outdoor Kitchen	2	6
Refrigerator	1	3
Exercise Equipment		
Treadmill	1	3
Exercise Bike	0.5	1.5
Weight Bench	0.5	1.5
Air Conditioner		
Outdoor unit	0.5	2
Solar water heater	2	5
Solar Panels	0.5	3
People		
Pedestrian Load	1.5	2
Crowded Event	2	4
Cleaning Equipment's	0.5	1

A planter-filled residential patio with furniture is shown in Fig.1. A residential terrace brimming with air conditioning units is shown in Fig.2. Imposed loads and live loads according to various codes are shown in Table2.

Fig:1 A residential terrace loaded with planters and furniture

Fig:2 A residential terrace loaded with AC units

Table 2: Live Load / Imposed loads as per various codes.

Country	Codal Provision	Roof Live Load (kN/m²)
India	IS 875- 2	1.5
United States	International Building Code(IBC)	1.9
Europe	Eurocode -EN1991 - 1	2.5
Australia	AS 1170-1	1.5
United Kingdom	BS 6399-1	1.5
Canada	NBCC	2.5

Fig 3 shows the visual representation of the load on roof as per various codes.

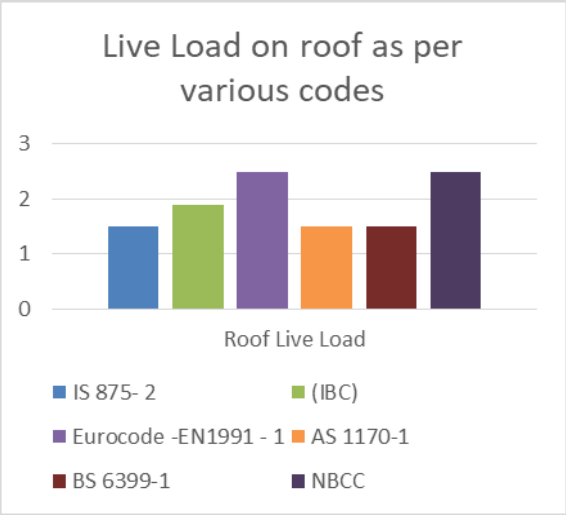

Fig 3: Live Load on roof as per various codes.

2.1.COMPARATIVE ANALYSIS

The collected data were compared with the live load requirements specified in different building codes. The study considered variations in occupancy density, furniture types, and usage scenarios. Key findings include:

2.1.1. Occupancy Density: The occupancy density observed on terraces often exceeded the values recommended by building codes, indicating the need for higher live load allowances.

2.1.2. Furniture Loads: The weight of furniture and equipment placed on terraces significantly influence the total live load. Existing codes may not adequately account for the variety and weight of furniture items.

2.1.3. Usage Patterns: The study identified seasonal and cultural variations in terrace usage, leading to fluctuating live loads. Building codes should consider these factors for more realistic load calculations.

The practical urban scenario load is calculated and tabulated in the table 3.

S.No	Type Of Building	Actual Load (kN/m²)
1.	Residential	2.9
2.	Commercial	3.5
3.	Institutional	4.0

Table 3: Actual Live Load / Imposed loads on terrace / roof

2.2.DISCUSSION

The comparison analysis draws attention to the differences between the real live loads on terraces and the statutory provisions. To guarantee safety, building rules often prescribe conservative load estimates, however these numbers might not necessarily correspond to actual situations. The table 2. shows that codes carry lighter burden than the real objects stored on the terrace.

3.CONCLUSION

In summary, this research article illuminates the actual live loads experienced by terraces, contrasting them with the stipulations outlined in various building codes. The findings underscore the necessity for a more nuanced and comprehensive approach to terrace design, one that transcends conventional code limitations. By refining the precision of live load calculations, structural engineers possess the means to elevate both the safety and functionality of terrace structures, thereby enhancing the well-being of building occupants. The study strongly advocates for further research and collaborative efforts among industry professionals and regulatory bodies. With urbanization driving the trend of storing numerous items on terraces, our study suggests a revision of existing codes to accommodate these increased loadings. Crucially, we emphasize the importance of verifying the weight of every item before placing it on a terrace to guarantee its safety and prevent it from surpassing the terrace's weight capacity. This precautionary measure is fundamental in safeguarding both the structural integrity of the terrace and the safety of individuals utilizing the space.

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