Risk Assessment and Challenges Faced in Repairs and Rehabilitation of Dilapidated Buildings

Khan Sahil Waquar[1], Karthik Nagarajan[2], Raju Narwade[2]

1. P.G. Student, Department of Civil Engineering, Pillai HOC College of Engineering and Technology, Rasayani, University of Mumbai, Maharashtra, India
2. Associate Professor, Department of Civil Engineering, Pillai HOC College of Engineering and Technology Rasayani, University of Mumbai, Maharashtra, India

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ABSTRACT

The use of concrete as parent material is now an old technique, but it is widely used today due to its unique characteristics. India has witnessed development in the construction field from Harappa civilization to the British era for many years. Even after independence, in 1947, India has advanced in construction techniques in concerning time. However, improper management, design, and ignorance of repairs and rehabilitation of structure cause the collapse of buildings which causes many deaths to occur every year in Mumbai and throughout the country. But the people living in dilapidated buildings risk their lives. Many people are constrained to live in them due to various reasons like skyrocketing rise in real estate prices, fear of losing their houses after vacating for redevelopment projects. Repair and rehabilitation are significant for preserving the structure's capacity and increasing its performance capacity, which deteriorates due to aging factors, environmental factors. The recent collapse of the building named Tarique Garden in Mahad caused the deaths of 20 people. Considering this as a manufactured disaster, it made a national highlight seeking the attention of mainstream media. A sample space of buildings from buildings in khed city, about 200 km from Mumbai, is taken as a research area as this is a developing city near Mahad city where the incident occurred. This paper aims to determine the various risks involved in dilapidated buildings by studying various health and safety factors that affect the age of the building. This research also focuses on scrutinizing various problems faced by the residing people in dilapidated buildings. The methodology adopted in this research is by doing unstructured interviews with a questionnaire survey of tenants, performing field surveys of various structures in the study area, and segregating the buildings based on the building's various safety and hygienic conditions. The result shows the DI (Dilapidation index) score, which is done based on the comfort level of tenants. Finally, this research signifies accomplishing various action plans taken by government authorities towards dilapidated buildings and proposing some suggestive measures that would help minimize such accidents.

1. Introduction

Due to globalization, the risk is an integral part of everyday life, as it is present everywhere in every aspect of our lives. There are two sides to a coin when tossed; there is a probability of getting either head or tail; thus, we can justify the risk involved even while tossing a coin. When there is no knowledge or precognition about the outcomes, and the activity results are risks. Risk management is the type of management that includes planning, identifying, analyzing, planning, monitoring, and controlling the complete projects. The varied stages in risk management are: - risk identification, risk classification, risk analysis & response to the risks: the risk management study and its usage in small construction projects, large construction projects, infrastructure projects. Every construction project is unique in its characteristics as the aim, and the purpose of every structure differ. Therefore, we can simplify that risks are not only involved during the construction of structures but also involved in the maintenance, repairs, and rehabilitation of the structures. Evolution in the structure materializes when the structure starts to accomplish its purpose.

Globally, over the years, it has been observed that countries like Brazil, Bangladesh, China, Egypt, South Korea, Iran, Japan, Nigeria, Kenya, Pakistan are facing problems of building failures and collapse, which causes the death of many people worldwide.

Fig. 1. A woman rescued from rubble from a building collapse in Nairobi.[36].

Building collapse is also a common phenomenon in Nairobi, which is the capital of Kenya. In view of the collapse, the country's president had ordered to do a structural audit of the buildings to know that if strength was up to the code where it resulted, 58 percent of the buildings were unfit for the habitation of the people [37]. Similarly, in May 2021, one of the tallest sky scrappers in Shenzhen, China, about 300-meter high, named SEG Plaza, inexplicably began to shake, which created panic among the people. Building collapses are not rare in china too, where lax building standards and breakneck urbanization lead to the construction done rapidly without maintaining standards. In the year 2008 Sichuan earthquake devasted China by causing about 69,000 deaths making the collapse of many buildings and schools causing the deaths of thousands of students[38]. South Korea is also widely affected by the problem of building collapse. The structural failure of the sampoong departmental store in the year 1995 caused 502 deaths and called a peacetime disaster [39]. In 2013, there was a collapse in a nine-story Rana plaza building, also known as the Dhaka garment factory collapse, which killed more than 1,100 workers, and injuries of about 2,600 people as slated the deadliest structural failure accident in modern human history. [40] In India, such incidents of collapse often occur. The metro cities in India like Delhi, Kolkata, Mumbai, Pune are the ones that are adversely affected due to this problem of the collapse of buildings. Thus, the buildings that have entirely lost their compressive strength to such an extent due to disrepair or damaged conditions are likely to collapse, which jeopardizes people's lives in the building called dilapidated buildings. Due to urbanization from the past 60-70 years,

development in Mumbai, its suburbs, and adjacent regions like Palghar, Raigad, and Ratnagiri. The rail connectivity of Mumbai and areas adjacent to it spread across 390 km, where 7.5 million commuters travel daily, which is one reason for urbanization. Over the years, several people living in residential buildings in Mumbai risk their lives by living in dilapidated buildings, citing various reasons. The city has many such dilapidated buildings, where people live without any choice left to them, and despite various efforts, the tenants do not get justice. There are more than 16000 dilapidated buildings alone in Mumbai, which subcategorizes in C1, C2, C3, where C1 are the buildings that cannot be repaired and should be razed at the earliest as they are unsafe to stay, C2 & C3 category are the buildings which need major and minor structural repairs respectively. Since 2013,300 deaths occurred, and such accidents in Mumbai stand at 3945.[41] [42].

Fig. 2. The collapse of Tarique garden building in Mahad Maharashtra, India.

Thus, this paper intends towards risk assessment of dilapidated buildings considering it indispensable.

2. Literature review

It was studied in the introduction that risk management is the systematic process of identifying, analyzing, and responding to the risk of the project. As every coin has two sides and has two probable outcomes & outcome is unknown as there is risk in tossing a coin. Repairs & rehabilitation of the structure is part of civil engineering, which has increased considerably in the last few decades. Numerous research work defines & access risk analysis and management for new construction projects and small construction projects. There is a restricted study carried on risk analysis of repairs of existing buildings or structures. Concerning this research, many research papers reveal a thesis published in reputed journals.[1] O'Flaherty et al., in their research study on Abandoned Buildings: a stochastic Analysis, made the study on abandoned buildings or dilapidated buildings in the United States of America, their life cycles study of old buildings their performance. [2] Reynaldo M. Pablo Jr projected his study on the Risk assessment of highway bridges: A reliable-based approach adopted to study the deteriorating bridge networks due to aging and growth of vehicular loads in magnitude and volume. The study of dead load effect statistics and live load statistics done along with its load-carrying capacity. [3] B Videvelli et al. focused on Risk assessment and management in construction projects. The outcome was on the survey questionnaire conducted by various bridge project construction and project managers of different sizes. The study was to identify risk factors that affect the performance of the bridge project as a whole and analyze by using appropriate tools and techniques and developing a risk management framework. [4] Meenu Mariyam Rajan focused on Risk assessment and management on small construction projects and determined the details of the

project with pilot studies and identification with data analysis with Reliability tests analysis of risks with the on-field survey. [5] J. Bhattacharjee, in his research on repair, rehabilitation & retrofitting of RCC for sustainable development with case studies, made a study of maintenance, repair, and rehabilitation, causes of deterioration of structures, method of repair and rehabilitation, a study on repair material, and techniques, case studies, and remedial measures. The author of the paper was directly involved in the planning and execution of the job. [6] Diwan Usama did his research on Managing retrofit projects. The study of the paper revolves around the present properties of concrete of the existing buildings. Its inadequacy of design towards earthquakes. The study of the paper highlighted principles of assessing and retrofitting techniques against seismic events during earthquakes, the investigation of the performance of the building by the finite element method. [7] Karthik Nagarajan et al. here, the author has used structural software such as Etabs and Staad to understand the loading patterns that cause cracks and fractures at the beam-column junction, rectifying loads redistributed across other members without causing and repair works in the future. [8] Pawel Szymanski made his research study on risk management in construction projects where the phases of the risk management cycle and identification of the project done according to the phases of the risk management cycle. The importance of risk various types of risks is studied where various stages probabilities were studied. [9] Rupalee Dharampal Sukhadeve, in her research on risk management in an infrastructure project in her research, undertook various factors in the completion of the infrastructure project. It included a study about various risks involved during the execution of work, classification of risk. [10] Ehab Solimanin, his research on risk

identification for building and maintenance projects, studied various risks involved in maintenance projects where he scrutinized risks involved by the questionnaire survey design, designed for the engineers and contractors working on the maintenance projects. [11] Rohit Newale et al., in their study on structural audit repairs & rehabilitation of buildings, focused on Structural audit of building with case studies it had various causes of deterioration, maintenance its importance. The paper evolved around to find types of structural defects, signs of material deterioration, signs of material distress, identification in properties of the existing concrete structure. [12] MihirPatilhande et al. this project emphasizes rehabilitation of a small village near Dasgaon in Maharashtra wherein the whole village hutments were destroyed due to landslides a decade before. Using a simple architectural and structural approach, the authors have constructed a load-bearing structure bound to take loads without any structural failures. [13] Sunilkumar Patel et al., during rainfall, the leakage of building leads to carks and repairs plays a vital role in the future life of the building. This project deals with blue roof technology. The author has collected the rainwater from the building roof and has taken it safely to the drainage pipelines without causing any crakes or leakages. [14] Ramesh B. et al., in their research on risk management in construction, identified the impact of risk management on the completion of successful construction projects, identifying the nature of the relationship between implementing effective risk management and construction project success. [15] Vinod vanvari et al. focused on the redevelopment of buildings in Mumbai city: Risks and challenges. The study focused on the risks in redevelopment projects in Mumbai. The study covered the study of risks, pitfalls, uncertainties, and challenges in redevelopment projects. It analyzed the level

of risk of redevelopment projects. [16] In his topic of A review on "Structural audit of residential buildings," Gaurav Sanjay Shinde focused on the need for a structural audit of the buildings and study of various NDT testing's done on residential buildings. [17] Okey Nwanekezie made his study on the "causes of uncompleted building projects and its effect on real property in Uyo metropolis, Nigeria." He detailed the effect on the property values from the estate surveyors' and valuer's perspectives. He made a pilot study and identified eleven factors on that basis made a questionnaire survey to the valuer's and real estate professionals, thus gave results such as wrong estimates of promoters, inflation, inadequate finance, incompetent project manager, natural disaster, political factors were some of the reasons of the causes of abandoned buildings. [18] Arya Vijayan et al. considering the importance of changes that the structures have in the future, the author has used IoT technique to manage the water leakage caused in the building, which later causes cracks and fractures and brings in the repair in a large amount. [19] Biradar Shilpa et al. here in this research, the author has created a smart material using E-waste concrete wherein the strength of the structure increases, increasing the life of the structure, thus reducing the repair works that may lead to the rehabilitation of the structure in the future. [20] Chowdary Mohanlal et al., this author has taken paramount efforts in using special software for managing the material management by which the optimization of the project can be done in the present and future using 4D GIS. [21] Chhaya Zende et al. here, the author under Swachh Bharat Abhiyan, has used recycled formwork wherein the member's strength during the construction phase is maintained well due to the good quality of materials used. [22] Mahesh S. Singh et al. recent methods such as the RII method are considered in this

research by the author for labour productivity of the masonry to maintain quality management and hence leads to better life of the structure reducing the repair works. [23] Pradhnya Patil et al., here the author emphasizes the NDT test to verify the strength of the members before repair works, hence verifying the life much before repair works are applied. [24] Pallavi Patil et al. considering the number of works needed in construction sites, the author has used the RMMM method to be applied in smart buildings with deeper effort in analyzing the cracks and weaknesses of members. [25] Divyashree Yadav et al. this research focuses on repairing the urban road using automatic road extraction techniques from satellite data by a fuzzy logic method. [26] Shrenik Shah et al., in this paper, carried detailed work on urban utility; at the same time, the construction was carried out in the initial phase using 3D modeling methods, which further utilizes the technique for repairs and rehabilitation detection. [27] Tanvi Nijampurkar et al. a good effort shown by the author using fuzzy logic classification method in the repairs and maintenance of road construction using satellite data. [28] Pranav Andhyal et al. here the author uses 5D CAD analysis for the estimation and billing purposes of the building, which can be cross verified with the repair works in the future to get the estimates in detail. [29] Atiye Farahani et al., in their study of the time-dependent structural behavior of repaired corroded RCC column in the marine site, concluded that the significant reason for premature deterioration and failure of R.C. structures in aggressive environments such as the Persian Gulf region is chloride corrosion in the steel. A finite element model was applied in the study to assess the time-dependent capacity of corroded R.C. structures applying nonlinear analysis; this includes the impact of corrosion on inelastic buckling and low-cycle fatigue degradation

of reinforcements. In this analysis, the author investigated shotcrete repair after the initial cracking of concrete cover as a rehabilitation method on a corroded square R.C. column's performance due to chloride-induced corrosion.[30] Daneshvar, M., Gharighoran, A., Zareei, S., Karamodin, A. made a detailed study on the 'Damage Detection of Bridge by Rayleigh-Ritz Method,' The paper is devoted to proposing a new and effective method for detecting, locating, and quantifying beam-like structures. This method is based on the RayleighRitz approach and requires a few natural frequencies and mode shapes associated with the undamaged and damaged states of the structure. The great advantage of the proposed approach against the other methods is that it considers all kinds of boundary and damping effects. This article considers lumped rotational and translational springs to determine the boundary conditions to detect damage using the penalty method. The results indicate that the proposed method is an effective and reliable tool for damage detection, localization, and quantification in the beam-like structures with different boundary conditions even when the modal data contaminated by noise. [31] Lale Arefi, S., Gholizad, A., Seyedpoor, S. in his research of 'Damage detection of Structures using modal strain energy with Guyan reduction method' made a detailed study of structural damage via an index based on MSE and reconstructed mode shapes. The author utilized the guyan reduction method (GRM) to reconstruct the mode shapes. Therefore, in the first step by employing GRM, mode shapes in slave degrees of freedom were estimated by those of master degrees of freedom. In the second step, the author used the modal strain energy-based index (MSEBI) to find damaged elements and assess the method's efficiency. Identification of damage done by comparing complete mode shapes and reconstructed mode shapes and the results together. The

outcomes show that the combination of MSE and GRM can be useful for structural damage detection when considering the noise. [32] Seyed Hooman Ghasemi and Andrzej S. Nowak, in their study of Reliability index for non-normal distributions of a limit state function, studied that reliability analysis is a probabilistic approach to determine a system's safety level. The main contribution of this paper was to define a sophisticated reliability index for limit state functions whose distributions are non-normal.the new definition of reliability index introduced for non-normal limit state functions according to the probability functions calculated based on the convolution theory. Eventually, this paper introduced a simplified method to calculate the reliability index for non-normal distributions as state-of-the-art and generate a non-normal limit state in normal distributions using Gaussian functions.

The study of risk management and assessment on repairs and rehabilitation projects is very scarce, even though various overwhelming and vast researches done on new construction projects. The repairs and rehabilitation of the buildings are now considered part of civil engineering, which needs to be taken as deep study as various risks are involved in this field.

3. GAPS

There are various studies done in the past decade as people worldwide face the problematic situation. Thus, various gaps found in the above literature review are: - (1) The work was done by the researchers on risk assessment and management of new construction projects. Large construction projects and small projects finalize with proper planning. However, rehabilitation projects reconstructed with no appropriate management systems and without any ethical guidelines and routine might not be a problem but can lead to a fatal risk outbreak

to the project endangering many lives in the buildings. (2) People in developing cities do not know the necessity of repairs and maintenance of buildings; thus, they stay in the buildings without any repairs to the structure and thus may lead to casualties of collapse of buildings. Thus, spreading awareness among the residents in developing cities is very much important. (3) Failures of structures are due to the improper design by the engineer and lousy quality work carried out by the developer as the lands in Konkan areas are mainly on the coastal regulation zone (CRZ). Specialization in the construction technique is required, which, if not done, cause the collapse of the building even before the completion of its purpose. (4) The redevelopment of buildings is directly dependent on the real estate sector, which is highly affected in India since the last decade. The challenges faced by real estate sectors are viz: - lack of clear land titles, inadequate finance, inadequate resources available, inflation, approvals of projects, the impact of "goods and services taxes" in market conditions of real estate, the impact of the introduction of "The Maharashtra Real Estate Regulatory Authority" (MahaRERA) in the year 2016. (5) There are about 300 deaths caused in Mumbai alone with about 4000 accidents of the collapse of either building slabs, columns, beams, walls thus making one of the essential complications since last six years to the people as well as government authorities. The appointment of the team of NDRF (National disaster response force) makes the rescue operations of the people for such accidents as the collapse of the building under the National disaster. (6) Tenants risk their lives by living in dilapidated buildings as they fear losing their claim on flats when they left before reconstruction starts. (7) About 5800 buildings in Mumbai are almost struck where almost 1,25,000 families have rendered homeless in the name of redevelopment. (8) Various studies are done

and observed that several safety indices can measure the system's safety level using reliability and resilience index. However, the author here has to assess buildings in the whole city of khed city. Thus, the used methodology was found suitable with the questionnaire survey conducted with the living tenants solving their fundamental problems.

Thus, these are the gaps found in the studies carried out by the researchers stated above in the literature review. Therefore, the various gaps found are dedicated to fulfilling this research.

4. Study area and problem statement

Considering various problems faced in our society due to the dilapidation of buildings in metro cities like Mumbai, Pune, the adjacent developing areas are also affected due to urbanization and development. This research study focuses on finding the risks people come across by staying in buildings in the Khed city located in Taluka-Khed, District-Ratnagiri, State-Maharashtra, India. Khed is a town with a municipal council in Ratnagiri district in Maharashtra situated on the Mumbai-Goa national highway N.H 66. Khed is the headquarters of khed taluka, which connects the district administration with village administration. The location of Khed is at 17.72°N 73.38°E. It has an average elevation of 82 feet above sea level. The area of the district is 8208 sq. km. The population of the district is 16,15,069. It has nine blocks with nine municipalities: Dapoli, Guhagar, Chiplun, Rajapur, Devrukh, Lanja, Khed, Ratnagiri, and Mandangad. The district has 1543 villages and 844-gram panchayats. The division of Ratnagiri district according to the areas are (1) Coastal area zone, (2) Hill area zone (3) Middle area zone. A collector and district magistrate head the district. A chief officer heads each municipal

council. Khed municipal council came into existence in the year 1948. chief officer heads each municipal council. Khed municipal council came into existence in the year 1948. Located on the banks of the Jagbudi river, which emerges from the Vashisthi river and ends in khopi near khed, is our study area. The river is the inhabitant of mugger crocodiles in it. Figure 3 shows the study area of khed city, the research area of the dilapidated conditions of buildings.
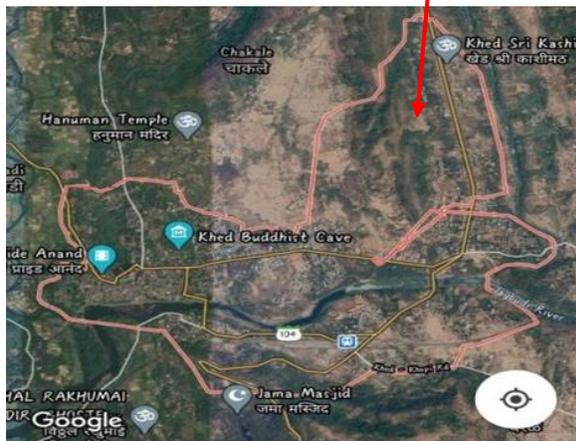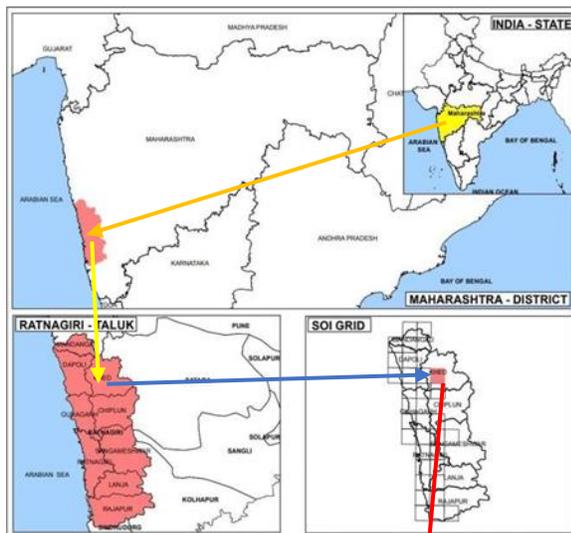

Fig. 3. Satellite view of khed city. [33] [34].

The problem does not lie to Mumbai city alone, along with urbanization and development of areas around Mumbai due to its best connectivity both in roadways and railways, and this problem has been found in adjacent developing areas too; thus, the

people should be made aware of the consequences of their negligence. Faulty designing of structures and negligence towards the quality of workmanship of the construction work according to the required specialization work in water-permeable areas of Konkan thus have endangered many buildings. Moreover, the regions in the Konkan broadly fall in Coastal Regulation Zone (CRZ); therefore, the sites need deep study about the type of projects to be constructed in this zone as these areas are prone to flood every year.

After a detailed study about the history of the research area, we found an incident of collapse of an under-construction building at Mahad-Naka area in khed town, which is also our research area in this paper in 2014, caused the death of one labor and injuries to 9 labors. The leading cause of the collapse was poor engineering and bad artistry where the quality of the material used was below the code, the sand used was not sieved, curing of the concrete members were not performed correctly, and the work was done without any proper supervision [42].

5. OBJECTIVES

Based on the gaps and study area and its problems faced as mentioned above, these are the following objectives assigned for this research; they are vital according to society's need today. Therefore, the study's goals are-
1) To understand problems faced by residing people in dilapidated buildings and reasons for risking their lives.2) To understand various action plans taken by government authorities towards dilapidated buildings and propose some suggestive measures to help minimize such accidents and ensure satisfactory comfort to the people in such dilapidated buildings.3) To scrutinize various risks involved in dilapidated buildings by studying various health and safety factors

that affect the age of buildings.4) To spread awareness among the residing people in the research area, as developing cities, if ignored, may cause building collapse and cause deaths of people with the help of local authorities.

Assignment of these objectives completes this research regarding beneficiaries towards people living in the Khed city, the study area adopting methodology shown in Figure 4.

Fig. 4. The collapse of an under-construction building in khed city in the year 2014.[43].

6. Methodology

Considering the objectives are mentioned above, the methodology adopted for

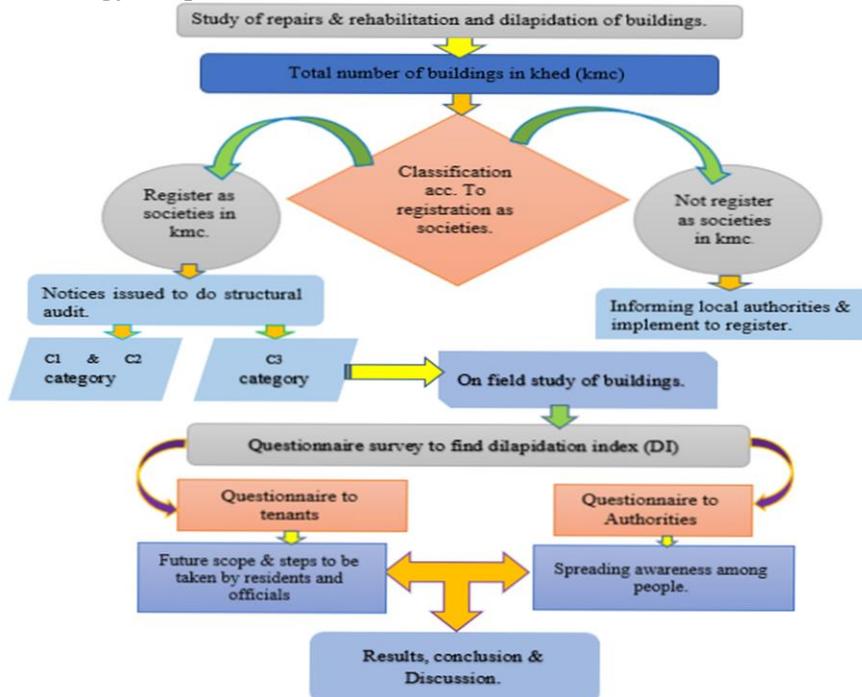achieving them, as showed in tabular form in Figure 5 and subdivided into three major categories:

Figure 5. Flow chart of methodology.

6.1. Classification

The initial stage is to classify the buildings into C1, C2, C3 categories. Next, the buildings are ranked based on their current conditions according to the need for structural repairs, i.e., to demolished, major structural repairs, minor structural repairs, respectively.

The next stage is to study whether the buildings are registered in the khed municipal council or not, which would help understand the legalities of the structure of the building. Finally, the khed municipal council area buildings are classified based on the registration of cooperative housing societies. The buildings that are not registered are made aware of registration. Then, a checklist is submitted to the local authorities to take suitable measures, as shown in the tabular flow chart in Figure 5.

6.2. Questionnaire survey & study using parameters

The buildings in the city are surveyed with the permission of local authorities. The methodology adopted for the research work includes determining health and safety parameters for dilapidated buildings. The survey comprises carrying out detailed information about the history of the building structures. After this, a site inspection is done in the areas that are accessible, i.e., interior area, lobby, to check physical and environmental areas of the buildings. The areas of drainage system water supply are also checked off the buildings. While carrying out inspection, photographs are taken for recording purposes. In addition, the current situation of buildings is taken where cracks, the current state of the structure, spalling of concrete, entry and exit of the building, growth of vegetation, condition of rooms and flats are checked.

Fig. 6. Visiting building for inspection while checking column.

Along with these, tenants are asked for a questionnaire survey by doing unstructured interviews of their own will to understand the present state of the building. With the emergence of reinforced cement concrete and high-speed lifts, control of building volume through the parameters mentioned earlier was too restrictive. Extraordinary loads imposed on the structure are often natural, such as heavy snowfalls on the structures, vibrations in the building during an earthquake, or the high-velocity winds of a storm or cyclone. A building constructed so that to stand for some years should meet these challenges and fulfill its purpose. An insubstantial or fragile flexible structure may withstand collapse in an earthquake, while a solid masonry structure built with stone and load-bearing structure would get collapse quickly. Natural disasters like Earthquakes may cause problems in the structure's foundation when moist or water-filled damp land liquefies water in it. The unexpected failure of the structural members of any structure is the most complex of the structure's collapse. Any

new type of structure is subject to unexpected failure until its unique properties are well understood.

The main reason for the collapse of buildings which contribute to physical damages to the life of the buildings are as follows:

1. Bad design.
2. Faulty workmanship.
3. Foundation failure.
4. Extraordinary loads.
5. Unexpected failure modes.
6. Combination of causes.
7. Improper planning and poor maintenance.

The health and safety factors identified for damage to the structure which should be preferred at utmost importance and repairs to carry out are:

1. Safety conditions: - Visible to naked eyes (spalling of concrete, cracks, roots & vegetation)

2. Hygienic conditions: - Proper sanitation of building, plumbing works, cleaning of water in tanks, pest control.

3. Safety conditions: - Proper electrical meters and wires could lead to fire, proper flood management, gas lines, water supply lines.

4. Building services: - Proper management of lifts, drainage system, backup of electricity.

5. Parking in building: -Adequate parking space available in buildings.

6. Availability of finance: - Arranging funds from society members for monthly or yearly maintenance of buildings.

7. Arrangement of daily cleaning of trash in building remises: - Disposing daily of garbage to local municipal authority by appointing people to collect waste and disposing of the same.

8. Monthly or Yearly inspection of structure visually: - The people residing should regularly check the premises if any damage to the structure.

9. Thus these factors play a vital role in increasing the age of the building and preliminary information about any collapse of the building or any accident that can transpire. These health and safety parameters deliberately focused on the comfort level of tenants in the questionnaire survey, which was conducted in the dilapidated buildings, as shown in Figure 5.

The questionnaire survey conducted among the tenants, and the questions asked with unstructured interviews gives detail about the past and present health of the structures.

1. What is the age of the structure?

2. What is buildings occupancy classification (residential/commercial).

3. What is the mode of construction of the building?

4. How many flats are there in the building?

5. What is the total number of people living in the building?

6. Is the building registered in the municipal corporation?

7. What is the condition of building in the monsoon?

8. Is any water seepage from external walls?

9. Has any accident of spalling of concrete has ever happened?

10. Have any repairs done to the structure yet either(Slab Recasting/column jacketing/structural repairs/tenantable repairs/waterproofing/painting?

11. Is there any alteration or modification from its submission drawing?

12. What is the condition of the drainage line and plumbing of the building?

13. Are there any vibrations in the building?

14. Is any kind of reinforcement exposed to air?

15. What are measures taken by the society members for repairs and rehabilitation of buildings?

16. What are the measures taken by authorities regarding the dilapidated buildings?

6.3. Spreading awareness and government policies

As shown in methodology Figure 5, the study enhances the building's dilapidation index (DI) level. In the study area considered, people were unaware of the dilapidation of buildings. The primary outcome expected out of this research was to minimize the accidents which had caused the number of deaths each year due to the collapse of the buildings. Thus the people were needed to be made aware of this. Hence the awareness was spread among the people living in the buildings as a part of the methodology. Maharashtra government is facing the problem of redevelopment and the collapse of dilapidated buildings for many years. Therefore, understanding the government policies towards which various action plans are assigned is part of the methodology in this research, where the motto is to scrutinize and minimize the risk.

7. Data analysis and result

As discussed in methodology and following methodology as flow chart shown in Figure 5, these are outcomes of the data after field research. Nature's beauty in the Konkan region with its essential location and tourist attractions has made khed municipal area develop in the past 20 years where 300 buildings built. During the study, 140 buildings out of 300 registered as societies under the municipal council of khed were moderately done. However, these buildings were not issued notices to carry out audit work. Thus after the detailed study was done, the submission of findings was handed to the chief officer of the khed municipal council, where these buildings should be registered as early as possible as requested. Out of the remaining buildings, the owner's/societies members were approached about the detailed study to be done. It became apparent that out of 160 buildings, 89 owners/societies questioned what would khed Nagar Parishad do if they don't carry out survey or audit work. Thus similar status report was submitted to the chief officer of the khed municipal council. Local conditions and parameters were considered for surveying 71 buildings, and an assessment of risks was done to them. The on-field survey was done where the study of Nagar Palika / khed municipal building was done by visual inspection, and photographs were recorded as shown in Figure 6. The present conditions were noted, as shown in Figure 7.

The buildings in the research area were surveyed by visiting the field. Accumulation of data and following interpretation in tabular form as shown in Table 1, to find mean and standard deviation by considering various cases. The age of the building as case 1 as shown in Table 1, by considering the number of flats in a building as case 2 as shown in Table 2, by considering the number of floors in the building as case 3 as shown in Table 3 respectively.

Age of the building (years) (Xi)	Frequency (Fi) (numbers)	(Xi Fi)
1	5	5
2	10	20
3	3	9
4	6	24
5	2	10
6	3	18
7	1	7
8	4	32
9	5	45
10	6	60
11	4	44
12	4	48
15	3	45
18	1	18
20	2	40
25	6	150
30	3	90
32	1	32
40	2	80
Total	N-71	777

Mean μ: $\sum\{Xi\ Fi/N\}$ where $\sum\{777/71\}$is equal to 10.94 (μ =10.94).

$$s = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \bar{x})^2},$$
μ= x̄= 10.94

$$s^2 = \frac{\Sigma(x_i - \bar{x})^2}{N-1}$$

$S^2 = 93.88$ $S=\sqrt{93.88}$ $S=9.68$

Table 1. showing details about the age of buildings and details about the buildings by data accumulation by visual inspection and data analysis and collection from the actual visit on the site. After surveying, the structures and results were interpreted in a Microsoft Excel sheet for finding the mean and standard deviation of the age of the building.

Table 2. A detailed compilation of data of the number of flats.

Number of buildings (Xi)	Frequency of no of flats (Fi)	(Xi Fi)
6	3	18
8	16	128
12	19	228
16	24	384
24	9	216
Total	N-71	974

Mean μ: $\sum\{Xi\ Fi/N\}$ where $\sum\{974/71\}$is equal to 13.71 (μ =13.71)

$$s = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \bar{x})^2},$$
μ= x̄= 13.71

$$S^2 = \frac{\Sigma(x_i - \bar{x})^2}{N-1}$$

$S^2 = 25.83$ $S=\sqrt{25.83}$ $S=5.08$

Table 3. A detailed compilation of data on the   number of floors.

Number of buildings (Xi)	Frequency of no of floors (Fi)	(Xi Fi)
2	9	18
3	39	117
4	23	92
Total	N-71	227

Mean μ: $\sum\{Xi\ Fi/N\}$ where $\sum\{227/71\}$ is equal to 3.19   (μ =3.19)

$$s = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \bar{x})^2},$$

μ= x̄= 10.94

$$s^2 = \frac{\Sigma(x_i - \bar{x})^2}{N-1}$$

$S^2=$ 0.411   s=√0.411   S=0.64

As discussed in 6.2, a questionnaire survey was conducted with the tenants of the buildings from the study area, and raw data were collected from the tenants, with hygienic factors and safety factors as studied in 6.2 and the buildings are given rating scales according to the performance of the building's facilities by considering safety conditions by the author.

Table 4. showing details about the rating scale.

Description	Rating
Good	1
Above average	2
Acceptable	3
Inadequate	4
Poor	5

Fig. 7. shows building conditions currently. (NDT Testing) An ultrasonic pulse velocity test.

Based on the average of health and safety parameters, the dilapidation index (DI) score

is calculated, shown in Table 5, and discussed in 6.2. The rating is shown in the table for all 71 buildings surveyed. Data is assigned using Microsoft excel, where all results and data obtained are compared with the parameters with the existing amount of dilapidation in buildings.

Table 5. showing the DI score of surveyed buildings.

	No of buildings
< 1	9
1.1- 2	26
2.1 - 3	13
3.1 - 4	11
> 4	12

Based on the ratings given as per safety and hygiene parameters from 1-5 as shown in table 5, which indicates one as good to five as poor respectively. The buildings were distinguished accordingly based on their present conditions, and ratings were given to the buildings, as shown in Table 5.

The strength of buildings depreciates with time from which it starts to perform to fulfill its purpose. According to their ratings, these surveyed buildings differ based on safety and proper management factors. The buildings surveyed on the eight parameters stated above and the dilapidation index thus with the detailed study are submitted to the local authorities for future use. The ratings of buildings were also shared with people residing in the buildings to make them aware of the buildings' present condition and spread awareness regarding the level of dilapidation of the buildings in which they are residing. People living in Mumbai are facing the problems of disrepair for many years. During

this research, it was found that people living in these dilapidated buildings echo the fear of living in these buildings of getting collapse anytime. One of the significant reasons for dilapidation is improper awareness among the people about the failure of buildings. The Maharashtra housing area and developing authority (MHADA) repair and reconstruction board has over 14,000 buildings over a century old [42]. Each year MHADA undertakes a structural audit of these buildings and releases structures in C1, C2, C3 categories. The building repairs were struck earlier due to various reasons. However, due to its importance in Maharashtra and metro city like Mumbai, which is highly affected due to this dilapidation, the Maharashtra government passed a central land act in 2020 where the right to safety was invoked. Under this act, amendments were made where the government can acquire the property forcibly and suspend the owner's right to property and redevelop the buildings if the owner does not initiate redevelopment of such structures in the given time frame. Earlier, the repair of the buildings was also not possible due to the requirement of a no-objection certificate (NOC) from either owner or tenants. But under this act, the government can repair the buildings without any consent from either owner or tenants.

8. Conclusion and future scope

Thus various measures can be taken by implementing technical supervision compulsory so that there should not be just buildings built in the name or sake of the development and endangering lives of the people. The study gives the local authorities study of the present state of the people's behavior and thus overcome any accident at a

very early stage. The research is done at the grass-root level in the khed city area. Many cities in Ratnagiri district are being developed like Dapoli, Chiplun which can be surveyed to avoid any mishap that occurred in the neighboring town of Mahad. The paper suggested doing awareness programs among the people of khed. The author made a similar approach in khed city, where awareness was spread among the people of khed about repairs and rehabilitation of structures. For spreading awareness and educating people in the town, the author was felicitated with the certificate by the people of khed from their local organization.

Numerous efforts were taken which were seen fruitful, and research was found successful when the municipal council found this topic very much sensitive, buildings were ordered to do structural audits to which the authorities issued notices to the buildings where they were sealed and made vacant, which was not the case earlier which is shown in figure 9.

As we know that there is the global problem of building collapse, and its consequences are known from developing to developed nations, these can be minimized by adopting a similar methodology, where the cities facing these problems should scrutinize the dwellings according to the dilapidation levels rated by taking safety and hygienic factors into priority. The local authorities should be made aware of the current situation of the buildings in their areas and suitable measures to be adopted to minimize accidents and thus to save many lives who fear losing their lives. The developers should use proper technology, and construction should be done following the standard codes and good quality material.

Societies should be formed where the sinking fund, property tax, and maintenance fund should be collected monthly, which should be used to repair and rehabilitate the buildings. Furthermore, it should be compulsory to submit the structural audit reports annually of every building by a reputed structural engineer where the dilapidated buildings can be easily segregated.

Buildings are built rapidly as the result of urbanization in developing cities. Development in Mumbai city started from the British regime. Today the town is haunted by the problems of dilapidation of buildings collapsing of buildings every year. Many deaths are occurring every year from the collapse of buildings. This same problem has started in the areas around Mumbai which are developing. The government of Maharashtra has come across the issues faced by the people. Thus, they have implemented a rule for redevelopment where the central land act was bypassed. The government has the right to suspend the landowner's right to property if the owner does not initiate and complete redevelopment within a suitable time frame. Thus, this paper suggests making proper awareness among the people of khed not to face the same problem that Mumbai is facing today. If good building services and adequate management are installed, they can serve its life period in the future. The study of dilapidation levels of buildings gives a brief knowledge to the owners to take suitable remedial measures to attain its future life. The dilapidation levels can make owners do repair work with proper methodology, thus prevent any accident in the city.

Fig. 9. shows the authorities' seal where the building is declared unfit to use under the C -3 category where entry of any person is not allowed (Dangerous building- entry restricted) written on the seal of the paper in Devanagari or Marathi script.

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