

# Diagnosis and Mitigation of Chronic Water Ingress in Multi-Storey Residential Buildings

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**Abstract:** *This case study involves finding the source of leakage and seepage in a ceiling of a room in a penthouse located in posh Versova area of Mumbai, the top metropolitan city of Maharashtra state in India. Running water has been detected on one of the ceilings of a room on level 1 of the penthouse. This case study explores and studies different suspected sources of leakage and moisture and also studies each source in-depth to zero-in the source of water. The study also explores potential causes, including structural anomalies and concealed pipelines, and proposes comprehensive waterproofing and repair strategies to mitigate the problem. The findings emphasize the importance of proper maintenance and timely intervention to prevent long term structural and health hazards in residential buildings.*

**Keywords:** leakage issues, building maintenance, waterproofing, residential buildings

## 1. Executive Summary

Leakages due to design or structural anomaly of buildings has dangerous consequences. Constant leakage slowly erodes the metal used in columns and beams at the time of constructing the building, which, in-turn, weakens the building to a critical extent and reduces the life span of the building/premises. Other than structural hazard, leakage results in health hazards for occupants. The outbreak of SARS for example, is very closely related to leakage and seepage problems in residential premises [1].

The issue of leakage in buildings in Mumbai is a widespread problem, irrespective of the age or location or the size or the price or the locality of the buildings or flats. Mumbai is located near the sea, and by default there is salinity in the air, which reduces the life of steel. Due to cracks and leaks, the water penetrates RCC (Reinforced Cement Concrete) slabs and impacts the steel, leading to erosion of the metal, weakening the structure. On top of that the multi-storied society system makes it difficult to detect sources of leakages in such type of a set up. In such a scenario, though inter-flat co-operation from society members/owners is immensely required, there are uncountable cases where the flat above the subject premises needs to be repaired for the leakage to stop from the subject flats/premises.

## 2. Purpose Statement

The purpose of this case study is to identify the source of an unexplained leakage in level 2 of a three level Penthouse located in Mumbai city in the state of Maharashtra in India.

### 2.1. Significance

This study is significant as it addresses a common but critical issue in urban residential buildings, particularly in coastal cities like Mumbai, where structural integrity and occupant health are at risk due to persistent leakage problems.

## 3. Introduction

This case study explores the problem of seepage in level 1 of a three-story penthouse located on the 14th, 15th and 16th floors of high-rise building in Mumbai city in India. The problem surfaced when a gyroc ceiling lost its strength due to presence of moisture and water and fell down-a serious life and health hazard. The subject ceiling is depicted in figure... Upon inspection we could clearly see huge signs of water leaking from the slab. However, we were informed there is a room above this room, with no water connections. Our task now was to find out other sources of water inlets, resulting into this sever water leakage.

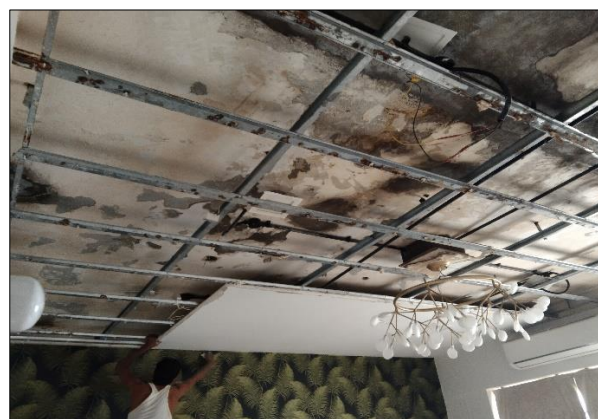


Figure 1: Condition of the Subject Ceiling on Level 1

Though the inhabitants are sure that the leakage is happening due to faulty and leaking under-floor pipes on level 2 of the penthouse, the problem requires an in-depth study. The case study delves deeper into other probable sources of water and moisture. Faulty plumbing could be one of the reasons, other reasons, however cannot be ignored without proper study and research on the premises.

## 4. Case Evaluation

We first made an elevation of all the floor levels in AutoCAD software to understand the structure properly. The subject

AutoCAD elevation is shown in Figure 1 of this case study. Leakage has been detected on the ceiling of a room on level 1 of the Penthouse. This ceiling has been marked in red in figure 1 for the sake of clarity.

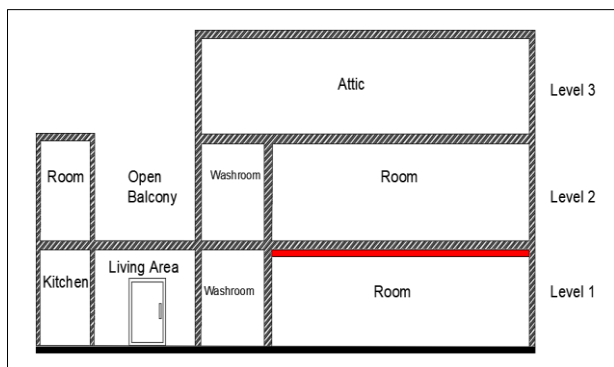


Figure 1: AutoCAD Elevation of the Penthouse

We can clearly see that there are a number of sources connected to the leaking ceiling, that could be potential sources of leakage in the subject ceiling. The next section deals with each and every suspected source of leakage, and why it is earmarked as such.

### 5. Discussion

The following figure, i.e. figure no 2, depicts all the possible sources of leakage which could be a reason for seepage from the subject ceiling. In this section we shall discuss each reason one and one and why we reason out that these could be the cause of seepage in the subject ceiling.

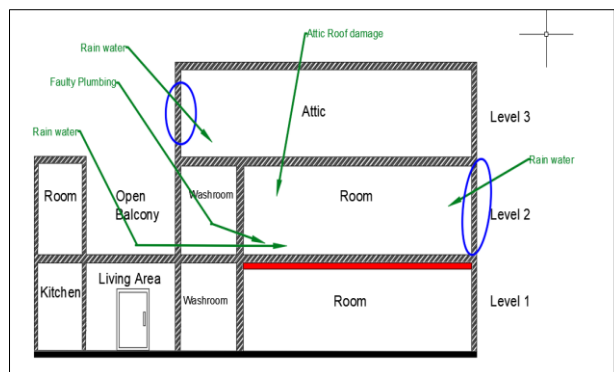


Figure 2: Marking of suspected Sources of Water

#### 5.1. The Window in the Room on Level 2

The first suspected leakage can happen from the window above the subject room. There is a room above the subject room on Level 2 and on inspection of the room, we found that there are no visible water connections or known pipelines under the floor which can become a probable source of leakage.

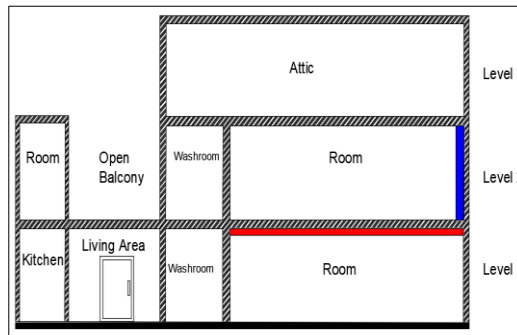


Figure 3: Window On Level 2

However, there is a huge French window in the room as shown in Figure 3, which does not have proper structured or a temporary awning outside the wall, meant to prevent rain water to enter the room during monsoons.

#### 5.2. The Washroom on Level 2

The second source of seepage in the subject room can be the washroom attached to the room above the subject room. There could be two possible sources of water leakage from this washroom. The first could be faulty underfloor plumbing, which could be releasing water to the surrounding areas, and this water could be leaking from the slab to the room below.

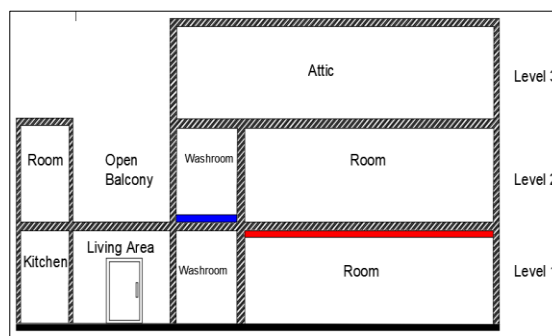


Figure 4: Washroom Above the Subject Ceiling

The second source could be faulty or absent waterproofing membrane in the washroom. We suspect that waterproofing has not been done in the sunk area properly due to which ant water or moisture must be leaking into the slab and reaching the ceiling of the subject room.

#### 5.3. Open balcony on Level 2

The next source of water could be the open balcony adjoining the washroom on level 2. This balcony has old flooring, numerous tiles and broken and grouting is missing.

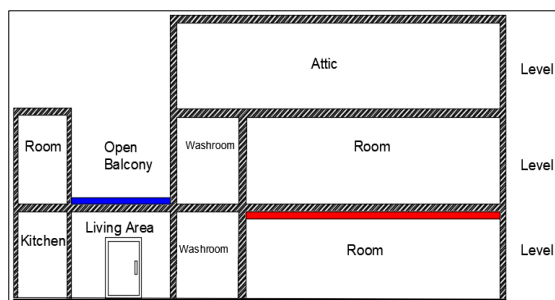


Figure 5: Adjoining Balcony on Level 2

The skirting is also missing at many places and thus our team thinks that there could be many pathways through which the water could be seeping into the slab underneath, making its way to the ceiling of the subject room.

#### 5.4. The Attic Window

The next source of leakage can be seen expected on the top level. There is a large round window with an old wooden frame. This wooden frame is in direct contact with heavy rainfall as well as high temperature direct sunlight, due to which the frame of the window is severely damaged and rotten. Moreover, the glass pane of the window has a missing part, which, according to the owner, has been sent for repair and by virtue of huge tasks of maintenance, the owner has completely forgotten about return delivery and installation. The figure below is a diagrammatic representation of the area from where water could be coming into the attic and seeping into its flooring. The water could thereafter, be seeping into the wall of the room on level 2, from where it could be seeping into the slab between the rooms at level 1 and level 2.

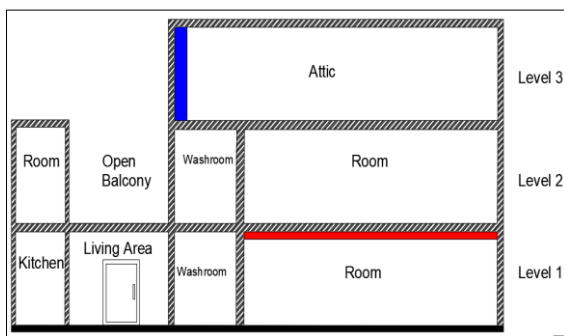


Figure 6: The Attic Window

#### 5.5. Open Area at Level 3

It has been noted that the size of the shed is smaller than Level 2, which means there is open area on the level 3 of the Penthouse. This open area could be a very major source of leakage due to the fact that the tiles in the flooring of this level are very old the grouting has come out and there can be seen a lot of cracks in the flooring. Moreover, the grouting is also missing. This could be a major source of water seeping into level 1.

#### 5.6. The Attic Roof

The attic has a slanting roof. This roof is very old and is made of slabs of terracotta. This terracotta, due to direct the engagement with a highest temperature from sunlight and also heavy rains in the monsoon could have developed cracks or could have broken due to which water maybe seeping into the shed flooring, from where it is going down to the level under it and seeping through the slab and going into level 1 so this is also a highly suspected source of leakage which has to be studied accordingly.

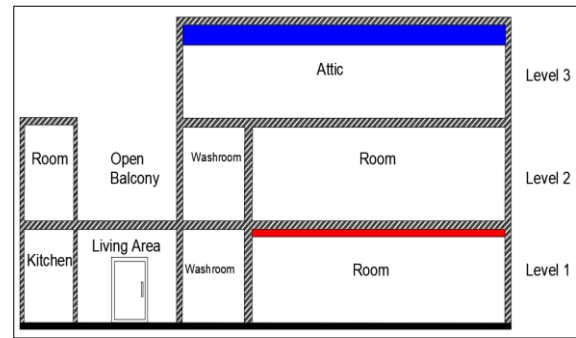


Figure 7: The Attic Slanting Roof

According to the AutoCAD elevation we can see that there are a number of major sources of leakage and all these have to be closely studied.

### 6. Recommendations

Since the flooring is old at many places and grouting is missing, it is highly recommended that first the grouting is repaired and the visible suspected areas of seepage should be worked upon, since there are a number of sources which can be worked without major breakage. If the problem reduced or gets resolved, it would be cost-effective.

It is highly recommended that all the suspected areas be opened and flooring of the suspected areas be removed and under floors have to be inspected carefully if the problem doesn't eliminate after all floor grouting and skirting is repaired. After the flooring is opened, the water connections have to be kept on to inspected the presence of water in surrounding materials have to be studied. Thereafter, water connections have to be closed and then again, presence of water in the sunk have to be inspected.

### 7. Work approved and carried out

Following of our suggestions were approved and we worked like-wise:

- 7.1. First the incoming rains from the window of the room on level 2 has to be studied.
- 7.2. After this the flooring of the room on level 2 has to be studied for any damages.
- 7.3. After the room, the open balcony has to be repaired in terms of the skirting and the grouting.
- 7.4. After the balcony, the flooring of the bathroom has to be dug up to study the faulty plumbing.
- 7.5. Next, we have to study the open area at level 3 and any damages have to be repaired.
- 7.6. Next, the frame of the window in the shed has to be completely repaired and made waterproof.
- 7.7. Since the shed has been neglected for a very long time and is rarely used, the complete structure has to be studied, including its flooring and walls.

### 8. Findings During Work Progress and Measures Taken

#### 8.1. The Window in the Room on Level 2

The first point in suspected leakage has been pointed out as any sources of water in the room above the subject room. On

inspection we found out that the furniture under the window had presence of water remains and high amount of moisture in it therefore we concluded that the window is a source of water entering into the room. So we removed the permanent cabinet structure to inspect the back side of the furniture in such a way that if its found to be in good condition, it can be put back and reused as earlier. Upon inspection it was found that the back of the furniture was completely spoiled due to the entry of water from the window.

The photo below depicts severe water input from the window and it has damaged the wall structurally.



**Figure 3:** Condition of the Window Wall on Level 2

This majorly happened due to the fact that the window had no protruding covering or awning above it to restrict entry of rain entering the room. Figure 3 and Figure 4 depict permanent and temporary awnings respectively for usually installed at residential as well as commercial premises exposed to heavy rainfall in the city of Mumbai.



**Figure 3:** Permanent Window Covering



**Figure 4:** Temporary Awning

Since the water is entering from the window directly behind the furniture, it does not get a chance to dry or to be cleaned, so the water has been seeping into the room and there is huge probability that this water seeps into the slab between level 1 and level 2 and has been a primary reason of leakage in the room below.

## 8.2. The Washroom on Level 2

The second suspected source of water of leakage that is to be understood or research is the faulty plumbing in the bathroom at level 2. Once the washroom was unearthed, we found out that plumbing is faulty, has been done in a hurry and completely unprofessional. Thereafter we also saw that there is a lot of collection of water under these pipes, which means when the bathroom is being used regularly, the water is seeping from the pipes and collecting under the pipes on the slab.



**Figure 5:** Water near Underground Pipes

There is a high probability of this water to seep into the slab and thus entering the ceiling of the subject room.

Other than the above, we also found that the waterproof membrane of the sunk slab has not been done properly. When we dug out the slab, we found loose sand and silt, the base made of bricks and cracks in the plaster as can be seen in the photo below.



**Figure 5:** Bricks used instead of Waterproof membrane

Bricks have high moisture absorbing capability and the absence of waterproof membrane has resulted into high amount of running water into the slab between Level 1 and Level 2.

### 8.3. Open balcony on Level 2

Next we started inspecting the open balcony adjoining the washroom on Level 2. The suspicion started from the fact that when we broke the flooring of the washroom and found out that the plumbing of the underground pipes was faulty, we suspected that there is high probability that concealed plumbing in the walls would also be faulty, since it had been done by the same team of plumbers. Therefore, we un-plastered the walls of the washroom and found out that there is a high amount of moisture and high amount of water behind the tiles. Alongwith the plumbing wall, we also un-plastered the wall adjoining the balcony, that had no water connections and this wall also had traces of moisture. We could pinpoint no other source of water behind the tiles other than coming from the balcony adjoining the washroom. Upon inspection of the balcony we found out the floor grouting in between the tiles is old and had been damaged from a number of places from where there is high suspension that water could enter the slab be seeping into the subject room below the washroom adjoining the balcony. We also saw that skirting of the balcony is broken and parts are missing from a number of places. This could have very much resulted to water seeping into the slab and then into the ceiling of the level below this balcony.

### 8.4. The Attic

The next place of suspicion is the attic level number 3. When we inspected this room, it was found that this room is not made of concrete CX 4 blocks and is neither made of bricks. The attic has been built with some kind of sand, mud and silt and the material does not seem very capable of restraining rain water from entering and also seems to absorb a lot of moisture. Even the flooring is made of only cement that too is cracked at a few places and no tiling has been done on the cement. This room has been permanently used as a store room, so no movement or maintenance has been done and water has got a good chance of standing permanently there, this seeping into the floors below.

### 8.5. The Attic Window

Next, there is a huge round window in this room which has a wooden frame. This wooden frame is completely spoiled due to presence of a lot of rain due to which there are large holes in this frame have been noticed. Moreover, a huge glass part of the pane is seen missing, which the owner says, broke a shattered a long time ago and has been sent for repair the previous year. This clearly means that this monsoon, there has been a large open window which has allowed all the rain water to enter the attic. We removed the whole wooden frame and replaced it with airtight, waterproof and insulated aluminium frame with acrylic pane, so as to make it stronger to bare the strong winds and rains.

### 8.6. The Attic Roof

Another source of leakage that we understand is the slanting roof of the attic. As mentioned before, the slanting roof is made of material which has high water absorbing capacity, maybe slate or terracotta. The Slate slabs are also very old and marks of cracks the marks of damage and due to wear and tear of high temperatures from sunlight and heavy rainfall can be seen. This shed is one of the major sources of leakage in the whole penthouse. Therefore, we brought a team of masonry and re-built the whole attic.

### 8.7. Open Area at Level 3

There is a huge open area adjoining the attic and similar to the balcony on Level 2, this area is also cracked on the flooring, there is broken grouting in between the tiles and the skirting is also missing at numerous places. Moreover, there is no outlet or outgoing pipe to collect rainwater. Upon checking the slant, we found that the constructors have not given any slant, therefore rain water stands still for days. We re-floored this area, provided a floor trap and installed drainage for proper disposal of rainwater.

## 9. Conclusion

After implementing the recommended repair and waterproofing measures, we monitored the premises through the monsoon season to ensure the effectiveness of the interventions. The successful resolution of the leakage issue highlights the importance of thorough inspections, timely repairs, and the use of appropriate materials in maintaining the structural integrity and safety of residential buildings.

## References

- [1] Siti Rosemawar Mohd Sahi, Norngainy Mohd Tawila, Nurfidatul Ema Saaidin & Kuan You Waib, "Case Study: Inter-floor Leakage in High-Rise Residential Buildings in Malaysia", UKM Journal Article Repository, SI -6 (1). pp. 197-206. ISSN 0128-0198, dx.doi.org/10.17576/jkukm-2023-si6(1)-16, <https://www.ukm.my/jkukm/wp-content/uploads/2023/si6-1/17.pdf>