Building Engineering 2024, 2(2), 1381.
https://doi.org/10.59400/be.v2i2.1381

Article

Sealing of roof penetrations during building construction

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CITATION

Lowe SA. Sealing of roof penetrations during building construction. Building Engineering. 2024; 2(2): 1381. https://doi.org/10.59400/be.v2i2.1381

ARTICLE INFO

Received: 15 May 2024
Accepted: 20 July 2024
Available online: 3 August 2024

Abstract: For new building construction, roofs typically have a large number of penetrations that are blocked out before the roof deck is poured. After the roof is poured, these penetrations need to be sealed temporarily to prevent rainwater entering the building. Unfortunately, it is all too common that the ad-hoc approach to sealing these openings results in penetrations left open to the elements. This results in water pouring into the building every time it rains. This paper shows examples of unsealed roof penetrations and of the subsequent damage caused. The penetrations relate to the work of several different trades, who may not place any priority on this issue. It is therefore suggested that this is a problem that the construction management team has to take charge of. At the very least, the roof should be inspected before impending rain events.

Keywords: safety; management; damage; conditions; decking

1. Introduction

During building construction, there are many temporary measures that must be undertaken to ensure both a safe and productive work environment [1,2]. One of the major safety risks on a worksite is wet conditions [3,4]. This increases the risks of slips and falls [5,6]. There is also an increased electrical hazard, as extension cords can end up sitting in standing water [7,8]. The risks are exacerbated when one finds water in unexpected areas, i.e., indoors, for example.

One of the more annoying conditions that are consistently observed on new building projects is seeing every floor of the building wet, even though the roof slab has been poured. The source of the problem is obvious if one visits the roof—roof penetrations that have not been sealed. As this is a construction process issue, no guidance will be found in the building codes like the International Code Council's (ICC) International Building Code [9].

Why this occurs is less a physical issue than a management issue. Temporarily sealing roof penetrations is not technically difficult. It is more a question of who will take responsibility. The penetrations will belong to many of the trades, from plumbers to electricians to HVAC contractors. Often penetrations are initially sealed, but then the seals are breached as pipes are centered in the block-out sleeves, for example. In this author's experience, once the initial seals are breached, very few people spend the time to reseal the area. This is now more complicated as it involves sealing a gap between the pipe and sleeve, with various centering wedges or a riser clamp also in place.

So obviously, ad hoc responsibility for roof penetrations is not a successful system. The consequences can be expensive—damages can quickly mount into tens of thousands of dollars, especially considering how many times it will rain over the course of the project. One slip and fall injury on a wet floor, or electrical mishap due

to power cords sitting in water, will cost much more [10–14]. So, someone must be given overall responsibility for maintaining the roof integrity, and that must likely come from the construction management team.

Whoever accepts the responsibility must be aware of the length and frequency of such a commitment. The time span between a roof being poured and the last penetration being finalized will typically be months, not weeks, for most projects. At any time, someone may unseal a penetration to do some work and leave it unsealed. So frequent inspections will be required to catch this. At the very least, a roof inspection before a projected rain event is required.

The remainder of this paper is broken into two sections. The first details typical roof penetrations and sealing issues. The second section shows examples of the damage caused by failing to real roof penetrations adequately.

2. Examples of unsealed roof penetrations

Roofs have a myriad of penetrations that are typically blocked out before the roof deck is poured. These include the roof drains themselves, plumbing waste system vents (soil stacks), vents from kitchens, vents from boilers, electrical conduits, Heating, Ventilation and Air Conditioning (HVAC) shafts, and even water pipes. Ideally, these would each be sealed temporarily, but comprehensively, to prevent rain pouring through to the floors below.

Figure 1 shows a vent pipe sitting within the sleeve that penetrated the roof. The tape remnants indicate that the sleeve was initially sealed, but whoever positioned the vent did not bother to reseal around the pipe perimeter. **Figure 2** shows a soil stack vent where again the temporary seal on the sleeve was removed but not replaced when the pipe was centered. This pipe was left like this for weeks. **Figure 3** shows four small penetrations, maybe for electrical cabling, that were never sealed.

Figure 1. Vent pipe positioned in a roof sleeve. The pipe is not sealed nor is the gap between the sleeve and the pipe.

Figure 2. Temporary sleeve seal was breached by the pipe and not resealed.

Figure 3. These four penetrations were never sealed.

Large penetrations cause large problems. **Figure 4** shows one method of dealing with a large penetration. The metal decking has been placed, but the concrete has been blocked out. This will work as long as the opening does not fill up with too much water—at which point the water will flow through any seams in the steel decking.

Figure 4. An alternative to leaving a large penetration is to place the metal decking but not pour over it.

Figure 5 is indicative of the lax approach to temporary sealing. This sleeve seal was opened at some point and never resealed. **Figure 6** shows a sheet of plywood that was used to seal a large duct penetration. The gaps along one side are obvious. It is also clear that plywood sitting on concrete will never create a water tight seal; it just gives the illusion of being a seal.

Figure 5. At some point the seal on this sleeve was opened but no one closed it back up.

Figure 6. This large duct penetration was covered by plywood but the gaps are obvious.

3. Examples of the damage caused

Figure 7a shows an auditorium floor that is recessed into the floor slab. As it began to rain, water immediately started to enter the auditorium area. **Figure 7b** also shows the auditorium an hour later, full of standing water. Notice how workers had to move bags of mortar off the floor and place them on some steel masonry reinforcement to keep them from being ruined.

(a) **(b)**

Figure 7. (a) As it started raining water immediately began to enter this sunken auditorium area; **(b)** An hour later the floor had standing water.

Figure 8. This was on the 1st floor of a six-story building. This drywall ultimately had to be replaced.

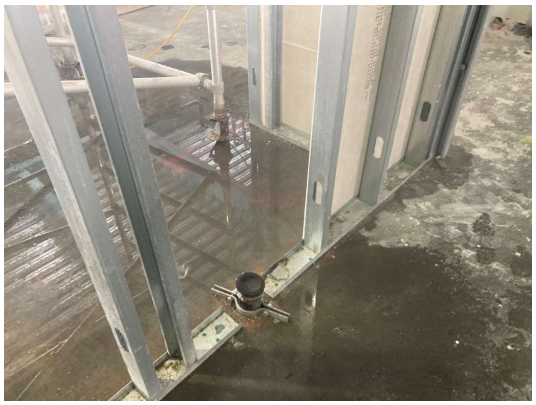

Figure 9. Water starting to spread to an area where drywall had just been installed—this also had to be replaced.

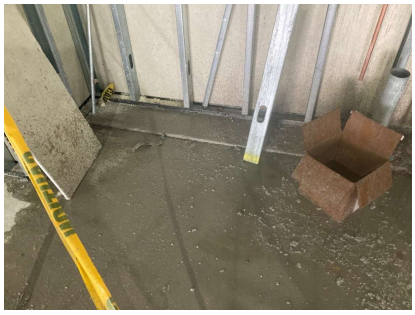

Figure 10. This was the day after the rain. The floors remained wet for another two days. Notice the caution tape and the wet drywall.

In steel-frame buildings, spray-on fireproofing is commonly used. This fireproofing does not interact well with water and easily sloughs off when exposed to almost any water. **Figures 11–14** show examples of this.

Figure 11. This fireproofing on the beam had already been patched (the light areas). It is in the process of sloughing off again as water leaks onto it – notice the exposed steel.

Figure 12. Water penetrating the fireproofing as it started to rain.

Figure 13. Fireproofing washed away as water ran down the inside of a precast wall panel.

Figure 14. This is fireproofing on the floor that had sloughed off a column.

Apart from damage, there are also the safety aspects. This includes power cords running across wet floors and workers carrying loads walking over wet floors.

Last, but not least, is the huge annoyance and inefficiency of having everyone working inside a topped-off building walking around in water. Any material that is staged and can be damaged by the water has to be restaged to remain dry. If that particular contractor is not on site that day, they may return to see their staged material ruined. Even if the leaks limit the water to certain areas of a particular floor, it will surely be trekked throughout the entire floor. The day after the rain, workers will have to be tasked to dry the floors and sweep up the mess.

Figures 15 and **16** give an indication of the poor work conditions roof leaks can cause.

Figure 15. Poor working conditions due to wet floors. This is several floors below roof level.

Figure 16. This bucket was placed under a leak. Eventually it filled up and overflowed.

Figure 17. This building has precast concrete wall panels. Water is running off the floor slab and falling down between the gap to lower floors.

Figure 17 shows a building with precast concrete wall panels as the façade. There is always a gap between the end of the floor slab and the wall panels. The figure shows water flowing to the edge of the slab and falling down between the gap to the floors below. This caused the damage to the sprayed-on fireproofing shown previously in **Figure 13**.

4. Conclusions

In new building construction, roof leakage from failing to provide adequate temporary sealing for roof penetrations is a common problem. The damage caused by the leaks can be extensive. Drywall is extremely vulnerable to water damage and will need to be replaced if it gets wet. Sprayed-on fireproofing easily sloughs off in the presence of water. The risk of slip and fall accidents and electrical mishaps is also present. Staged material can also be damaged, e.g., mortar bags sitting on the floor that get wet.

As roof penetrations belong to various trades, it means that overall responsibility must likely fall on the construction management team. The timeframe from when the roof is initially poured to when the last penetration is finalized is likely to be months—so this is not a short-term commitment. Sealed penetrations can be unsealed at any time as work progresses and will often not be resealed. This means frequent inspections. At the very least, the roof should be inspected before impending rain events.

Conflict of interest: The author has no conflict of interest.

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