

# Review on Existing Methods of Concrete Roof Cooling

*Trijo Tharayil<sup>1</sup>, Mohammad Israr<sup>2</sup>*

<sup>1</sup> Lincoln University College, Malaysia and Department of Mechanical Engineering, Sree Buddha College of Engineering, Pattoor, Alappuzha-690529, Kerala, India <sup>2</sup> Maryam Abacha American University of Nigeria, Hotoro GRA, Kano State, Federal Republic of Nigeria

Email ID: <sup>1</sup> [pdf.trijo@lincoln.edu.my](mailto:pdf.trijo@lincoln.edu.my), <sup>2</sup> [president@maaun.edu.ng](mailto:president@maaun.edu.ng)

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**Abstract:** In tropical regions, the roofs of buildings and houses are made of concrete. During summer, these roofs absorb heat and act like a thermal storage material. As a result, inhabitants face a great thermal discomfort during day and night. In order to overcome this discomfort, people use air conditioners, coolers and fans which puts an extra burden on the power plant leading to environmental impact. The various existing methods used to cool concrete roof are cool roof, asphalt shingles, green roof, phase change material cooling, roof pond and evaporative cooling. Even though all these methods provide some reduction in roof temperature, they have many disadvantages like glare issue, water leakage, and maintenance problem, issues like durability, water consumption, extra pumping power, cost and long-term stability. This paper critically analyzes the previous works on various existing methods of concrete roof cooling. The review shows that the real time use of these methods are limited even though researchers have reported good thermal performance. As a future work, pulsating heat pipe (PHP) is suggested in this paper. Since PHP works on two phase flow, large heat transfers are possible. The advantages of PHP promote the use of PHP for concrete roof cooling applications.

**Keywords:** Concrete roof cooling; Pulsating heat pipe; Urban heat island; Sustainable buildings; Passive cooling

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## Introduction

The atmospheric temperature goes beyond 35° C during summer months and it increases the temperature of the concrete roofs of houses and buildings. Conventional concrete roof surfaces can reach a temperature of 60° C - 70° C at midday in hot summer. This temperature may go higher in future because of climate changes and greenhouse gases. The methods such as truss work, cool roof, green roof etc. are used to reduce the temperature of concrete roof. However, these methods are not very effective as the concrete roof gets heated up by different modes of heat transfer.

Similarly, the roofing materials also contract and expand daily as they heat up during the day and cool down at night. A roof experiencing such large daily temperature fluctuations will undergo thermal fatigue which later leads to degradation of the roof. High roof temperatures also increase the rate of any chemical breakdown. High temperature can create cracks in roofs which can be avoided by keeping the roofs at lower temperatures. Similarly rains in summer season increases the chances of cracks in concrete as it is

suddenly cooled. A cool roof can increase its life and significantly decrease roof maintenance and expenditures. Keeping home cool in hot weather is also becoming increasingly expensive due to rising energy, servicing and maintenance costs.

Urban Heat Island effect experienced in metros and cities aggravate this problem as the buildings and houses are closely packed. These buildings absorb heat during day time and radiate heat into the atmosphere during night which results in higher atmospheric temperature during night. People use various electric appliances for thermal comfort which demands extra power generation from power plants. This can cause environmental impact.

Researchers have attempted different methods to reduce the temperature of the concrete roof. The different methods used to cool the concrete roof to reduce the indoor room temperature are ventilation, asphalt shingles, Phase Change Material (PCM) cooling, evaporative cooling, green roof, roof pond and reflective roof. This paper looks into various existing methods of roof cooling and the previous works done by researchers on these methods. At the end, PHP is proposed as a promising solution for concrete roof cooling highlighting its advantages.

### **Existing Methods for Roof Cooling**

#### **Cool Roofs**

Cool roof or reflecting coating use a reflective paint on the top surface of the roof. This paint reflect a part of the sunlight hitting the roof surface. This reduces the roof temperature. Various reflective paints are available in the market for purchase. The advantages of cool roof are easy implementation and reduction in roof temperature. Figure 1 shows the method of applying reflective coating on the roof surface. The disadvantages include the issue of glare, water contamination during rainy season, performance reduction over time and reduced durability due to high ultraviolet exposure.



*Figure 1. Cool roof [1]*

#### **Asphalt Shingles**

These are tile like structures placed on the top of the roof. These tiles have very low thermal conductivity. So these materials prevent the flow of heat into the concrete roof and keep the roof at a lower temperature. The various advantages of asphalt shingles are low cost, fire resistance, easy of application, and moderate durability. The disadvantages are short lifespan, degradation in performance over time,

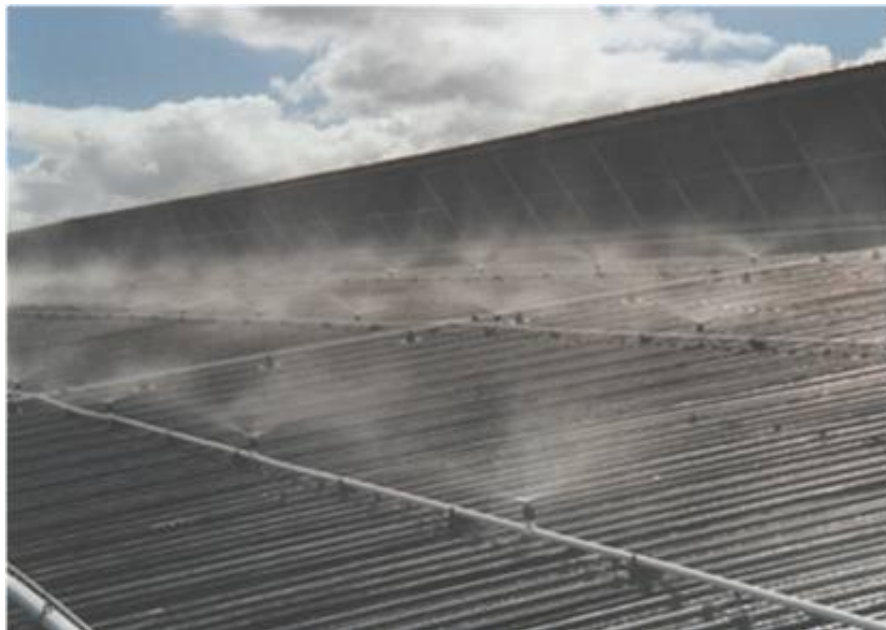
maintenance and environmental issues as these tiles are not ecofriendly. Figure 2 shows the application of shingles.



*Figure 2. Asphalt Shingles [2]*

### **Evaporative Roof Cooling**

In this method, water is sprayed on the concrete roof at intermittent intervals. The water particles absorb heat from the roof keeping it at a lower temperature. Hence, a mechanism is required to spray water intermittently on the roof surface. So it causes extra electricity consumption for cooling. The advantages of this method are low initial cost and effective cooling as it utilizes evaporation. The disadvantages are electricity consumption, need of water supply, possibility of water leakage and structural damage to building. Figure 3 show the method of evaporative cooling.

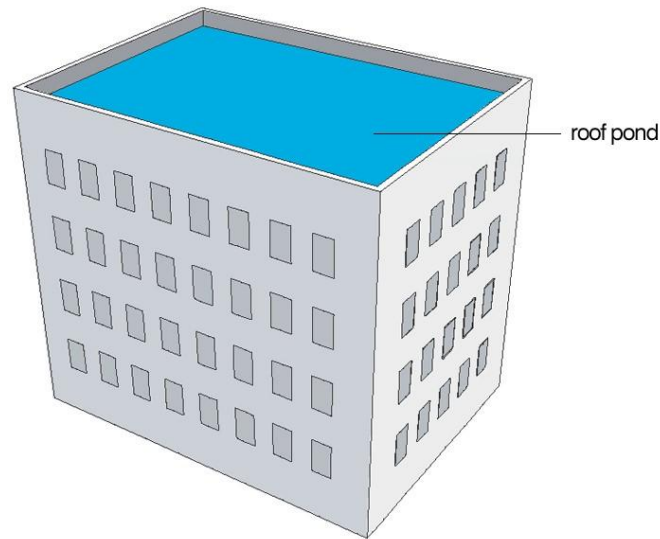


*Figure 3. Evaporative Cooling [3]*

### **Roof Ponds**

Roof ponds represents ponds kept on the top of the roof. The water present in the pond will absorb heat during the day time thereby preventing the concrete roof reaching a higher temperature. As the name suggest, a pond is kept on the top of the roof. The advantages of this method are water can absorb

significant amount of heat. The disadvantages are issue of water leakage, maintenance, and issues of structural stability. Figure 4 shows the roof pond concept.



*Figure 4. Roof pond [4]*

### **Green Roofs**

Green roofs use plants and vegetation on the top of the roof to reduce the roof temperature. Various plants have been identified to use them on the roof top. These plants cover the roof surface preventing it from getting heated. The advantages of green roof are improved air quality, reduction in roof temperature and ecofrienliness. The disadvantages are high installation cost, water leakage issues, structural damage and limited heat dissipation efficiency. Figure 5 shows a building with green roof.



*Figure 5. Green roof [5]*

### **Phase Change Material (PCM) Cooling**

Phase change materials are materials which change their phase on heat absorption. Usually solid type PCMs are employed for roof cooling. A layer of PCM is applied on the top of the roof. These PCMs are capable of absorbing heat during daytime. These materials reject heat into atmosphere during night.

Various PCMs have been identified for use on roof top. The advantages of PCMs are passive operation and good thermal performance. The disadvantages are stability concerns, corrosion issues and high cost. Figure 6 shows the application of PCM for roof cooling.

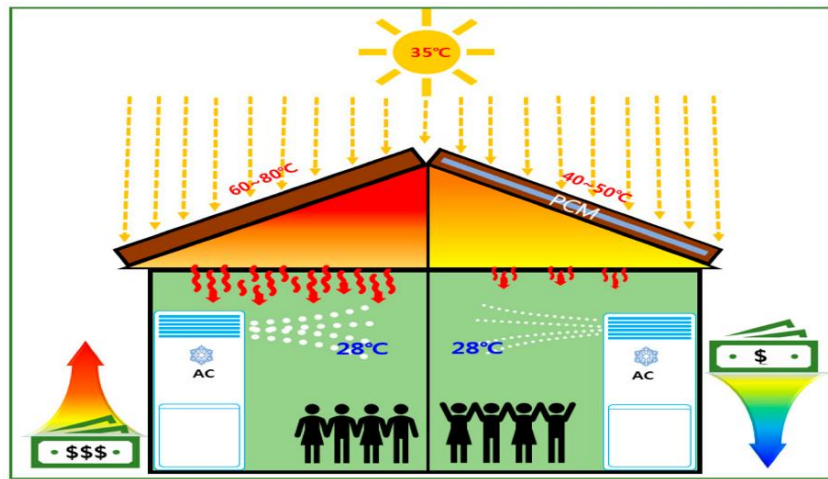


Figure 6. Phase change material cooling [6]

### Previous studies on existing methods of concrete roof cooling

Researchers have attempted various methods as explained above to keep the concrete roof at a lower temperature. These studies are described below.

Wai et al. [7] analysed the effectiveness of reflective coatings using an experimental study in reducing urban heat island effect and making the thermal performance better from building. The experimental results shows that a temperature reduction of 8.7°C to 34.2°C is possible with cool roof. The experiments were performed under realtime conditions. They suggested cool roof as a promising method for cooling the concrete roof.

Alrashidi et al. [8] investigated the effectiveness of evaporative cooling using an experimental study to regulate temperature in buildings. In this study, the effect of controlled evaporation of water on the temperatures of concrete roof is analyzed. They also considered its effect on indoor temperature. The experimental results indicate that evaporative cooling can reduce the roof temperature significantly providing thermal comfort conditions inside the room. Authors recommends evaporative cooling as an effective method for thermal discomfort.

Jamei et al. [9] studied the effect of green roof on the thermal performance of concrete roofs under the climatic conditions of Melbourne. They used both experimental and analytical methods for this study. They studied the effect of vegetation layers on the roof air temperature considering the heat transfer into the buildings. They reported a reduction of 1.5°C at roof air temperature during daytime. This reduction in temperature provided better thermal comfort. The authors suggested green roof as an effective solution for roof cooling. However, they commented that thermal performance can vary depending on the plant type, climate and maintenance levels.

Jiang et al. [10] performed experimental study and numerical study to analyze the heat transfer performance of phase-change-material (PCM) for concrete roof cooling. The study mainly focused on the heat transfer behaviour of PCM and the possible temperature reductions on roof. They reported a roof temperature reduction of 30°C with the use of PCM. Similarly a reduction of 6°C is reported for indoor air temperature. This provided better thermal comfort. As a conclusion the authors recommended the use

of PCM for concrete roof cooling. However, they pointed out that proper PCM selection is important for better performance in various climatic conditions.

Tang et al. [11] analysed the thermal performance of a roof pond configuration in reducing the roof temperature to enhance thermal comfort in buildings. The authors studied new designs of roof pond using floating wet cloth systems to analyze the thermal performance of roof pond. The experimental results indicate that the new configuration of roof pond has better thermal performance prospects compared to old roof pond systems. Finally authors recommended the use of optimized roof pond designs for passive cooling of the concrete roof. They also highlighted the challenges such as maintenance and structural issues during real time application.

From these previous studies it can be concluded that the existing methods provide significant reductions in roof temperature with better thermal comfort. However there are many disadvantages for each method when it comes to real time application. Table 1 summarizes the various studies conducted on existing methods of concrete roof cooling.

*Table 1. Experimental studies on various existing methods of concrete roof cooling*

SI No	Title	Major results
1	Experimental Analysis of Cool Roof Coatings as an Urban Heat Mitigation Strategy to Enhance Thermal Performance [7]	Surface temperature reductions of 8.7–34.2 °C under real outdoor conditions.
2	Thermal regulation for buildings using evaporative cooling technique: Experimental study [8]	Significant indoor cooling and roof surface temp reduction with minimal water consumption
3	Investigating the cooling effect of a green roof in Melbourne [9]	Green roofs reduced daytime air temperature at roof level by ~1.5 °C
4	Experimental and numerical study on thermal performance of phase-change-material cool roofs in summer [10]	PCM cool roofs reduced peak roof temperatures by up to ~30 °C externally and ~6 °C internally
5	Experimental studies on a novel roof pond configuration for the cooling of buildings [11]	Floating wet cloth systems reduced temperatures more effectively than traditional static ponds

### **Future direction-Pulsating Heat Pipe Technology**

Pulsating heat pipe (PHP) is a passive heat transfer device that can be used for roof cooling application. It consists of a copper coil having capillary dimensions bent into many turns as shown in Figure 7 and its ends are joined by brazing process. It contains a working fluid at a very low pressure. PHP works on boiling and condensation principles thereby giving high heat transfer rates. The PHP can be divided into evaporator and condenser region. The portion of the PHP going inside the concrete roof is the evaporator. The portion projecting outside is the condenser region. There is no need of adiabatic region in concrete

roof cooling. When concrete gets heated, the working fluid inside the PHP absorbs this heat and vapourises. The vapours move to condenser side where it is converted into liquid. The liquid will come back to evaporator. PHP is continue to work as long as heat is applied at the evaporator. The advantages of PHP are high heat transfer capability, electricity free operation, reliability, maintenance free and passive operation.

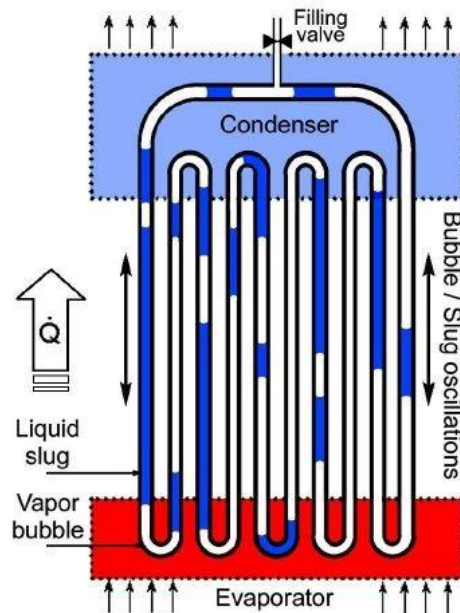


Figure 7. Pulsating heat pipe [12]

### Conclusion

Concrete roof cooling is an important area of research requiring new methods for concrete roof cooling. Thermal comfort demand more promising solutions for concrete roof cooling. The existing methods provide significant reduction in roof temperature. However, their disadvantages limit their use in real time applications. Pulsating heat pipe is suggested as a promising solution for concrete roof cooling as it relies on boiling and condensation for its operation. More research has to be performed on PHP before it is applied on a real concrete roof.

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### References

1. Proofing Master, "Proofing Master – Heatproofing and waterproofing services," Proofing Master. [Online]. Available: <https://proofingmaster.com/>. [Accessed: 15-Apr-2026].
2. Jugu Alb Inc, "All roofing services," Jugu Alb Inc. [Online]. Available: <https://jugalbinc.com/all-roofing-services/>. [Accessed: 15-Apr-2026].
3. V. Keith, "Clip on architecture: Reforesting cities," *Urban Omnibus*, Jan. 13, 2010. [Online]. Available: <https://urbanomnibus.net/2010/01/clip-on-architecture-reforesting-cities/>. [Accessed: 15-Apr-2026].

4. WeKnowExcel, "AutoCool – Roof cooling system," WeKnowExcel. [Online]. Available: <https://www.weknowexcel.com/autocool.htm>. [Accessed: 15-Apr-2026].
5. iStock by Getty Images, "Green building design stock photos and images," iStock. [Online]. Available: <https://www.istockphoto.com/photos/green-building-design>. [Accessed: 15-Apr-2026].
6. H. G. Kim, Y.-S. Kim, L. K. Kwac, M. Park, and H. K. Shin, "Role of phase change materials containing carbonized rice husks on the roof-surface and indoor temperatures for cool roof system application," *Molecules*, vol. 25, no. 14, p. 3280, 2020. <https://doi.org/10.3390/molecules25143280>
7. C. Y. Wai, H.-W. Chau, P. Paresi, and N. Muttill, "Experimental analysis of cool roof coatings as an urban heat mitigation strategy to enhance thermal performance," *Buildings*, vol. 15, p. 685, 2025. <https://doi.org/10.3390/buildings15050685>
8. A. Alrashidi, S. Abdo, M. A. Abdelrahman, A. A. Altohamy, and I. M. M. Elsemary, "Thermal regulation for buildings using evaporative cooling technique: Experimental study," *Case Studies in Thermal Engineering*, vol. 61, p. 104891, 2024. <https://doi.org/10.1016/j.csite.2024.104891>
9. E. Jamei, G. Thirunavukkarasu, H.-W. Chau, M. Seyedmahmoudian, A. Stojcevski, and S. Mekhilef, "Investigating the cooling effect of a green roof in Melbourne," *Building and Environment*, vol. 246, p. 110965, 2023. <https://doi.org/10.1016/j.buildenv.2023.110965>
10. L. Jiang, Y. Gao, C. Zhuang, C. Feng, X. Zhang, J. Guan, and S. Dong, "Experimental and numerical study on thermal performance of phase-change-material cool roofs in summer," *Sustainable Cities and Society*, vol. 99, p. 104936, 2023. <https://doi.org/10.1016/j.scs.2023.104936>
11. R. Tang, Y. Etzion, and E. Erell, "Experimental studies on a novel roof pond configuration for the cooling of buildings," *Renewable Energy*, vol. 28, no. 10, pp. 1513–1522, 2003. [https://doi.org/10.1016/S0960-1481\(03\)00002-8](https://doi.org/10.1016/S0960-1481(03)00002-8)
12. CEA IRAMIS (SPEC), "Postdoc 2022 on experiment and simulation of pulsating heat pipes with code CASCO," June 14, 2022. [Online]. Available: <https://iramis.cea.fr/en/spec/2022/06/postdoc-2022-on-experiment-and-simulation-of-pulsating-heat-pipes-with-code-casco/>. [Accessed: 15-Apr-2026].