CFAES

DEPARTMENT OF FOOD, AGRICULTURAL AND BIOLOGICAL ENGINEERING

# Technical, economic and environmental performance of soy methyl ester emulsions applied to aging asphalt roofing

Juliana Vasco-Correa and Ajay Shah*

## INTRODUCTION

- About 80% of home roofs in the U.S. are made of asphalt shingles[1].
- Weathering makes shingles brittle due to oil losses and asphalt hardening.
- The average life of a roof is 10-20 years[2].


*Fig. 1 Construction and demolition (C&D) waste, asphalt shingle waste and percentage of shingle recycling in the U.S.[3,4].*

### Soy methyl ester emulsions (SMEEs)

- Recently commercialized SMEEs are used to "rejuvenate" asphalt roofing[5].
- SMEEs are sprayed on aging roofs, and penetrate through the granules into the asphalt layer (Fig. 2).
- SMEEs restore oil content on weathering asphalt layer.

**Hypothesis:** SMEEs improve the physical properties of asphalt shingles while providing economic and environmental benefits.

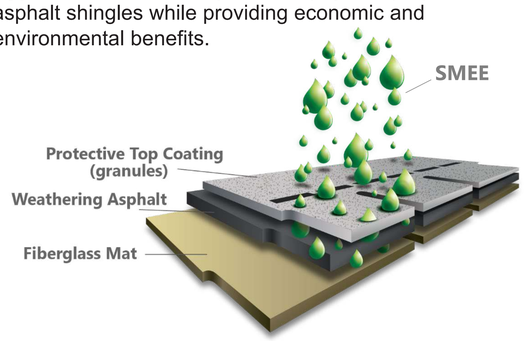



*Fig. 2 Typical structure of asphalt shingles and penetration of soy methyl ester emulsion[5].*

## OBJECTIVE

Evaluate the technical performance and the potential economic and environmental implications of the application of a commercial SMEE formulation on aging asphalt shingles.

## MATERIALS AND METHODS

### Technical performance of SMEE on asphalt shingles

- **Material**: three-tab asphalt shingles from a 17 years-old roof in central Ohio.
- SMEE formulation: Roof Maxx™.
- **Treatment**: 1 gal of SMEE per 100 ft² of roof.
- **Control**: untreated shingles.
- **Test** – performed by PRI Construction Material Technologies, LLC according to the following standards (Fig. 3):
  1. Pliability: ASTM D3462.
  2. Granule adhesion: ASTM D3462 and D4977.
  3. Permeability: ASTM E96.
  4. Hail impact: UL2218 Class 4.
  5. Spread of flame: ASTM E108 Class A.


*Fig. 3 Test performed to treat asphalt shingles and main technical findings[5].*

### Economic analysis assumptions

- Lifespan of house: 60 years[6].
- Lifespan of roof: 10,15 and 20 years[2].
- Roof life extension by applying SMEE: 5 years[5].
- Size of average house: 2,000 ft² [6,7].
- Size of roof: 3,200 ft² [7].
- SMEE applied once per roof, at the end of their regular lifespan.
- Market interest rate (personal loan): 10%[8].
- Cost of SMEE applied: $2,400 per roof ($0.75/ft²)[5].

### Environmental analysis

- Weight of asphalt per roof area: 2.4 lb/ft² [9].
- Calculation of greenhouse gas emissions as $CO_2$ equivalent for:
  - Production of 3-tab shingles based on manufacturer reports[4].
  - Waste shingle disposing based on Waste Reduction Model (WARM)[10].

## RESULTS

### Technical performance

#### 1. Shingle pliability

- SMEE treatment improved shingle's pliability: passed test.

*Table 1. Pliability results according to ASTM D3462.*

| | SMEE treated | Untreated |
|---|---|---|
| **Weather-Side Up MD** | Pass | Pass |
| **Weather-Side Up CMD** | Pass | Pass |
| **Weather-Side Down MD** | Pass | Fail |
| **Weather-Side Down CMD** | Pass | Fail |

*MD: machine direction. CMD: cross machine direction.*

#### 2. Granule adhesion (protective top coating)

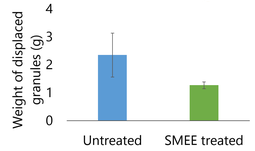



*Fig. 4 Weight of displaced granules.*

- Granules displaced by a 50 cycles of a test brush.
- Weight of displaced granules decreased by 46% → SMEE increased granule adhesion.
- New shingles are expected to have an average weight of displaced granules =< 1.

#### 3. Shingle permeability

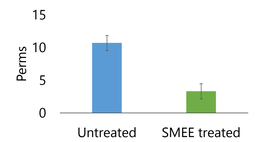



*Fig. 5 Permeability of aged asphalt shingles.*

- Permeability measured vapor water transmission through shingles.
- SMEE treatment reduced permeability by 60%.
- New asphalt shingles have a permeability of around 0.9 perms[11].

#### 4. Hail impact

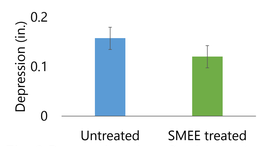



*Fig. 6 Depression size after impact test.*

- Average depression size decreased by 24% with SMEE treatment.
- Decrease in hail impact likely due to increase in flexibility (pliability).

#### 5. Spread of flame


No visual difference in the spread of flame → no increase in fire risk with SMEE treatment.

*Fig. 7 Spread of flame in asphalt shingles decks.*

SMEE treatment improved the characteristic of 17 years-old asphalt shingles, restoring them to values close to those of new shingles. This was likely due to the replenishment of the oil content of the asphalt layer with the oil present in the SMEE.
Thus, SMEE potentially extends the service life of asphalt roofs.

### Economic Analysis

**Amount saved in 2019's dollars over the lifespan of a 2,000 ft² house by applying SMEE**

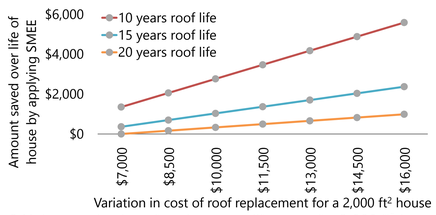



*Fig. 8 Net present value of savings over lifespan of a 2,000 ft² house by applying a SMEE to extend the life of the roof.*

Roof replacement cost and service life vary with location, type of shingles, and complexity of the roof. However, for all the conditions evaluated, SMEE treatment generated savings for the homeowner.

### Environmental analysis

Applying SMEE to one house avoids:

*Over lifespan of an average 2,000 ft² house*

- **3.8 tons of waste to landfills.**
- **80 kg of $CO_2$ eq. due to waste.**
- **1420 kg of $CO_2$ eq. due to asphalt shingles manufacturing.**

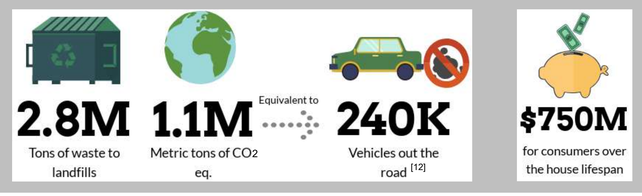
## CONCLUSION

SMEE treatment improved the shingle's characteristics to levels close to new shingles, potentially extending the service life of roofs. This would have to be corroborated using accelerated aging tests in future research. SMEE has economic benefits to homeowners and benefits the environment by reducing waste and avoiding new production of new shingles.

## OVERALL IMPACT

The roof of about 7% of homes in the U.S. is replaced every year[2]. If 1% of single-family homes applied SMEE instead of replacing the roof:

It will avoid: and it will save:

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DEPARTMENT OF FOOD, AGRICULTURAL AND BIOLOGICAL ENGINEERING
*Corresponding author: shah.971@osu.edu