COLORADO STATE UNIVERSITY

Using laser leveling technology in constructing concrete slabs: Reducing concrete and cement waste and associated scope three greenhouse gas emissions

Garrett M. Cole, Jason C. Quinn

MECHANICAL ENGINEERING
SUSTAINABLE RESEARCH LABORATORY
Mechanical Engineering
1374 Campus Delivery
Fort Collins, Colorado 80523-1234

Commissioned by Somero Enterprises Inc.

September 13, 2023

1 Introduction

Laser screeding and subbase grading technologies like the Somero Floor Levelness System® represents an innovative technology for constructing concrete slabs (Figure 1). This technology represents a substitute for traditional hand held vibratory screeds. Comparatively, laser screeding and leveling technology has enabled a reduction in the amount of concrete and therefore cement used to construct a concrete slab. The Sustainability Research Laboratory at Colorado State University built a tool in Microsoft Excel to evaluate the reduction in greenhouse gas emissions associated with concrete in slab construction using laser screeding and grading when compared to the current business as usual technology. A comprehensive life cycle assessment (cradle to grave) was not conducted due to a lack of data. Instead a life cycle inventory assessment based on life cycle methodology was completed with results focused on a direct comparison of emission associated with concrete for the two different technologies for the construction of concrete slabs. The tool and methodology were third party reviewed by Construction Management faculty and the Institute for the Built Environment at Colorado State University along with a Construction Management faculty at Middle Tennessee State University.

Figure 1: Laser screed

2 Methods

2.1 Functional Unit

The functional unit was 1 m^2 of concrete slab constructed in a specified thickness. It is assumed that laser screeding and subbase grading are performed in unison with the same software so that the slab thickness is uniform, resulting in the greatest reduction in the amount of concrete used.

2.2 System Boundary

This assessment does not consider Scope 1 emissions from the operation of screeding equipment, excavating equipment, or generators. Likewise, Scope 2 emissions from on-site utilities during construction are not considered. Only Scope 3 emissions from the upstream concrete supply chain and employee transit to the work site are considered within the system boundary. The system boundary is justified by the expectation that Scope 3 emissions from the upstream concrete supply chain are the largest contributor to greenhouse gas emissions during slab construction. This definition of the system boundary is anticipated to be conservative, in that it is expected to slightly underestimate the benefit of laser screeding and subbase grading technology when compared to the conventional state of technology because the conventional state of technology is expected to have greater Scope 1 and Scope 2 emissions. This consideration is due to less efficient 2-stroke engines for screeding and a longer construction period using the conventional state of technology. The system boundary is provided in Figure 2.

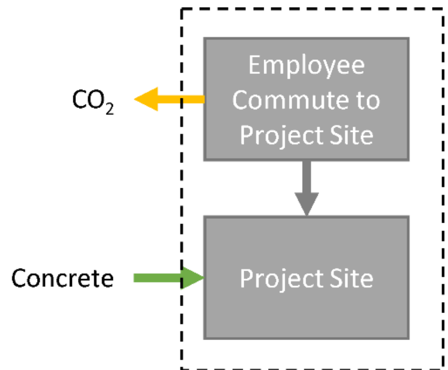

Figure 2: System boundary.

2.3 Engineering Process Model

The engineering process model calculates the mass of concrete required at the job site and the number of employee commute miles required to complete the project. These values are defined by the excess concrete ordered, the depth of the concrete pad, the length of time required for the pour, and the number of employees required to operate the selected screeding machinery. Excess concrete is defined as anything above the minimum amount required to fill the volume defined by the slab area and depth and is required for a number of reasons including subbase penetration and leveling error. Less excess concrete is ordered using the laser screeding and grading technology due to flatter and smoother floors which result in less leveling error relative to the conventional state of technology. Through expert consultation it was determined that laser screeding and leveling technology reduce concrete waste by 3% compared to the conventional state of technology. These parameters are provided in Table 1. To be consistent with the average commute in the United States, it was assumed that 63% of employees commute alone in a passenger vehicle and 22% carpool in a passenger vehicle [1]. The rest were assumed to walk or take public transportation.

Table 1: Project parameters used in this study.

	Conventional State of Technology	Laser Screeding and Grading
Slab Area	100,000 square feet	100,000 square feet
Slab Depth	6 inches	6 inches
Excess Concrete Ordered	5%	2%
Commute Distance to Project Site	60 miles	60 miles
Number of Employees	20	10
Length of Pour	13 days	5 days

2.4 Life Cycle Assessment

This assessment adheres to ISO 14044 and Greenhouse Gas Protocol standards for the applicable processes considered within the system boundary. The assessment is not a comprehensive life cycle assessment. The mass flows that were calculated by the engineering process model were assigned carbon intensities from supply chain data. The carbon intensities (embodied carbon) of employee transportation and concrete are provided in Table 2. The average transportation distance of concrete from the factory to its site of use (I.e. the project site) is included in the provided value.

Table 2: The carbon intensities (embodied carbon) of mass and energy flows included within the system boundary.

Material/Energy Flow	Carbon Intensity	Reference
Concrete	337 kg CO_2 eq.·m^{-3}	[2]
Transport by Passenger Vehicle—Alone	0.31 kg CO_2 eq.·$passenger^{-1}$·$mile^{-1}$	[3]
Transport by Passenger Vehicle—With Others	0.16 kg CO_2 eq.·$passenger^{-1}$·$mile^{-1}$	

3 Results

The greenhouse gas emissions associated with the upstream supply chain for concrete production and employee commuting during the construction of a concrete slab are presented in Figure 3. The 3% reduction in concrete waste using laser screeding and grading technology relative to the conventional state of technology directly correlates to a 3% reduction in the scope three emissions associated with upstream concrete production. The reduction in employee commute miles is relatively small comparatively.

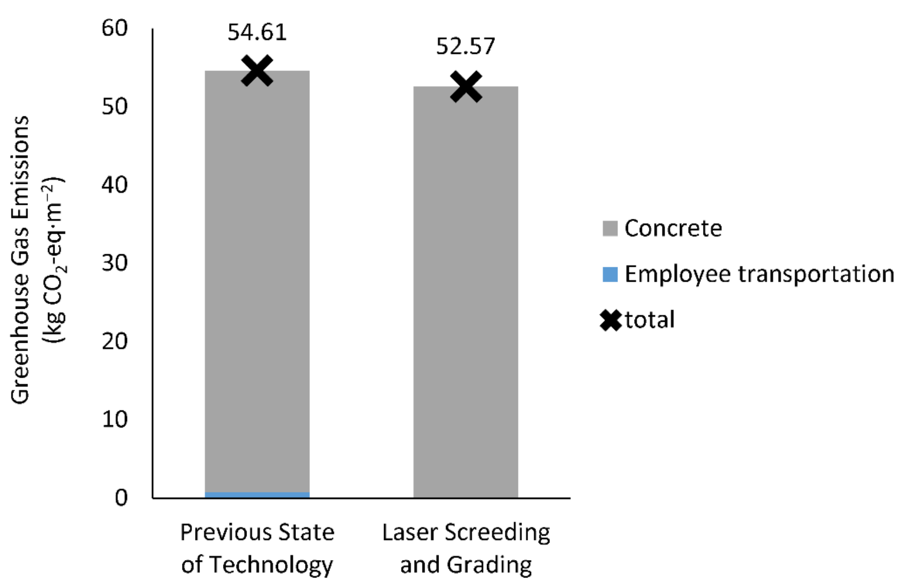

Figure 3: Scope 3 greenhouse gas emissions associated with the upstream supply chain for concrete production and employee commuting during the construction of a concrete slab.

4 Conclusions

Laser screeding and leveling technology is believed to reduce concrete waste by 3% compared to the conventional state of technology. This waste reduction slightly reduces the greenhouse gas emissions associated with upstream concrete production in the construction of a concrete slab. Although there is a great reduction in employee commute miles to construct a slab with laser screeding and grading technology, the embodied emissions associated with concrete are so large that the carbon savings benefit from reduced employees and travel is small compared to the 3% concrete reduction from the use of laser screeding and leveling technology.

5 References

[1] P. Weidman and B. Goldberg, “2005 Omnibus Survey Results,” Bureau of Transportation Statistics, 2008. [Online]. Available: https://www.bts.gov/archive/publications/omnistats/volume_04_issue_01/index

[2] “ecoinvent.” [Online]. Available: https://ecoinvent.org/the-ecoinvent-database/

[3] “GHG Emission Factors Hub.” [Online]. Available: https://www.epa.gov/climateleadership/ghg-emission-factors-hub

Jason C. Quinn, PhD
Operational Director
Energy Institute
Professor
Mechanical Engineering
Colorado State University
jason.quinn@colostate.edu

Garrett M. Cole, M.S.
Research Associate III
Mechanical Engineering
Colorado State University
garrett.m.cole@colostate.edu