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# Lowering the Carbon Footprint When Using the Wafflemat™ System for Concrete Slab Foundations

## A Climate Change Gas Emissions Analysis on the Production, Transportation, and Use of Concrete in Slab Foundations

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***Use of the WAFFLEMAT System in residential home construction can reduce the level of climate change emissions by 20% [the equivalent of 4 to 9 tons less CO<sub>2</sub> released into the atmosphere per home] when compared to the use of conventional slab foundations. Other emissions reductions are also projected.***

### EXECUTIVE SUMMARY

Carbon dioxide (CO<sub>2</sub>) is the main anthropogenic gas contributing to the buildup of greenhouse gases in the earth's atmosphere. Emissions of CO<sub>2</sub> from a specific project are collectively referred to as the "carbon footprint." CO<sub>2</sub> emissions result from use of fossil-derived energy during the production and transport of materials.

The following is an assessment of the reduced carbon footprint resulting when a typical amount of concrete is used in the foundation of an average-sized residential home vs. when the WAFFLEMAT System is utilized.

## TODAY'S REGULATORY ENVIRONMENT

Before considering any analysis, it's helpful to have a general understanding of today's regulatory environment. Globally, the 1997 Kyoto Protocol is an agreement made under the United Nations Framework Convention on Climate Change (UNFCCC) in which participating countries commit to reduce emissions of carbon dioxide and five other greenhouse gases (methane, nitrous oxide, sulfur hexafluoride, HFCs, and PFCs) beginning in 2005 by 5.2% compared to those of 1990 (but note that, compared to the emissions levels that would be expected by 2010 without the Protocol, this target represents a 29% cut). National targets range from 8% reductions for the European Union, to 7% for the US, 6% for Japan, and permitted increases of 8% for Australia and 10% for Iceland.

In the US, individual states have legislated requirements for local emissions. For example, California (the world's 12th largest source of carbon dioxide) recently adopted Assembly Bill 32, requiring the state's emissions be reduced to year 2000 levels by 2010, year 1990 levels by 2020, and 80% below year 1990 levels by 2050. This will be accomplished through an enforceable statewide cap on emissions. In addition, and in order to effectively implement the cap, AB 32 directs the California Air Resources Board (CARB) to develop appropriate regulations and establish a mandatory reporting system to track and monitor emissions levels.

## EMISSIONS ESTIMATE ANALYSIS

### ***Portland Cement***

According to US EPA AP-42, the CO<sub>2</sub> emissions from Portland Cement Manufacturing are generated by two mechanisms. As with most high-temperature, energy-intensive industrial processes, combusting fuels to generate process energy releases substantial quantities of CO<sub>2</sub>. Additional, and again often substantial, quantities of CO<sub>2</sub> also are generated through calcining of limestone or other calcareous material. This calcining process thermally decomposes CaCO<sub>3</sub> to CaO and CO<sub>2</sub>. Typically, Portland Cement contains the equivalent of about 63.5 percent CaO. Consequently, about 1.135 units of CaCO<sub>3</sub> are required to produce 1 unit of cement, and the amount of CO<sub>2</sub> released in the calcining process is about 500 kilograms (kg) per Mg produced (1,000 pounds [lb] per ton of cement). Total CO<sub>2</sub> emissions from the pyroprocess depend on energy consumption and generally fall in the range of 0.85 to 1.35 Mg of CO<sub>2</sub> per Mg of clinker.



Once cement is manufactured, it's mixed with fine & coarse aggregate and sand to make concrete. In the United States, it's not uncommon for residential concrete to be designed with a water/cement ratio of 0.45. To meet this specification, concrete will contain 519 to 639 pounds of cement per cubic yard depending on the amount of substitutes (such as fly ash) utilized for cement. Concrete weighs 3996 lbs/cubic yard, or about 2 tons per cubic yard.

Combining the data, a range of 440 to 862 pounds (0.22 to 0.43 tons) of CO<sub>2</sub> emissions are generated per cubic yard of concrete during its production. Concrete with a high fraction of substitutes, produced in a more efficient facility, will have the lower CO<sub>2</sub> emission rate.

## TRANSPORTATION OF CONCRETE

Each gallon of diesel fuel consumed in the transport of concrete emits 22.6 pounds of CO<sub>2</sub> when using petroleum derived diesel fuel (in contrast to biodiesel). Total CO<sub>2</sub> emissions – wellhead to wheel – are about 20% higher depending on refinery location and efficiency, or about 27 lbs/gallon.

Cement is transported to a concrete batching facility in cement bulk tankers. A cement tanker hauls approximately 26.5 tons of cement in a load, and the truck averages about 6 mpg. The average round trip to haul cement is approximately 150 miles. Aggregates are transported in various haul trucks. The average delivery is 25 tons, and the average round trip is 40 miles.

Concrete is hauled in a specialized concrete mixer truck. Because of the excessive idle time, a concrete mixer truck averages about 4 mpg. The average load size in a concrete truck is approximately 8.5 cubic yards.

Combining the CO<sub>2</sub> emissions for various elements of transportation needed for production and delivery of the concrete to the job site results in about 34 to 35 lbs (low cement fraction vs. high cement fraction) of CO<sub>2</sub> per cubic yard of concrete.

## OTHER ATTRIBUTES

Beyond the reduction in CO<sub>2</sub> emissions, reduction in oxides of nitrogen (NO<sub>x</sub>), particulate matter, hydrocarbons, and carbon monoxide would also occur. These could be quantified as well, but would track and correlate to the predicted reduction in CO<sub>2</sub>.

## CO<sub>2</sub> EMISSIONS TOTALS

The manufacture and transport of cement/concrete to a job site results in 474 to 897 lbs (0.24 to 0.45 tons) of CO<sub>2</sub> per yard of concrete. The majority of CO<sub>2</sub> comes as a result of the production of cement for the concrete with a significantly lesser amount contributed by transportation of the material.

## CONCLUSION

Comparisons of numerous floor plans have shown, on an average 1,800 – 2,000 sf home, the WAFFLEMAT System typically reduces the use of 5 – 40 yards of concrete (depending on size of any interior beams utilized) when compared to an equivalent Ribbed or 10" Uniform Thickness Foundation (UTF) slab. Assuming 20 yards of reduction, corresponding CO<sub>2</sub> emissions would be reduced by 4.8 to 9.0 tons, or about 20% lower than conventional slab foundations.

In other words, CO<sub>2</sub> emissions reduced when using the WAFFLEMAT System are equivalent to those emitted when using 405 to 766 gallons of gasoline (23.4 lbs/gal, full fuel cycle), or enough fuel to drive an automobile averaging 35 MPG 14,000 to 27,000 miles.

## SUMMARY

Use of the WAFFLEMAT System in residential home construction can reduce the level of climate change emissions by 20% – the equivalent of 4 to 9 tons less CO<sub>2</sub> released into the atmosphere – when compared to the use of conventional slab foundations. Other emissions reductions are also projected.

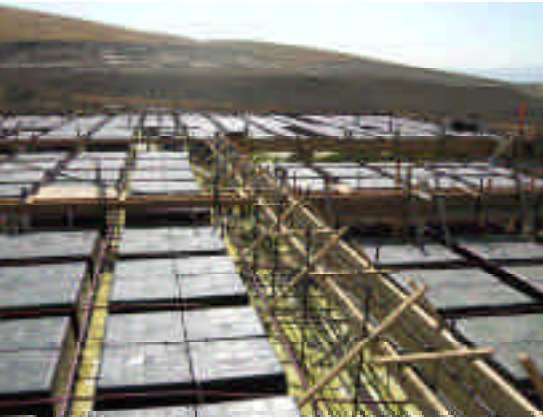
## REFERENCES

United States EPA AP-42, January 1995  
WAFFLEMAT™, US Patent 5,540,524, 1996  
Kyoto Protocol, UNFCCC, December 1997  
California Assembly Bill 32, December 2006

## CONTRIBUTING

Joe Sostaric, President, RS Solutions LLC

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## APPENDIX | The WAFFLEMAT

PHS



The WAFFLEMAT foundation forming system creates a post-tensioned foundation especially for expansive soils. It offers the ease of constructability of a Uniform Thickness Foundation, along with the efficiency of a Ribbed Foundation.

The system sits on pad grade, and comes in either 8½" or 12" high 19" x 19" thermal grade heat resistant WAFFLEBOXES (note: the boxes are made of recycled plastic and are "environmentally friendly"). The WAFFLEMAT is created by connecting a series of bottomless WAFFLEBOXES together, and evenly spacing them throughout the footprint area. A five inch post-tension reinforced concrete slab is then monolithically poured, the bottomless WAFFLEBOXES allowing for any expansive soil movement. The pour also creates concrete beams running through the footprint and perimeter.



The system can be easily installed. The plumbing is brought up through the WAFFLEBOXES with rebar reinforcement. The slab set up and pour is a two-day or less process, eliminating trenching and reducing soil preparation by providing less over excavation and re-compaction, reducing building cycle-time.



The WAFFLEMAT possesses the greatest floor stiffness of any system in its class, with sufficient strength to resist differential swelling resulting from landscaping practices, surface drainage or flooding from any source. In addition, the WAFFLEMAT does not require presoaking underlying soil pads, and there is no need for footings – meaning, no earth spoils. And, since the WAFFLEMAT slab is typically 12" above grade, it provides the option of no gravel, sand, or moisture barrier.

The WAFFLEMAT, first installed in 1995, has been used in nearly 7,000,000 square feet of residential living space without one reported structural failure.