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

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

Use of the Ecodome™ System in residential home or light commercial construction can reduce the level of climate change emissions by 20% [the equivalent of 3.6 to 8.16 tonnes less CO_2 released into the atmosphere per building] when compared to the use of conventional slab foundations. Other emissions reductions are also projected.

EXECUTIVE SUMMARY

Carbon dioxide (CO_2) is the main anthropogenic gas contributing to the build-up of greenhouse gases in the earth's atmosphere. Emissions of CO_2 from a specific project are collectively referred to as the "carbon footprint." CO_2 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 building vs. when the Ecodome™ 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, sulphur 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.

Although New Zealand have followed the Kyoto Protocol in the past and achieved the goal, the current climate change goals are set under the UNFCCC and the Paris agreement. The Current goals for New Zealand are as Follows:

- 2020 target is to reduce emissions by 5% below the 1990 levels, this is not Kyoto but apply the same rules have been applied for accounting to ensure transparency
- 2030 target is to reduce emissions to 30% below 2005 levels. The Paris agreement means the overall goal is to limit the global temp increase to 1.5-2°C
- 2050 target is to reduce emissions to 50% below 1990 levels and the future of carbon emissions and the Zero Carbon Bill ("New Zealand, 2018")

EMISSIONS ESTIMATE ANALYSIS

Portland Cement

According to US EPA AP-42, the CO_2 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_2. Additional, and again often substantial, quantities of CO2 also are generated through calcining of limestone or other calcareous material. This calcining process thermally decomposes $CaCO_3$ to CaO and CO_2. Typically, Portland Cement contains the equivalent of about 63.5 percent CaO. Consequently, about 1.135 units of $CaCO_3$ are required to produce 1 unit of cement, and the amount of CO_2 released in the calcining process is about 500 kilograms (kg) per Mg produced. Total CO_2 emissions from the pyro process depend on energy consumption and generally fall in the range of 0.85 to 1.35 Mg of CO_2 per Mg of clinker.

Once cement is manufactured, it's mixed with fine & coarse aggregate and sand to make concrete. In New Zealand, it's not uncommon for concrete to be designed with a water/cement ratio of 0.65. To meet this specification, concrete will contain 235 to 290 kgs of cement per cubic metre depending on the amount of substitutes (such as fly ash) utilized for cement. Concrete weighs 3055 kg per m^3 Combining the data, a range of 199 to 390 kilograms of CO_2 emissions are generated per cubic metre of concrete during its production. Concrete with a high fraction of substitutes, produced in a more efficient facility, will have the lower CO_2 emission rate.

WORLDWIDE AVERAGES OF TRANSPORTATION OF CONCRETE

For every 3.8 litres of diesel fuel consumed in the transport of concrete emits 10.25 kgs of CO_2 when using petroleum derived diesel fuel (in contrast to biodiesel). Total CO_2 emissions -- wellhead to wheel -- are about 20% higher depending on refinery location and efficiency, or about 3.24 kilograms per litre

Cement is transported to a concrete batching facility in cement bulk tankers. A cement tanker hauls approximately 24 tonnes of cement in a load, and the truck averages about 2.55 kilometres per litre (kpl). The average round trip to haul cement is approximately 240 kilometres. Aggregates are transported in various haul trucks. The average delivery is 22.6 tonnes, and the average round trip is 65 kilometres.

Concrete is hauled in a specialized concrete mixer truck. Because of the excessive idle time, a concrete mixer truck averages about 1.70kpl. The average load size in a concrete truck is approximately 6.5 m^3

Combining the CO_2 emissions for various elements of transportation needed for production and delivery of the concrete to the job site results in about 15 kilograms (low cement fraction vs. high cement fraction) of CO_2 per 0.76 m^3 of concrete.

OTHER ATTRIBUTES

Beyond the reduction in CO_2 emissions, reduction in oxides of nitrogen (NOx), 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_2.

CO2 EMISSIONS TOTALS

The manufacture and transport of cement/concrete to a job site results in 215 to 406 kg of CO_2 per 0.91 metres of concrete. The majority of CO_2 comes as a result of the production of cement for the concrete with a significantly lesser amount contributed by transportation of the material.

SUMMARY

Use of the Ecodome™ System in average-sized building construction can reduce the level of climate change emissions by 20% -- the equivalent of 3.6 to 8.1 tonnes less CO_2 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
Ecodome™ by CUPOLEX® TM, Patent
Kyoto Protocol, UNFCCC, December 1997 California
Assembly Bill 32, December 2006
New Zealand and the united nations framework convention on climate change. (2018). Retrieved from https://www.mfe.govt.nz/climate-change/why-climate-change-matters/global-response/new-zealand-and-united-nations-framework

APPENDIX | Ecodome™

Ecodome™ is a patented structural dome flooring system made from 100% recycled non- toxic plastic modular elements. Each element easily inter-connects to create a self -supporting structure which acts as a permanent form work, replacing gravel, hard fill and provides under slab voids for ventilating.

Ecodome™ is the main component that, along with Beton stop, complete a system that quickly and easily inter-connect, forming a self-bearing structure on a pre- arranged base to admit the pouring of concrete. Ecodome™ units are available in a range of heights from 50mm to 700mm depending on the slab thickness required.

The system can be easily installed and the plumbing is brought up through the Ecodome™. The slab can be set up and ready to pour in one-day or less, potentially eliminating trenching and reducing soil preparation by providing less over excavation and re-compaction, reducing building cycle-time.

The Ecodome™ possess 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 Ecodome™ does not require pre-soaking underlying soil pads, and there is no need for footings – meaning, no earth trenching and spoils. And, since a typical Ecodome™ slab is typically over 225mm above grade. Where top soil layers are thick, higher Ecodome™ can be used to create a deeper slab. This replaces the hard fill that typically is required to bring the slab to level and eliminate the costs associated with importing, compacting and certifying engineered fill.

Ecodome™ Benefits & Advantages

- Up to 20% reduction in concrete consumption
- Up to 20% reduction in reinforcing steel
- Up to 80% reduction in interior box forming for grade beams, footings, and foundations
- Ease of transportation of components 52m^2 pallet
- Reduced labour costs, 150 m^2 laid in 2 man hours, fast assembly with minimal site work requirements
- Can replace, gravel, engineered fill or hard fill and associated compaction costs.
- Reduced plant and machinery requirements allowing for Minimal construction traffic damage on site;
- Substantially reduces dampness, mould & mildew by controlling moisture wicking through slabs, eradicating resultant problems with tiles or carpets lifting;
- Reduces Slab curling and shrinkage cracks;
- Provides space for running services such as cables, conduit, ductwork, chases, etc.;
- Eliminate the need for expensive mechanical ventilation piping systems on contaminated soils;
- Under-Slab can be fully ventilated to disperse VOC's, Radon, Methane and other harmful gases; that can be found in U.S. and European sites
- Considerable cost savings in poor load-bearing soils especially in expansive soils.

The products are made of entirely recycled polypropylene Homopolymers. Polypropylene is an environmentally responsible product, which is composed of carbon and hydrogen, and is manufactured without any dangerous emissions or by-products. It can be recycled, incinerated, or disposed of in landfill sites without any harm to the environment. When burnt it will give off water vapour and carbon dioxide, which is converted by photosynthesis.

It does not contain any heavy metals or plasticizers, and is chemically stable. All production waste is recycled and post-consumer waste can be recycled without difficulty. It is very hard wearing withstands extreme temperatures and ageing, does not break or tear, and when creased, a change in the molecular structure increases the material's resistance to mechanical stress.

The Ecodome™ by Cupolex® first installed in 1995, has been used in millions of square metres of building without one reported structural failure.

CONCLUSION

Comparisons of numerous floor plans have shown, on an average 167 – 185 square metres of building, the Ecodome™ System typically reduces the use of 4.57 –36 metres of concrete (depending on size of any interior beams utilized) when compared to an equivalent Ribbed or 25cm Uniform Thickness Foundation (UTF) slab. Assuming 18 metres of reduction, corresponding CO_2 emissions would be reduced by 4.35 to 8.16 tonnes, or about 20% lower than conventional slab foundations.

In other words, CO_2 emissions reduced when using the Ecodome™ System are equivalent to those emitted when using 1,533 to 2,899 litres of gasoline (2.80 kilos/litre, full fuel cycle), or enough fuel to drive an automobile averaging 14.88 kpl 22,530 to 43,452 kilometres. In a year the average New Zealand car will travel between 10,000 to 15,000 kilometres.

How Ecodome™ can reduce the carbon footprint of your concrete slab

Manufacturing Ecodome™ H260 pod is 0.088kwh running off hydroelectric power generation. The energy used to charge your phone eleven times, is equivalent to producing enough Cupolex for a 200m^2 home. The other pieces run slightly lower.

Ecodome™ is manufactured using 100% recycled materials from products such as bottle caps, car battery cases, plastic cutlery, medicine containers and straws. Which can also be recycled again, therefore there is no waste product from production and any 'seconds' are ground down and re fed back into the moulding process.

Ecodome™ is manufactured in NZ reducing the carbon foot print of importation.

Ecodome™ by Cupolex® is both Branz appraised and also carries the CodeMark certification so can be used throughout NZ as standard or can also be site specific design, this ensures that the foundation is designed in the most efficient way as well as being fit for purpose.

Ecodome™ is a compact delivery. One pallet contains 52m^2 of product, this means that a 200m2 house fits on four pallets. The equivalent of polystyrene would be a full truck and trailer unit. One pallet of Ecodome™ can replace 3-4 trucks of gravel fill, reducing site traffic and CO2 emissions.
With this in mind the same full truck and trailer unit would contain over 15 Ecodome™ (200m2) floors and a CO2 emission saving of nearly 7000kg of Carbon Dioxide over the 15 foundations in polystyrene. By the time this is delivered Ecodome™ would have used 6% of the diesel required to deliver the polystyrene

Ecodome™ can also reduce consumption of concrete and steel in a foundation both reducing the Carbon footprint. Please see attached.

Ecodome™ has excellent thermal value which will contribute to lower heating costs. We can also incorporate other thermal breaks to further improve this. Ecodome™ Thermal wrap will increase the R value without adding to the laying process as it acts as a DPM as well as a thermal break.

Waffle Pod vs. Ecodome™

This analysis is based around the manufacturing of both waffle pods and Ecodome™ from distribution to manufacturing and the construction of the project 100kms from the manufacturing plants.
It is broken down into 4 areas:

- Raw material used in each product
- Manufacturing process of each product
- Transport from manufacturing plants to site
- Concrete delivery
- Waste

The final evaluation is measured in diesel litres per house finished – hence each area has a measure in diesel fuel

	Waffle Pods	**Ecodome™**
Raw Materials used in each product	-As a derivative of ethylene and benzene, 2.2kgs per 220-300pod -135 pods per house x 1ltrs (for this exercise we have averaged 1ltr of petroleum based product to produce 2.2kgs of raw EPS product) **135 Litres**	-100% reclycled material – no petroleum based products used in the raw materials **0 Litres**
Manufacturing Process on each project	-Energy consumption will be similar. -Water consumption is equal. -Steam required in the styrene (EPS) process to expand the raw material to 40 times its size. -Because of similarity a calculated volume of 20 Litres of diesel per house on each product (0.5 litres of diesel per 3.5klwats of power) **20 Litres**	-Energy consumption will be similar. -water consumption is equal. -Cool water is required for the moulding process to release product from mould. - Ecodome™ is manufactured using hydroelectric energy the equivalent of 0.88 kwph **0 Litres**
Transport from manufacturing plant to site	-135 x 220mm pods delivered direct to site from manufacturer by a truck -30 litres of diesel per 100km based on a 6-8 tonne truck with trailer. **30 Litres**	-30 litres of diesel per 100km based on a 6-8 tonne truck with trailer. - this is the mass equivalent of 17 houses per truck and trailer, meaning per house the diesel use is 1.7Litres **1.7 Litres**
Concrete	-220-300mm plus 85mm topping = 40 cube of concrete (+/-) - Based on a concrete truck holding 6 cubic metres and averaging 2.2km per litres of diesel, travelling 20km to site from the batching plant, the diesel consumption would be: **7** Trucks trips at 9.09litres per trip = **63.63** (concrete volumes are averaged from several 200sqm projects)	-260 dome plus 60mm slab topping = 35 cube of concrete (+/-) - Based on a concrete truck holding 6 cubic metres and averaging 2.2km per litres of diesel, travelling 20km to site from the batching plant, the diesel consumption would be: **6** Trucks trips at 9.09litres per trip = **54.54** (concrete volumes are averaged from several 200sqm projects)

Additional Information

The building project would be based on the average 200sqm domestic building. Using 220-300mm pods or 260 domes
This analysis does not take into its measures the diesel to supply the raw materials to the batching plant

The table below is the total of each area per domestic house 200sqm

Product	Raw Materials	Manufacturing process	Transport	Concrete	Total
Waffle Pods	135 Litres	20 Litres	30 Litres	63.63 Litres	248.63 Litres
Ecodome™	0 Litres	0 Litres	1.7 Litres	54.54 Litres	56.24 Litres
Difference	135 Litres	20 Litres	28.3 Litres	9.09 Litres	192.39 Litres

To create the waffle pods from manufacturing to delivery requires an extra 192.39 Litres of fuel.
Under the international standards 1 Litre of diesel = 2.7Kgs of CO_2, therefore 1 Waffle pod slab, In a radius of 100km from the manufacturer, is admitting an extra 524.85kg of Kgs CO_2 into the atmosphere, which is three times more than a Ecodome™ finished slab.

The comparisons are only dealing with the areas suppliers have accountability for and that provide opportunities to improve our carbon footprint in the supply chain.

Cost savings gained by using Ecodome™

Cost savings to the builder and concreter are divided into two areas – tangible and non-tangible savings

Tangible Savings
With the large numbers of slabs installed so far in New Zealand, an average material cost saving has been established across all distribution areas.

- Concrete – an average of 8% saving in concrete volume will be achieved across good ground sites
- Requirements – on average a 4% saving in reinforcing steel can be achieved compared to a waffle pod
- Installation cost – to date, the time taking to install an Ecodome™ slab is between $1-$2.50 a square metre less than waffle pod slab.

Non-Tangible
This area covers the savings gained in the speed if installation from motivated concretes and the non-stoppages due to windy weather or on site damage. As we know waffle pods cannot be installed in windy conditions over 15-20 knots of wind or wet weather. Ecodome™ is not affected by winds and can be installed during light rain.

One major issue with waffle pods is on site storage and the environmental damage that can happen if cutting on site has occurred or winds or storms blow polystyrene around the community

Specific Savings

- Increase in cash turnover due to no delays in installing Ecodome™.
- No time or wages wasted in staff collecting polystyrene from a storm, wind damage or off cuts
- Improved site storage as Ecodome™ takes up very little site space.