

# CONCRETE FOR A MILLENIUM: THE GREAT STUPA OF DHARMAKAYA

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# | A STUPA?



A spiritually  
empowered monument



Which liberates on seeing



To honor  
Chögyam Trungpa Rinpoche,  
The founder of the  
Shambhala Mountain Center



# BUT...



The Location is at Red Feather Lakes, Rocky Mountains, Colorado.



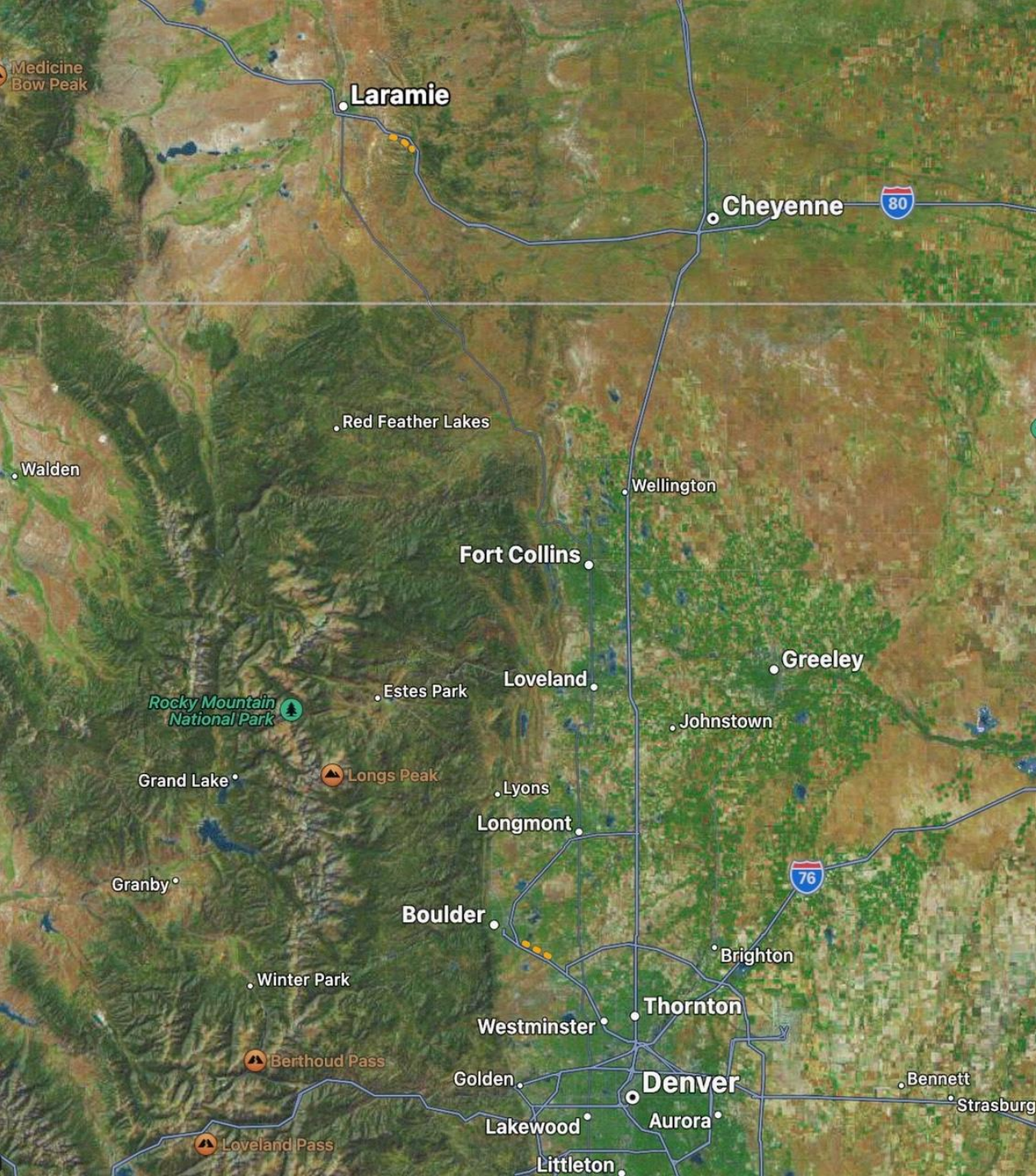
It's at **8,500** feet elevation (~2,600m), and the local ready-mixer is in Fort Collins.



And we'd like the concrete to last for more than **1,000 years, please.**

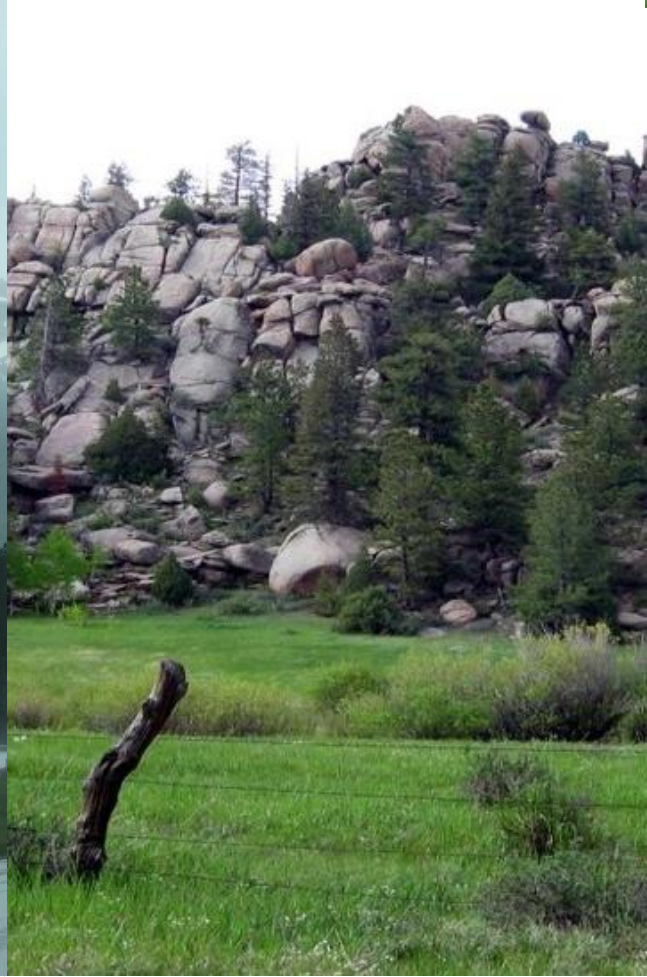


**Plus, it's being built by volunteers, so it may take some time... like... years...**





**It can be a bit rough in winter**



**Not a lot of roadway**



**Access is a bit difficult**



**It's fine during summer, once you're there**

Okay, we're going to have to think about that mix design then...

Strength? 6,000 psi @ 28 days

Anything else? Entrained Air @ 5%

And don't forget 1,000-year lifetime...

# A FEW MORE THOUGHTS...

**It's going to take about an hour for the ready mix trucks to get to 'the bottom of the hill' – then it's going to be 'manhandled' to the site...**

**There's going to be some big blocks to pour and some delicate facias to cast, so we'll want a creamy mix with good workability, at the site, for a couple of hours or so...**

**With that time frame, that's going to be tough for the air entrainment if we don't want to lose any air...**

**Good amount of Class 'C' fly ash in there – long term strength and durability.**

**Addition of silica fume – seal it up from the start – extra strength, water, chloride and sulfate resistance – enhanced durability.**

**That triple blend will give a fine paste, so a good finish for facias and a dense surface to resist damage.**

# WHAT ABOUT THAT AIR?

'just on the market' was a product called *Micro-air*.

1<sup>st</sup> synthetic air entrainer.

*Well, here's a "Baptism of Fire" for it...*

Target: 100% freeze thaw resistance = 300 cycles.

Achieved over 500 cycles – and at that elevation, the cycles would not be as frequent as usually expected.



# CONCRETE MIX DESIGN AND STRENGTHS

Mix Design Materials :	lbs / yd <sup>3</sup>	kg / m <sup>3</sup>
Cement, Type I / II	730	433
Fly Ash, Class C ( 11 % replacement)	94	56
Silica Fume ( 9 % addition )	76	45
Aggregates	to yield;	5 % air-entrained
High Range Water Reducer	1.3 - 1.5 gal / yd <sup>3</sup>	4 - 5 ltr / m <sup>3</sup>
Water / Cementitious Ratio	0.35	0.35
7 day compressive strength	6,900 psi	48 MPa
28 day “	8,700 psi	60 MPa

# DID ANYONE THINK OF THE CARBON FOOTPRINT?

Not at the time (35 years ago!) but:

Using general figures for OPC, Fly Ash and Silica Fume of 950kg; 90kg and 15kg per tonne respectively, the variations that could have been used come out at:

Pure OPC	507kg
OPC and Silica Fume	462kg
OPC and Fly Ash	456kg
<u>OPC and Fly Ash plus Silica Fume</u>	<u>417kg. (~700lb/yd<sup>3</sup>)</u>

The triple blend had the lowest carbon footprint anyway...

# BIG AND SOLID FOR THE MAIN PART



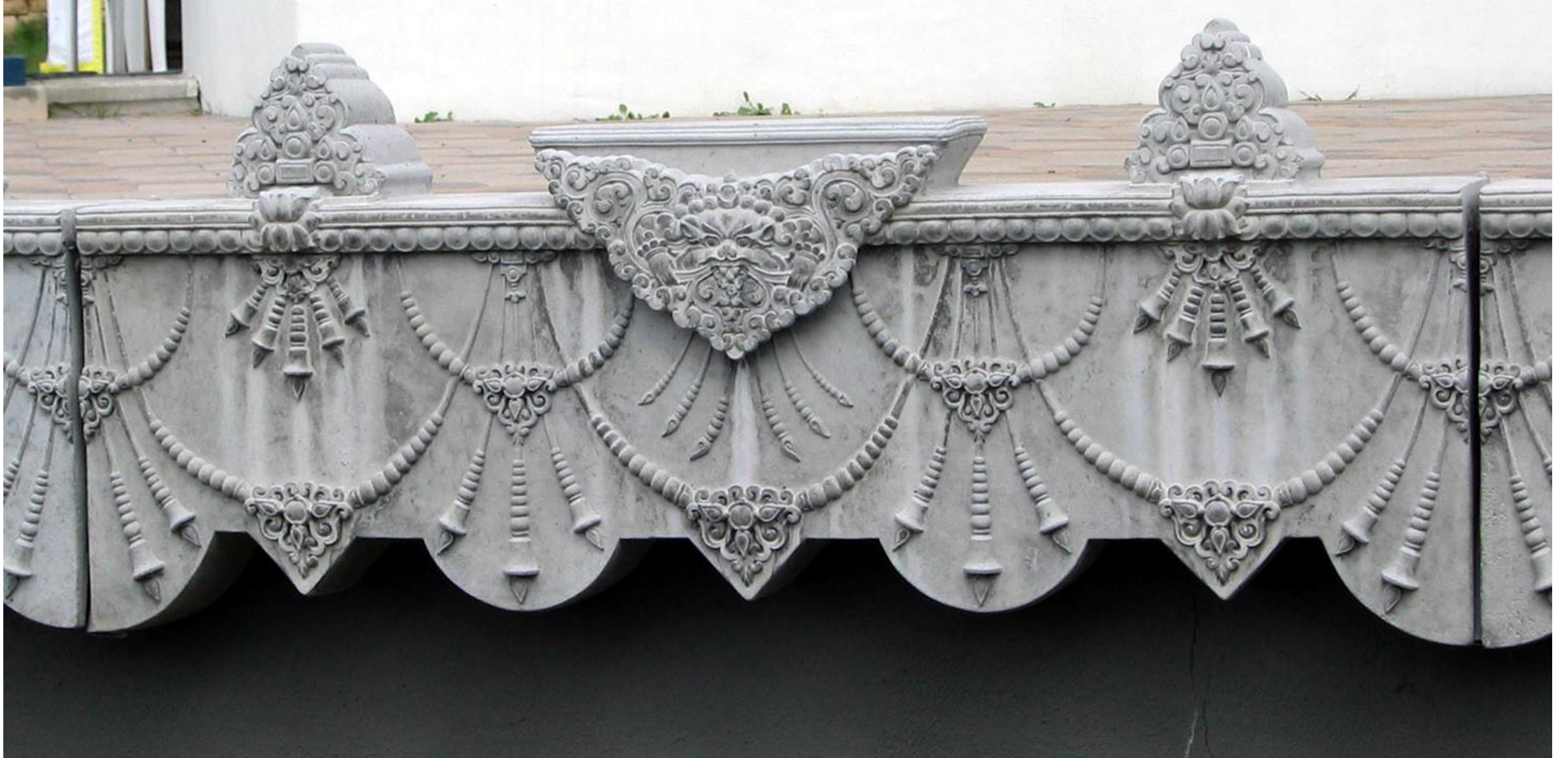
# SHARP LINES AND SMOOTH SURFACES



# NOT BAD FOR CAST IN-SITU



# DELICATE FACIA FINISH



# CLOSE UP.



# EXTERIOR FINISHING







## **The Great Stupa of Dharmakaya**

**It took over 15 years to build – but the result is truly impressive!**

**And yes, it probably does stand a good chance of lasting 1,000 years –**

**and at that, it can be classified as ‘sustainable construction’.**

# Thank you.

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