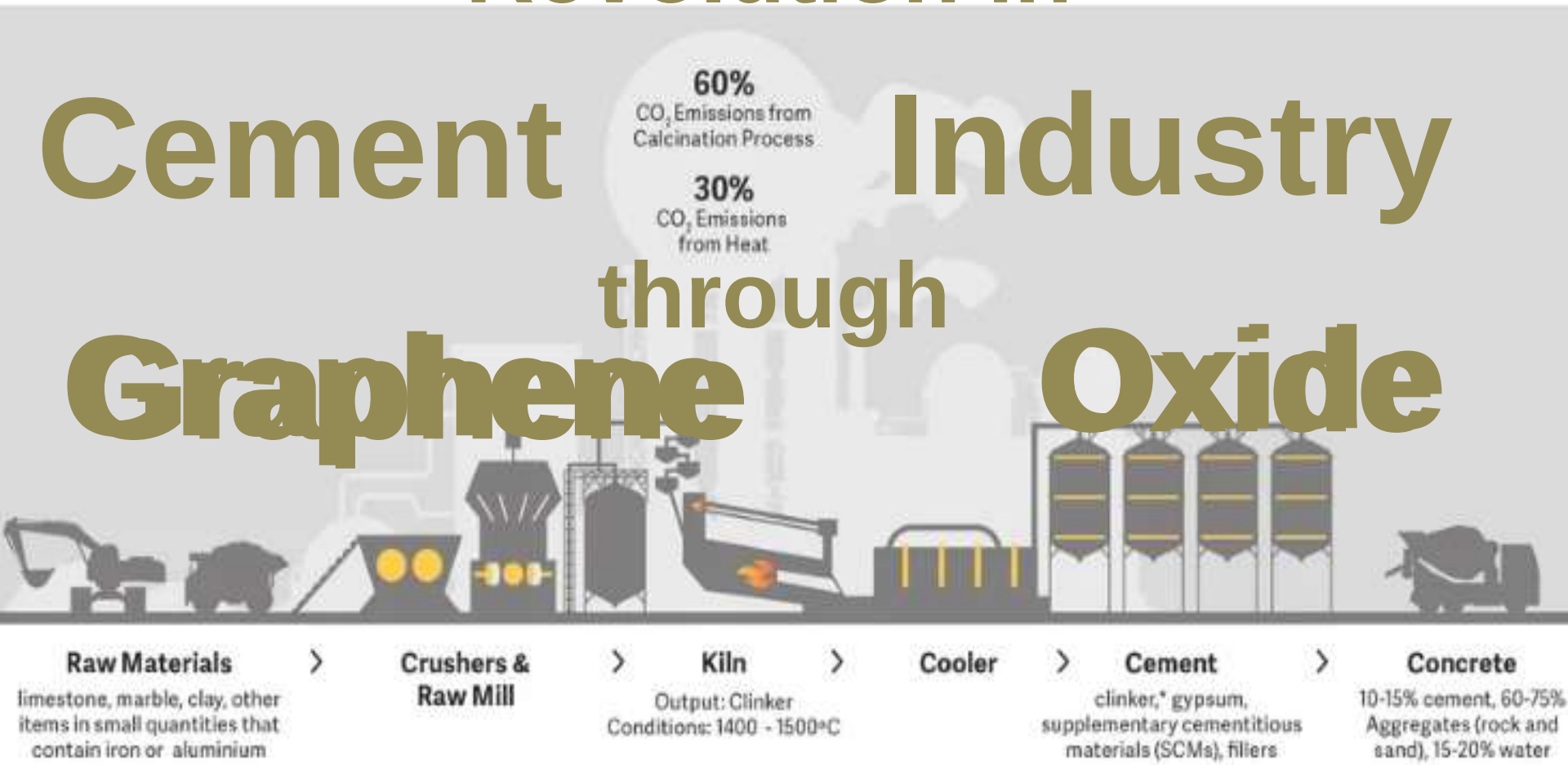
GRAFNOTEK NANO SOLUTIONS

In Scientific and Technical Collaboration With

RI Instruments & Innovation India

Revolution in Cement Industry through Graphene Oxide



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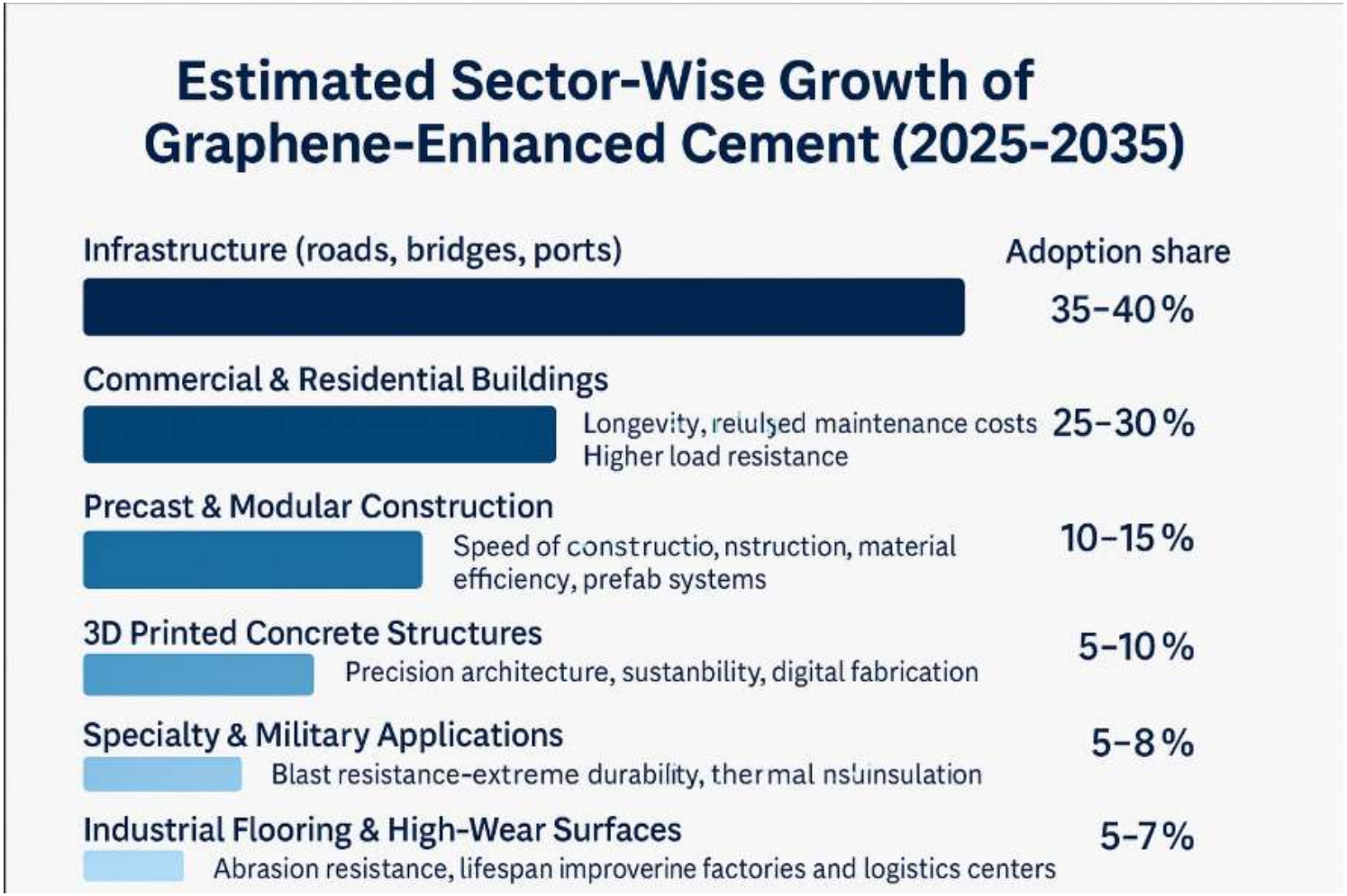
Graphene-Enhanced Cement: Global Market Outlook and Environmental Impact



What "Revolution" Means with GO

Clinker Modification

Act as an **internal nano-reinforcement** with calcium silicates, calcium aluminates etc in the final cement

Improve **toughness** and **resistance to thermal or mechanical shock**

Stronger, Smarter Microstructure

GO helps to form a more compact and crack-resistant C-S-H (Calcium Silicate Hydrate) matrix.

Self-healing and more resilient to environmental damages.

Functional Cement

Cement becomes more than just a binder—it gains functional properties:

- **Thermal conductivity**
- **Electromagnetic shielding**
- **Sensing capability (e.g., for smart infrastructure)**

Why This Is Revolutionary

Graphene oxide makes cement *smarter, stronger, and nano-engineered*.

This isn't just a substitution—it's a material-level transformation:

- **From a chemically reactive filler → to an intelligent nanomaterial integrator**
- **From passively setting → to actively optimizing microstructure, longevity and being tunable.**

Cement that heals small cracks on its own

Structures that last 100+ years without major maintenance

- **Like bridge deck twice as durable …..**
- **Cement production with approx 30% to 60% less CO_2 thanks to GO- aided efficiency**

GO Cement Revolution

Feature	Graphene Oxide
Scale of Action	Nanometer (1–100 nm)
Primary Composition	Carbon with oxygen-containing functional groups
Additive Level	0.01–0.05% additive
Interaction Mode	Nano-reinforcement, nucleation, crack-bridging

GO Cement Revolution

Feature	Graphene Oxide
Strength Impact	Boosts early and long-term strength
Durability Enhancement	Densifies matrix, reduces crack propagation
Thermal Conductivity	High increase in hydration heat flow

Industry Benefits

Thermal Conductivity Enhancement During Kiln Processing

GO has **excellent thermal conductivity**.
It leads to **more uniform heat distribution in the kiln bed**, potentially:

- Reducing local **overheating or underburning**
- **Lowering fuel consumption** by 10-20%
- Improving kiln efficiency and clinker uniformity
- Allow for **lower-energy grinding post-kiln**, this results in additional lowering of fuel consumption by 10-20%
- **Process time saving** due to faster cooling by 10-20%
- **Waste reduction by** 8-10 % in every production cycle
- Approx 10% less **maintenance cost**

End User Benefits

Increased Compressive Strength

Graphene-enhanced cement can exhibit 50% or more **higher compressive strength** with optimal concentration

Higher Flexural Strength

Improves the ability of cement to resist bending and cracking, with **20–80% increases in flexural strength**.

Reduced Permeability

Graphene creates a denser microstructure, minimizing pore connectivity, which **reduces water and chemical ingress** that causes corrosion.

Faster Setting and Curing Time

The nucleation effect of graphene speeds up hydration reactions, potentially **reducing curing time by 10–30%**, which is valuable in construction.

Reduced CO_2 Emissions

Since less cement is needed for the same strength, graphene incorporation could **cut cement use by up to 30%**, indirectly reducing carbon footprint.

End User Benefits (Cont.)

Improved Durability and Longevity

Resistance to chloride ion penetration, freeze-thaw cycles, and sulfate attack is enhanced, prolonging structural lifespan.

Reduced Shrinkage and Cracking

Graphene acts as a nano-reinforcement, limiting microcrack formation during drying shrinkage, which improves structural integrity.

Self-Sensing and Smart Capabilities

Graphene's conductivity allows the development of self-monitoring cement for stress, strain, or damage detection using embedded sensors.

Improved Bonding with Reinforcements

It enhances the interfacial transition zone (ITZ) between cement and steel rebar, improving overall adhesion and load transfer.

Potential for Lightweight Structures

Due to increased mechanical properties, less material can be used while achieving the same or better performance, leading to lighter structural components.

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MANUFACTURING PROCESS BENEFITS FOR CEMENT

- **10x** increase in shelf life of stored cement
- No change in process
- No Capital expenditure needed
- **4x** Improvement in life expectancy of expensive parts

- **20** Days of downtime saved per year
- **25%** Improvement in throughput
  - → Less energy cost
  - → Less labor cost
  - → Less maintenance cost
- Significant reduction in carbon emissions
- **28%** Reduction in cost of manufacturing