Essentials for making Modern Concrete

“Chemistry for Construction”

Contents.

1. Environmental Challenges to us.
2. Needs of Modern Construction & Concrete Industry.
3. BASF Value addition to concrete industry.
4. BASF’s contribution to Iconic local projects.
5. Conclusion.
Environmental Challenges for the Construction Industry

Cement Produces More Pollution Than All the Trucks in the World

There are greener ways to make it, but customers are slow to embrace the change.

By Vanessa Dejmek
June 23, 2019, 1:00 AM EDT

- FLIR Systems
- Contributes to 30% of the global greenhouse gas emissions
- Causes 10% of the world's emission of fine dust
- Displaces the most productive land
- Contributes to loss of biodiversity and ecosystems
- Concrete: most widely used man-made material (1m³/Pers/annum)

Concrete: most widely used man-made material (1m³/Pers/annum)
### Impact of Climate Change: *Water is coming!*

<table>
<thead>
<tr>
<th>Date</th>
<th>Global Population billions)</th>
<th>Global GDP ($10^{12}$ US$ yr$^{-1}$)</th>
<th>Per Capita Income Ratio</th>
<th>Ground Level O$_3$ Concentration (ppm)</th>
<th>Global Temperature Change ($^o$C)</th>
<th>Global Sea-Level Rise (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>5.3</td>
<td>21</td>
<td>16.1</td>
<td>—</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>2000</td>
<td>6.1-6.2</td>
<td>25-28</td>
<td>12.3-14.2</td>
<td>40</td>
<td>0.2</td>
<td>2</td>
</tr>
<tr>
<td>2050</td>
<td>8.4-11.3</td>
<td>59-187</td>
<td>2.4-8.2</td>
<td>~60</td>
<td>0.8-2.6</td>
<td>5-32</td>
</tr>
<tr>
<td>2100</td>
<td>7.0-15.1</td>
<td>197-550</td>
<td>1.4-6.3</td>
<td>&gt;70</td>
<td>1.4-5.8</td>
<td>9-88</td>
</tr>
</tbody>
</table>

Source: IPCC (Intergovernmental Panel on Climate Change)
Impact of Climate Change in Asia

Figure 1. Total Occurrences of Natural Disaster Events (1970-2014)

Figure 2. Occurrences of Natural Disaster Events in Asia and the Pacific by types (1970-2014)

Source: unescap.org
UN estimates a population increase of up to 9.6 bn people in 2050
What is desired today?
What Is Desired Today?
Iconic Skyscrapers in the World - Trend

- 508m
  - Taipei 101
  - Self Consolidating Concrete

- 541m
  - One World Trade Center
  - Green Sense Concrete

- 601m
  - Makkah Royal Clock Tower
  - MasterGlenium

- 632m
  - Shanghai Tower
  - Smart Dynamic Concrete MasterSure

- 828m
  - Burj Khalifa
  - MasterGlenium SKY

- ~1000m
  - Kingdom Tower (under construction)
  - MasterGlenium SKY

All skyscrapers in the world above 500m height are built with premium range BASF admixtures.
Needs and demands of the modern construction industry.

➢ **Productivity enhancement.**

➢ Durable and Sustainable structures.

➢ Robust solutions.

➢ Better Utilization of space - UG and Skyscrapers.

➢ To build lighter and stronger elements.

➢ Enhancement in resources efficiency. (Men, Material and Machinery).

➢ Alternative building materials.

➢ Digitalization in construction-BIM

➢ Safe work environment.

➢ To minimize the construction cost and maintenance cost in particular.
Construction Skilled Labour Shortage – The Challenges in Malaysian Construction Sector
Needs and demands of the modern concrete industry.

➢ Productivity enhancement.

➢ Robust solutions to accommodate fluctuations in concrete making materials.

➢ Faster mixing, Less sticky mixes. (Operational efficiency)

➢ Flexibility in mobility. (Logistics efficiency, faster turn around of trucks).

➢ Easy placement. (Time efficiency and no post application challenges).

➢ Enhancement in strength. (Accommodates the fluctuations and Inefficiency of Concrete Ingredients).

➢ Safe working environment
Challenges in Concrete Placement

Issue 1: Compaction

![Concrete Placement Image]

- Point of Insertion of Vibrator Needle
- Zone of Influence
- Poorly Compacted - Chance of Voids
Challenges in Concrete Placement
Issue 1: Compaction
Challenges in Concrete Placement
Issue 2: Management of Skilled Workforce

Management of Skilled Workforce

Workmanship Control !!!
Challenges in Concrete Placement
Issue 3: Complicated Shape of structure

Concrete Pour

Possible Honeycomb
Peak Productivity with Smart Dynamic Concrete

Reduced manpower requirement, Faster Completion, less wastage and better finish.
Peak Productivity with MasterSure
Concrete’s limited shelf life is a big challenge for Concrete Technologists globally.
Peak Productivity with MasterSure
Long Haul concrete, minimize rejection, Retention as per the demand, flexibility in design, economical.
The effect of water on rheology of concrete

- Water helps the workability and finishability of concrete.
- Water is the only component acting on both, the plastic viscosity & yield stress of concrete.

- Theoretically ~25 liters of water is sufficient to hydrate 100 kg of cement, however workability of such a mix is very low.

- Any surplus water is only required for rheological reasons.

- But this does not come without consequences...
What’s the solution?

MasterEase

Rheology made easy

✓ MasterEase reduces the Viscosity of concrete hence improves Rheology making it less Sticky, which means that…..

✓ MasterEase makes it easier to Produce, Pump, Place, Vibrate, Trowel & Finish
# Batching

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Longer mixing time</td>
<td>Quick dispersion and homogeneity</td>
</tr>
</tbody>
</table>

- **Faster Wet out** –
  - Increased Productivity by 20%
  - Lesser wear & tear
  - Reduced maintenance cost by 25%

MasterEase - 01:32 Min

Standard PCE 02:25 Min
Pumping

**Challenge**
To achieve concrete output equal to pump output

**Solution**
Reduce pressure & friction factor requires to pump concrete

- Lower yield stress
- Lower capital cost
- Increased productivity
- Lesser Wear and tear cost

**Nomograph**
Pump output increased by 10 Cu.M. /Hr
Pressure can be reduced by 25%

**Plastic viscosity**
Pump pressure

- Poor Rheology
- Better Rheology

**Graphs**
- Plastic viscosity: PCE Slump retainer vs PAE slump retainer
- Pump pressure: PCE Slump retainer vs PAE slump retainer

Pressure can be reduced by 25%
Piping

Challenge
Pipe line choking & bursting

Solution
Reduced stickiness & concrete pressure

» Reduced Plastic Viscosity-
  ■ Maintain Safety
  ■ Saving in piping and man hour cost
  ■ Reduced concrete wastage
Concrete Finishing Solution: MasterEase
Why MasterEase?

Max. 25% water reduction
Easy to handle
Higher Setting time

BNS

MasterEase

Water reduction = Standard PCE
Longer workability retention
Better Rheology Retention

Excellent water reduction
Higher Early Strength
Concrete becomes sticky

PCE
**Rheology of concrete**

- Rheology defines the flow and inherent behavior of fluids.

- Concrete rheology measurements are typically expressed in terms of the Bingham model, which is a function of:
  - **Yield stress**: the minimum stress to initiate or maintain flow (related to workability).
  - **Plastic viscosity**: the resistance to flow once yield stress is exceeded (related to stickiness).

**The Bingham Model**

\[ \tau = \tau_0 + \mu \dot{\gamma} \]

- **Shear Rate**, \((1/s)\)
- **Shear Stress**, \((Pa)\)

**Graphical Representation**
- The graph shows the relationship between shear stress and shear rate for different concrete types:
  - **Near zero yield stress**
  - **Slump**
  - **Flowable, but sticky**
  - **Flowable, but segregated**

**ICAR rheometer**
MasterEase applications

Example: Reduced viscosity of a SCC C35/45
MasterEase applications

Example: Comparison of slump and T500 of a SCC C35/45 mix
MasterEase applications

Example: Comparison in V-funnel of a SCC C35/45 mix
MasterEase applications

Example: Comparison in L-flow box of a SCC C35/45 mix

Identical mix design

Identical slump flow
Strength Redefined
Master X-Seed STE
An innovative admixture for strength enhancement
What is the big headache for Concrete Producers?

Solutions?
In Real Life – what happens after that?
Factors influencing Strength and Properties of Concrete

- Hardening (setting)
- Workability (consistency)
- Compaction
- Methods of placement
- Climate curing methods
- Porosity
- Concrete properties
Scale of Things – Nanometers and More
1,000,000 nm in one millimeter

Human Hair
~ 50,000 to 150,000 nm

Portland Cement
~ 20,000 to 45,000 nm

Master X-Seed Particles
~ 50 to 100 nm
Master X-Seed STE – Crystalline Calcium Silicate Hydrate (CSH) Nanoparticles

Admixture Includes CSH Seeds
- Nanoparticles improve cement hydration
- Breakthrough technology – creating a new category of admixture performance

Unmatched Strength Enhancement
- Improves strength development
- Ability to increase the use of supplementary cementitious materials

Improving Concrete Performance
- Provides for strength safety factor and expanded performance space
- CSH nanoparticles provide flexibility in concrete design and production
Master X-Seed STE – Product Value

Improving Concrete Strength
Flexibility in Design

That’s chemistry at work

Environmental Sustainability
...all through use of CSH seeding
Applications

<table>
<thead>
<tr>
<th>Icon</th>
<th>Feature</th>
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</thead>
<tbody>
<tr>
<td>![Arrow Up]</td>
<td>Enhanced Strength</td>
</tr>
<tr>
<td>![Money]</td>
<td>Cost Savings</td>
</tr>
<tr>
<td>![Diamond]</td>
<td>Increased durability</td>
</tr>
<tr>
<td>![Arrow Down]</td>
<td>Reduce Carbon Footprints</td>
</tr>
</tbody>
</table>
Applications

Enhanced Strength

- **Scenario 1**
  Upgrade the strength by one grade

- **Scenario 2**
  Expand or increase the safety margin factor of concrete

- **Scenario 3**
  As a stop gap measure for poorer quality cement and/or aggregates

- **Scenario 4**
  Earlier form stripping
Applications

<table>
<thead>
<tr>
<th>Cost Savings</th>
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<tbody>
<tr>
<td><strong>Scenario 1</strong></td>
</tr>
<tr>
<td>Increase the use of cheaper SCMs</td>
</tr>
<tr>
<td><strong>Scenario 2</strong></td>
</tr>
<tr>
<td>Use of poorer quality cement and aggregates</td>
</tr>
<tr>
<td><strong>Scenario 3</strong></td>
</tr>
<tr>
<td>Faster turnaround of molds</td>
</tr>
</tbody>
</table>
### Applications

<table>
<thead>
<tr>
<th>Increased durability</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scenario 1</strong></td>
</tr>
<tr>
<td>Increased SCMs for better durability</td>
</tr>
<tr>
<td><strong>Scenario 2</strong></td>
</tr>
<tr>
<td>Reduce heat of hydration for raft foundation or mass concreting</td>
</tr>
<tr>
<td><strong>Scenario 1</strong></td>
</tr>
<tr>
<td>Higher SCMs</td>
</tr>
</tbody>
</table>

**Reduce Carbon Footprints**
Small addition → Great values

**Master X-Seed STE**
- Improves concrete strength
- Allows higher incorporation of SCMs
- Zero negative influence on air content, workability and workability retention

**Robustness**
- Strength increase observed across varying mix designs and raw materials
- Performs in warmer climate (30°C)
- Works best with PCE admixtures

**Sustainability**
- Increase SCM content up to 20% to 40% with comparable 28-day strength
- LEED

**Durability**
- Increased durability without loss of strength
- Low heat of hydration for mass concrete casting
Specific performances are designed by adjusting functional building blocks.

- **Side chain**
  - Water reduction capability

- **Functional building blocks**
  - Viscosity control
  - Workability retention
  - Thixotropy control
  - Cement affinity

Design of advanced polymers to formulate the Admixtures “customized to application”
Customized formulations

Water demand

Viscosity control

Strength control

Cement affinity
BASF Value addition to the Malaysian Iconic projects
Penang Second Bridge
- One of the Longest Bridge in South East Asia

- High Early strength requirements for Precast elements
- Ready Mix Concrete - Long slump retention up to 8 hours
Signature Tower: Record-breaking foundation concrete pour in KL Malaysia

- One continuous pour over 48 hours
- Specially developed concrete mix design to control heat of hydration
- Exclusive MasterGlenium & MasterEase product to maintain good workability & improve concrete rheology/stickiness
What are some of the Challenges that Innovative Admixtures can Address?

<table>
<thead>
<tr>
<th>Process Step</th>
<th>Admixture Solutions for:</th>
</tr>
</thead>
</table>
| Materials    | 1. Higher Usage of *Manufactured Sand*  
                   2. More *Sustainable* Concrete Mixtures |
| Mixing       | 3. Faster *Mixing Times*  
                   4. Production of *Ultra High Strength* |
| Transit      | 5. Improved *Slump Retention* |
| Placing      | 6. Reduction of *Concrete Stickiness*  
                   7. Easier & *Faster Placement* of Concrete |
| Hardening    | 8. Faster *Early and Late Strength* Development |
Say good bye to most of your day to day concrete issues by using Innovative Admixtures with right chemistry.
Beyond properties of concrete to project completion
It’s not just about cost per cubic meter

Through innovation we have developed a smarter concrete which results in earlier completion and better performance
Concrete

IN THE UNENDING SERVICE OF NATION BUILDING.

LET US LEARN THIS SUBJECT TO BE A PART OF NATION BUILDING TEAM.
- M S SHETTY.
BASF’s brand for the construction industry