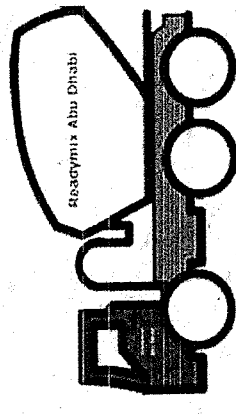


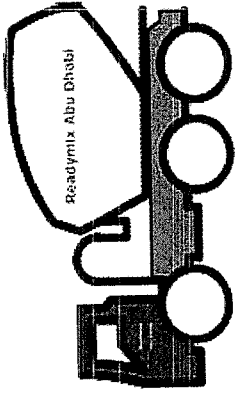
# **Towards Performance Based Specifications Case Studies on Construction Projects in Abu Dhabi**

**Fouad Yazbeck / Wassim Mansour**

**Readymix Abu Dhabi**



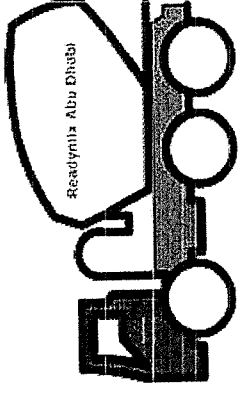
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## Outlines

- I. Definitions and facts
- II. Case study 1: Al Raha Beach Re-development Project
- III. Case study 2: Zayed National Museum Project, Phase I
- IV. Keys of successful performance specifications
- V. At a glance: Extreme performance in a single mix

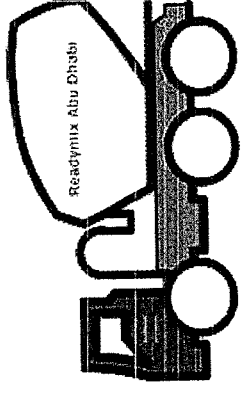
# I – Definitions and facts



- **Prescriptive Specifications:**
  - Properties of raw materials
  - Mix proportions
  - Batching, mixing, and transporting of concrete
  - Placing, curing and repairing
  - Sometimes, end-product performance (Hybrid spec)
- **Facts related to prescriptive specifications:**
  - Effectiveness of the specification is solely related to the specifier and his knowledge in all the above concrete related aspects
  - An ineffective specification may result in the construction team meeting all the requirements while the structure fails to perform as desired\*

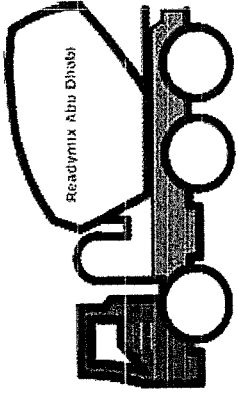
\*ACI ITG 8R-10: Report on Performance-Based Requirements for Concrete

# I – Definitions and facts



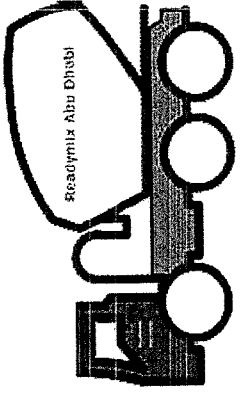
- A conservative specification that “over-specifies” relative to the owner’s needs will increase the cost without enhancing in-place performance
- Prescriptive specifications may hinder the contractor and/or concrete supplier from using innovative materials and ideas that support the sustainability aspect and performance of the end product
- **Performance Specifications** start with the end-product in mind:
  - They mainly define the required end-results and criteria to judge the performance
  - They set the verification methods and bonus/penalty provisions
  - Details about materials selection, proportioning, construction means are left up to the party bound contractually to complying with the specifications

# I – Definitions and facts



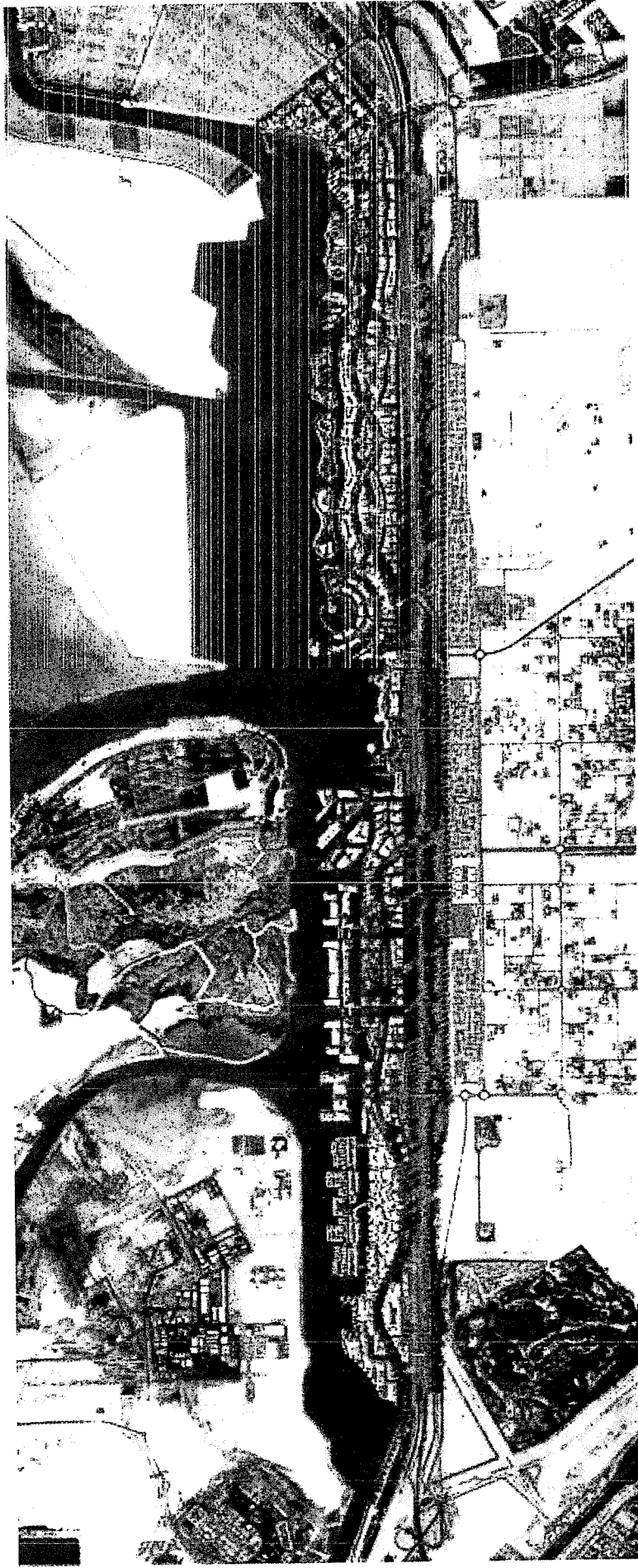
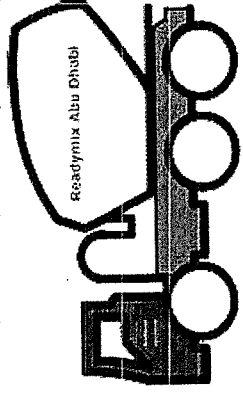
- ❑ **Facts related to performance specifications:**
  - Great chance to meet the intended performance at an effective cost (i.e., by eliminating the chance of overdesigning issue)
  - Better involvement of all team members of the project (designer, supplier and applicator)
  - Better chance for the construction team to come up with **innovative ideas** which can eventually enhance the **performance** and **sustainability** of the end-product

## II – Case Study 1: Al Raha Beach Project

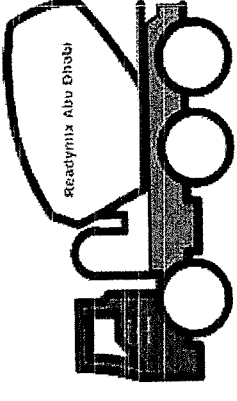


- Project: Al Raha Beach Redevelopment Project, Abu Dhabi
- Client: ALDAR Properties
- Contractors: ALDAR Laing O'Rourke, Al Futtaim Carillion and many others
- Concrete supplier: Aldar Readymix/RMAD
- Type of structures: Sea shore protection walls, Residential, Office and Utility Buildings and Infrastructure
- Total concrete volume: 10,000,000 m<sup>3</sup> (Phases 1 and 2)

## II – Case Study 1: Al Raha Beach Project



## II – Case Study 1: Al Raha Beach Project



### □ **Overview**

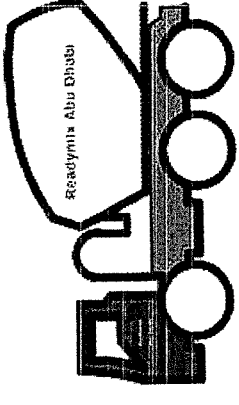
- The sheer scale of the project brought its own set of challenges
- The project involved various types of structures subjected to a wide range of exposures

### □ **Initial stage of the project**

- Many designers/specifiers were initially involved in this job
  - Hundreds of concrete requirements and mixes were initially proposed
  - Expected 20 concurrent jobsites in a congested area. Very high demand of concrete of various types
  - Serious shortage of concrete raw material
- ### □ **Constructive initiative**
- A team was formed in order to deal with this complexity

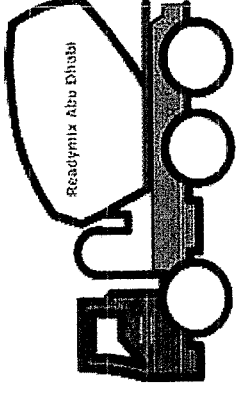


## II – Case Study 1: Al Raha Beach Project



- The **team** was composed of major key players on the project:
  - Client representative
  - Project Management Company
  - 4 Representatives of international consultants active on the site
  - Main contractor
  - Readymix supplier
  - Consultant hired to write a comprehensive concrete specification
  - Third-Party testing lab
- **Key targets:**
  - Streamlining the requirements and writing blanket specifications document (to a wide extent performance based)
  - Concrete sustainability and waste limitation
  - Organizing the flow of concrete ordering, delivery and testing

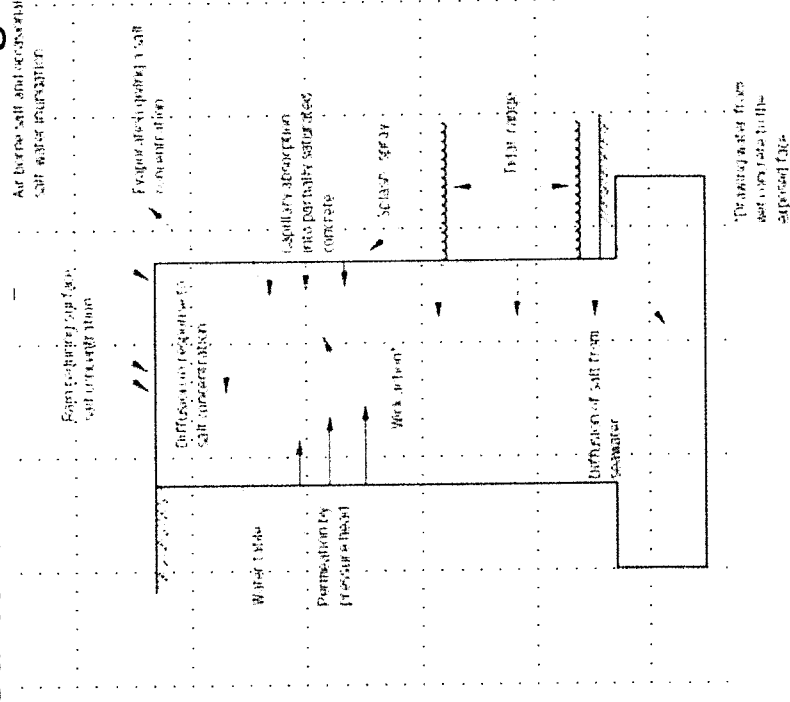
## II – Case Study 1: Al Raha Beach Project



- ❑ **Durability design:**
- Based on the ground and ambient conditions, a comprehensive durability design was undertaken by the appointed consultant.
- Intended service life was 50 years
- Exposures were identified and correlated to concrete chloride migration values and required concrete cover

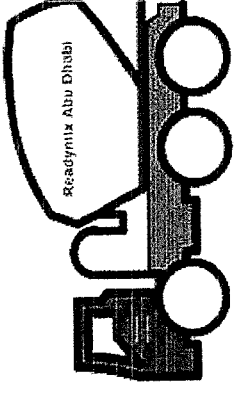
- ❖ Submerged zone
- ❖ Splash/Tidal zone (Cyclic wet/dry)
- ❖ Atmospheric zone

Exposures were identified and correlated to concrete chloride migration



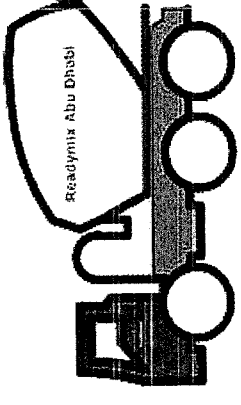


## II – Case Study 1: Al Raha Beach Project



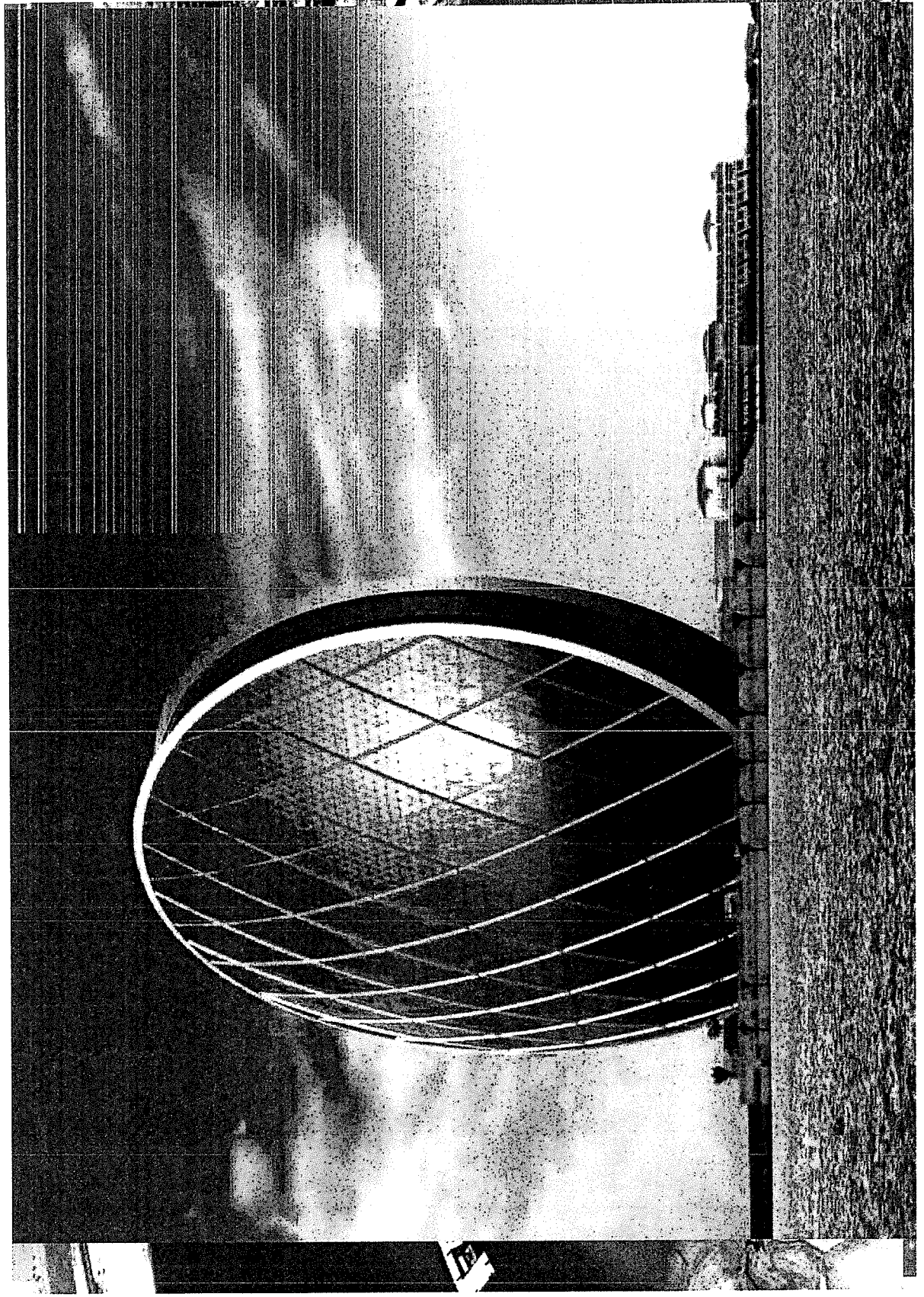
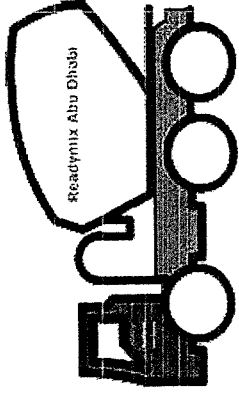
- **Course of actions:**
  - A list of 32 concrete mixes was prepared according to the durability design and RMAD strength/durability model
  - This list became the main **concrete performance document** which was distributed to all designers on this project
  - For durability and sustainability purposes, almost all mixes were designed to include GGBS (even low grade mixes)
  - **Streamlining** drastically reduced the chance of having over-designed mixes (RMAD model)
  - **Streamlining** minimized concrete waste by making concrete re-direction easy in case of over-ordering or site breakdowns

## II – Case Study 1: Al Raha Beach Project

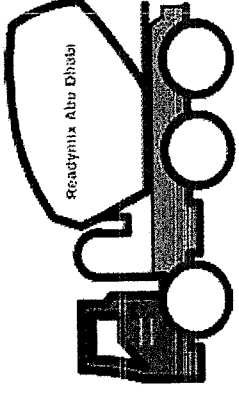


- **Performance verification methods** were also streamlined. Third party lab would test based on mixes and not on sites
- In order to further streamline the operations, a central ordering mechanism was set up
- **A system of bonus** in order to reward the projects that actually used as much concrete as they ordered. These sites got priority when placing their orders

## II – Case Study 1: Al Raha Beach Project

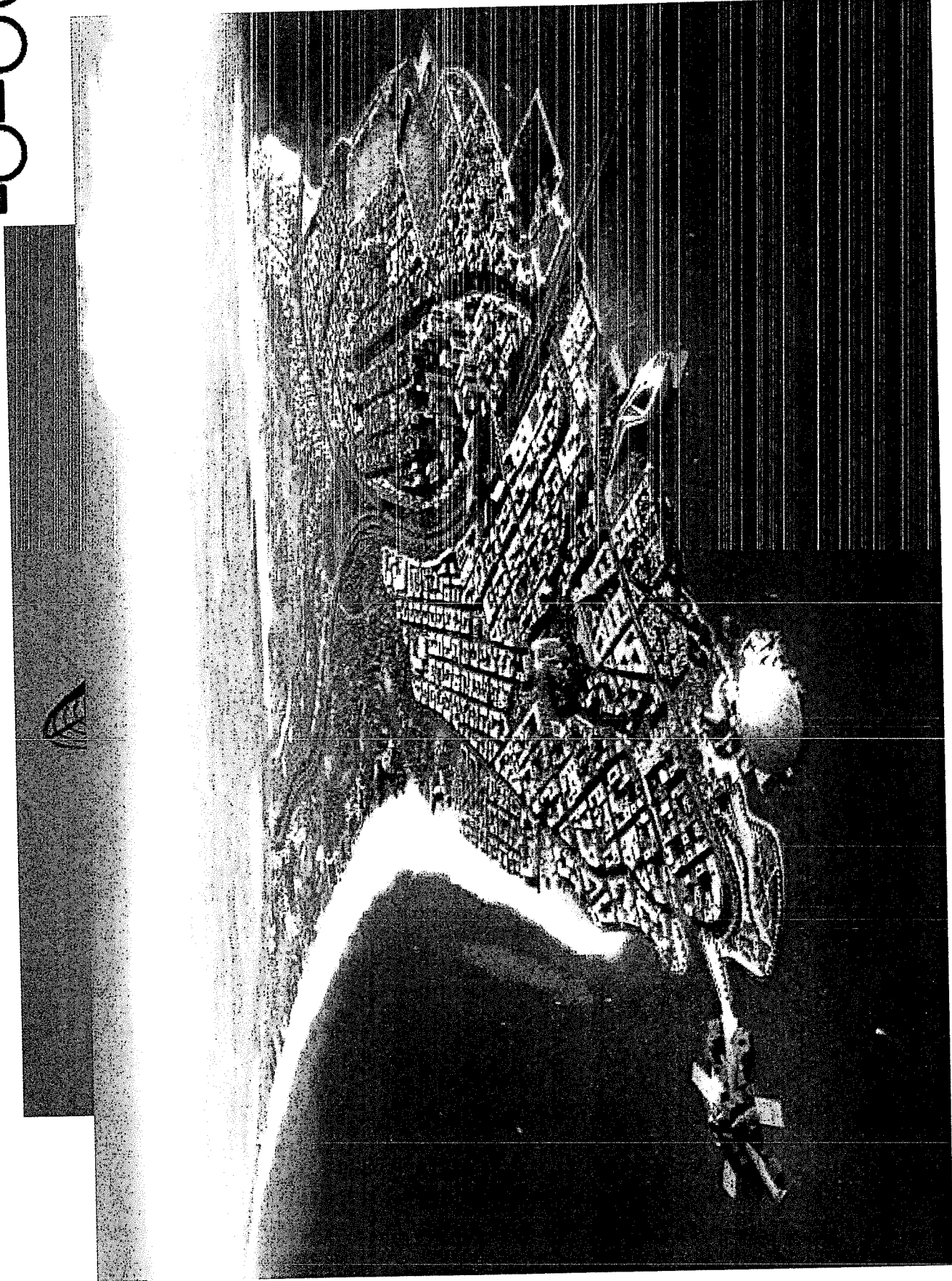
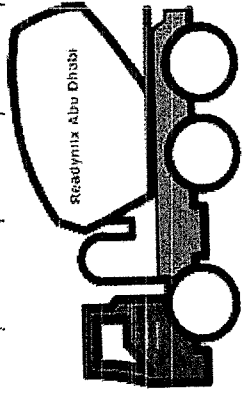


### **III – Case Study 2: Zayed National Museum**



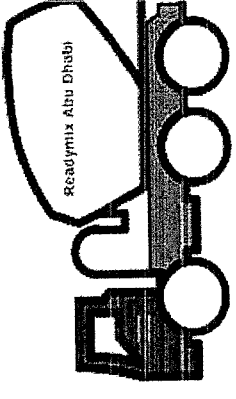
- **Project:** Zayed National Museum (Phase I), Abu Dhabi
- **Client:** TDIC
- **Main contractor:** Habtoor Leighton Group
- **Concrete supplier:** Readymix Abu Dhabi
- **Type of structure:** Cast in-situ, Architectural Fair-faced Walls (7x7x0.5m)
- **Total concrete volume:** 3,000m<sup>3</sup>
- **Duration:** 1 month

# III – Case Study 2: Zayed National Museum



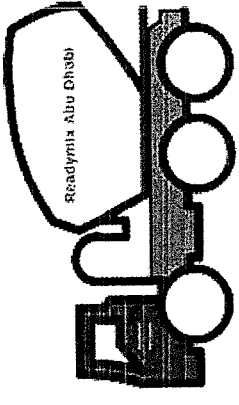


### III – Case Study 2: Zayed National Museum



- ❑ **Prescriptive requirements (fair-faced walls):**
  - Compressive Strength: 60 MPa
  - RCP (ASTM C1202):  $\leq 800$  Coulombs
  - Water Absorption:  $\leq 1.2\%$
  - Slump:  $150 \pm 25$ mm or slump flow:  $550 \pm 50$ mm
  - GGBS content: 60 to 65% of the total cementitious
  - SF content: 5 to 6% of the total cementitious
  - Design service life of 100 years
  - Architectural finish: Fair faced concrete where only very minor surface blemishes can occur. Discoloration, water marks, staining, joints and cracks are strictly not permitted.

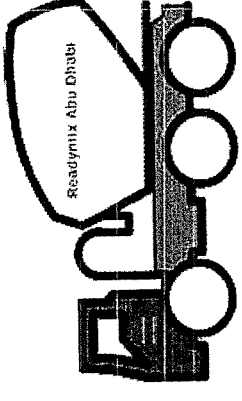
### III – Case Study 2: Zayed National Museum



#### Facts:

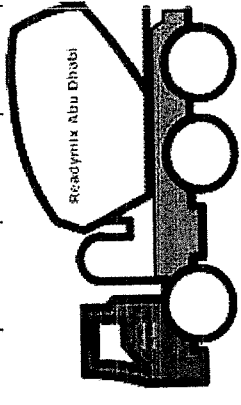
- Prescriptive requirements are contradictory and would definitely fail in achieving the intended service life and architectural performance.
- The specified cementitious contents would not guarantee the required concrete durability required for a service life of 100 years
- Conventional vibrated concrete would not do the job. Risk of workmanship errors has to be eliminated.
- Placing SCC with conventional pumping methods would also fail in achieving the target surface finish. Specified slump flow limits would not do the job
- Combination of innovative mix design and special placing method to be followed

### III – Case Study 2: Zayed National Museum



- **RMAD Proposal:**
  - The client is to disregard the existing prescriptive requirements
  - RMAD is to deliver and guarantee a robust SCC mix which can meet the intended performance requirements of 100 years service life and high quality surface finish
  - The mix design remains undisclosed where it can be kept in a safe box for a period of 2 years
  - Upward and slow pumping is to be followed (rate of 2 linear meter/hour).
  - Mockup wall to be cast prior to starting the job
  - Performance criteria for fresh concrete: slump flow of  $700 \pm 50\text{mm}$  without segregation nor bleeding
  - Performance criteria for strength: 60 MPa cube strength at 28 days

### III – Case Study 2: Zayed National Museum

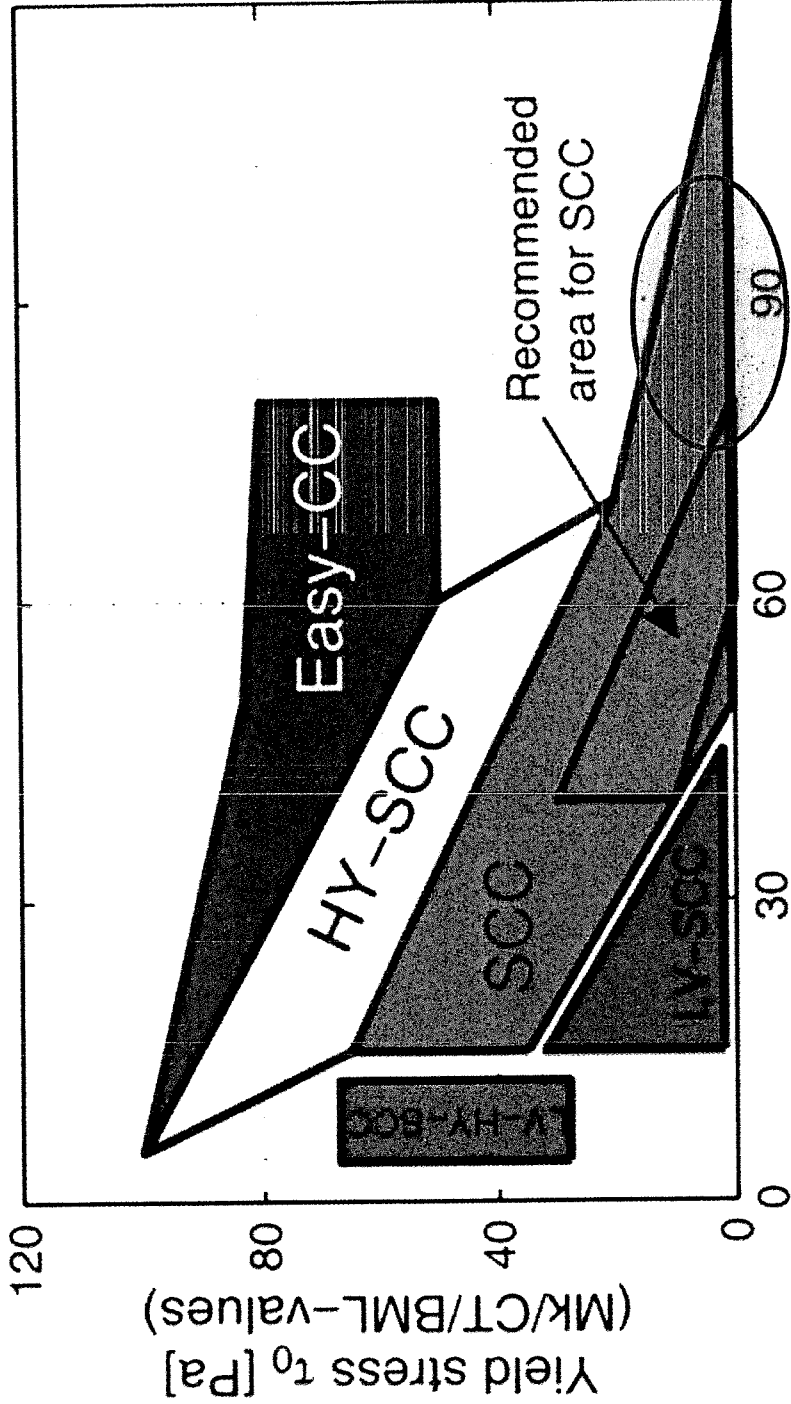
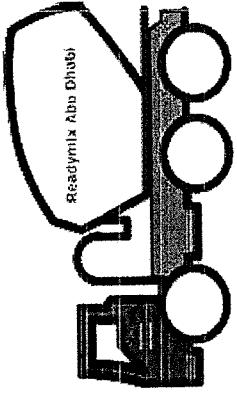


- ❑ **SCC mix:**
  - Target rheological properties, strength and durability of the SCC mix were achieved by means of a complex blend of SCMs, fines and VMA (not included in the original prescriptive specifications)
  - Uniformity of the concrete surface color and appearance was mainly achieved by maintaining a stringent control on the mix and placing rate
  - State-of-the-art portable Rheometer was used to maintain consistent rheological properties of the mix throughout the whole job

#### ❑ **Average results:**

| Strength | Chloride migration @ 28days                | Slump flow | J-ring | V-Funnel | Static Segregation |
|----------|--|------------|--------|----------|--------------------|
| 76Mpa    | $0.89 \times 10^{-12} \text{m}^2/\text{s}$ | 730mm      | 700mm  | 10 Sec.  | 6%                 |

# III – Case Study 2: Zayed National Museum

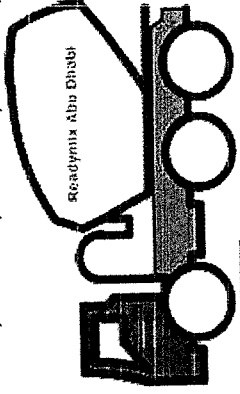


**Yield Stress**

Less than 15 Pa

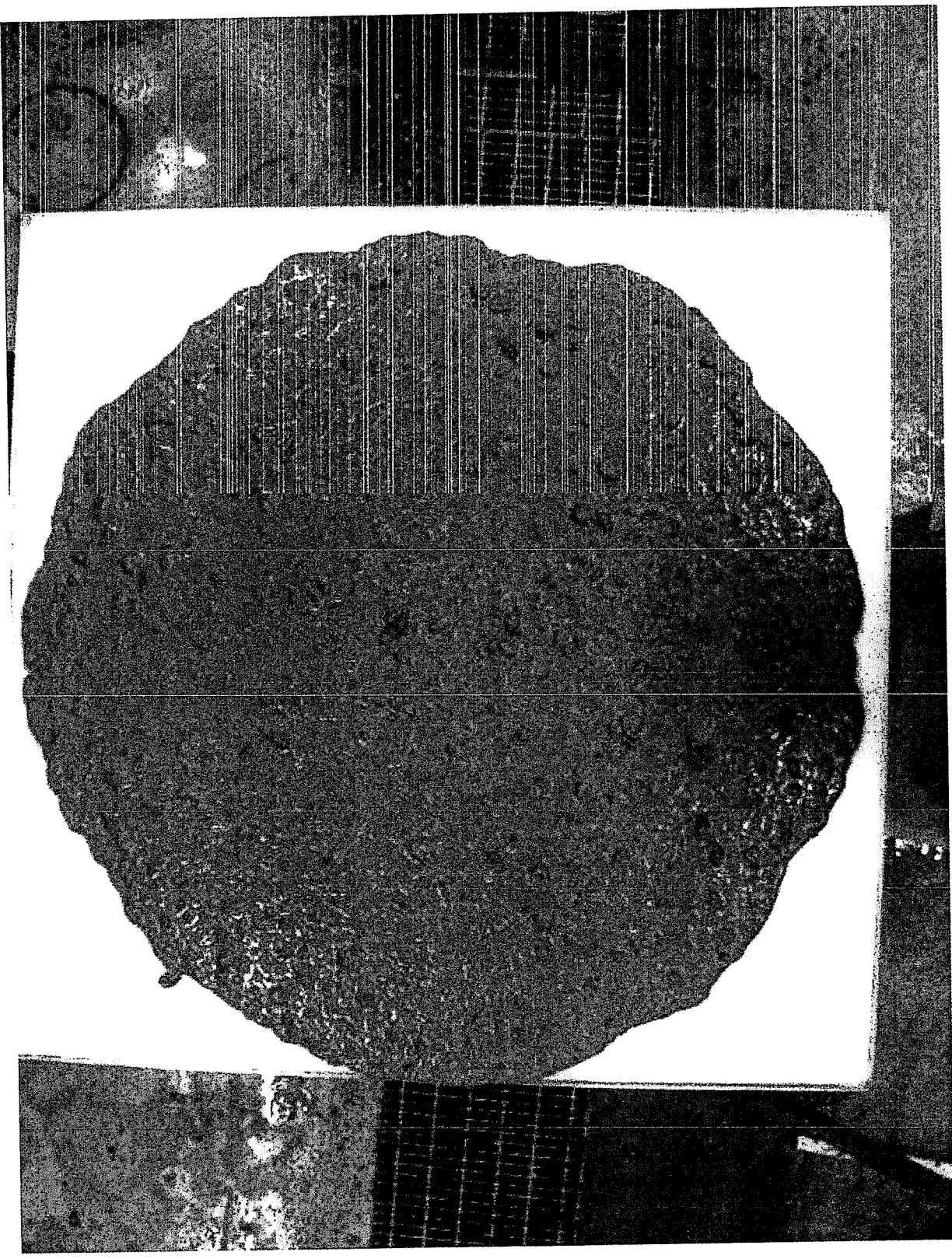
**Average Plastic Viscosity**

92 Pa.s

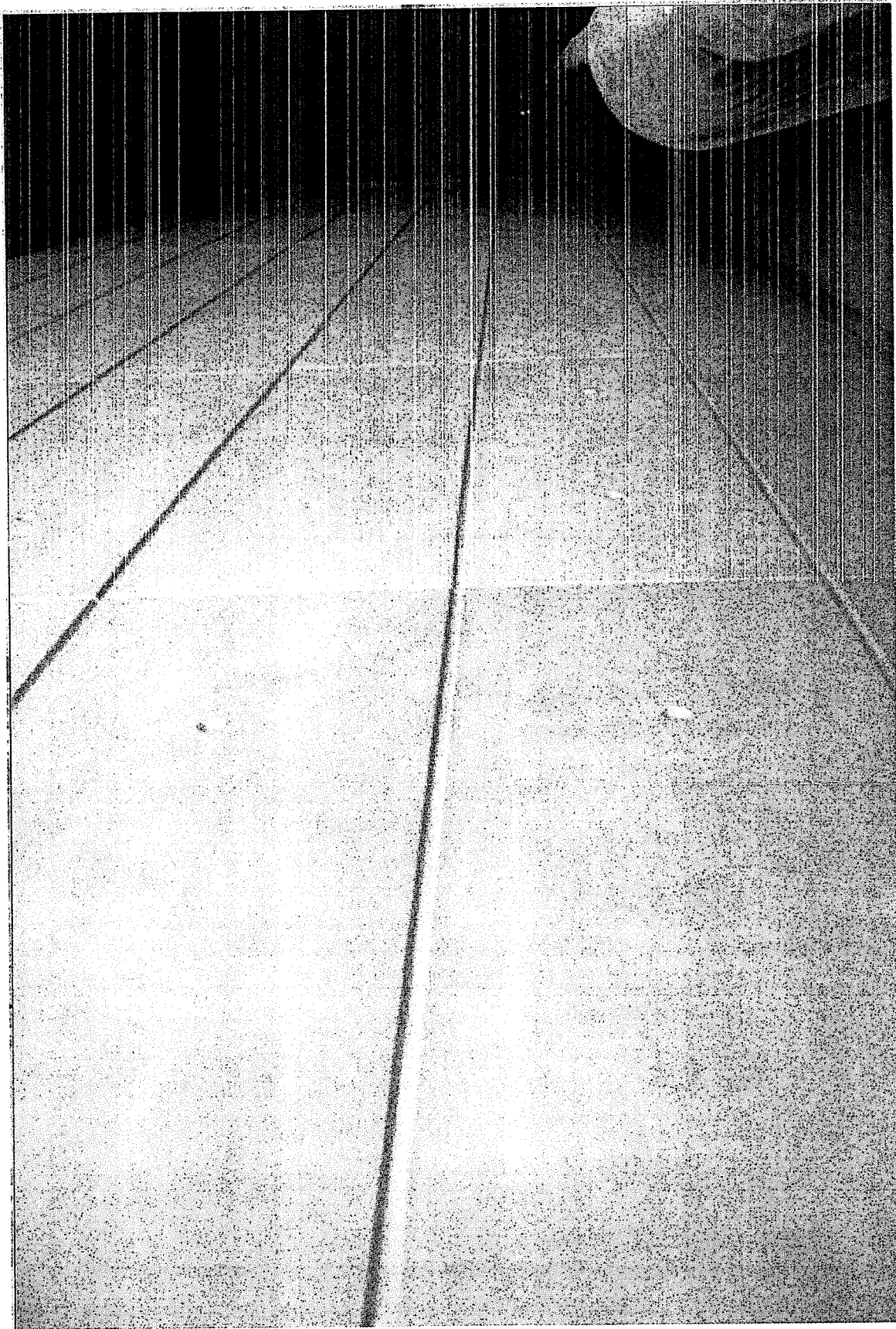
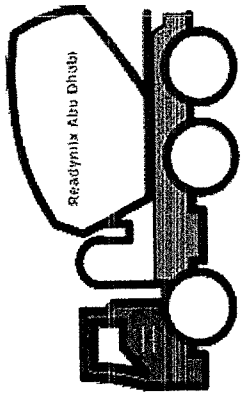


Recycledmix Abu Dhabi

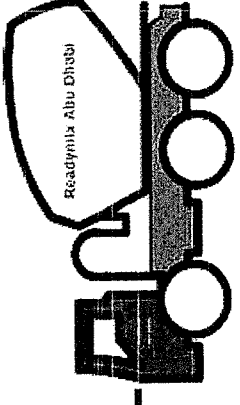
# III – Case Study 2: Zayed National Museum



# III – Case Study 2: Zayed National Museum



## **IV – Successful performance specifications**



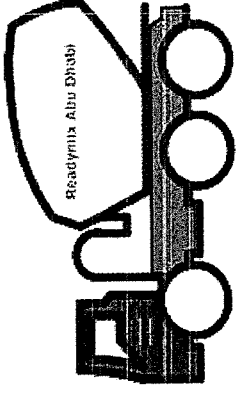
Factors contributing to successful performance specifications:

- Ability of the specifier to define the required performance of concrete based on the owner's expectations
- Performance criteria should be set in a manner that it can be eventually evaluated
- Developing performance criteria may require expertise beyond that required to write prescriptive specification that have historical bases
- Competence of all involved parties: Ability of the construction team to develop concrete mixtures and construction techniques leading to end results that comply with performance requirements
- Creation of a climate of trust where the owner and specifier can interact with the construction team in a cooperative manner

\*ACI ITG 8R-10: Report on Performance-Based Requirements for Concrete.



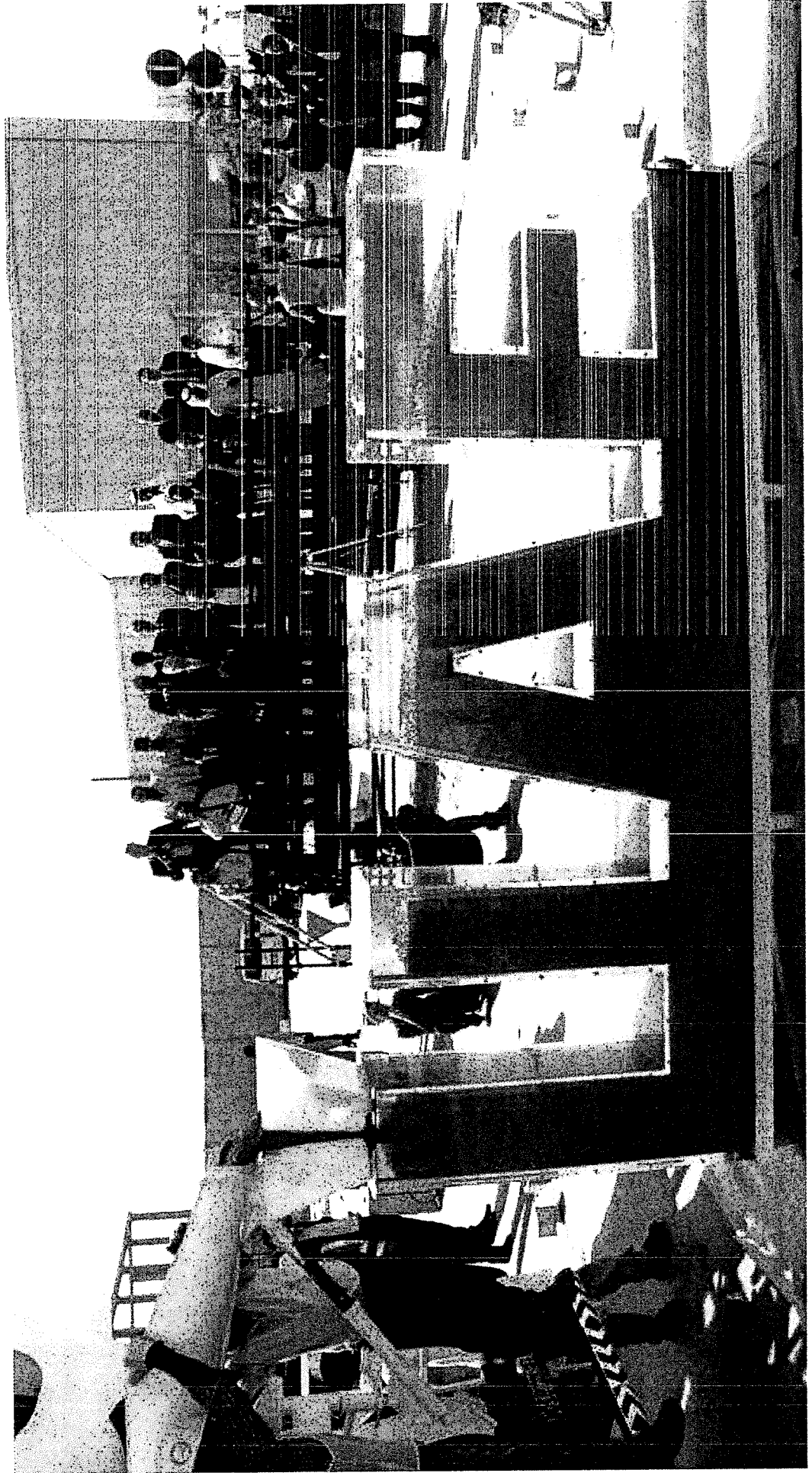
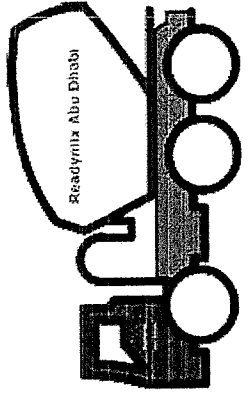
## V – Extreme performance in a single mix



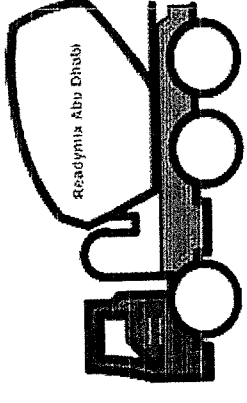
- Highly flowable, easy to place, stable and robust SCC
- High strength
- Highly durable (equivalent to more than 100 years of service life based on Life365 design and assuming a harsh exposure)
- OPC content of less than 80Kg/m<sup>3</sup>
- At least 80% lower in CO<sub>2</sub> compared to conventional SCC mix
- Cost effective

# Eco-Crete® Xtreme

# V – Extreme performance in a single mix

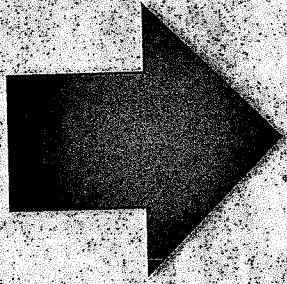


### III – Case Study 2: Zayed National Museum

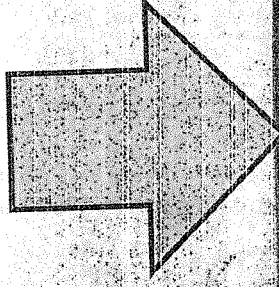


- Performance criteria for service life: chloride migration value of less than  $2 \times 10^{-12} \text{m}^2/\text{s}$  at 56 days (based on a service life design jointly carried out by the designer and RMAD)
- Performance criteria for architectural finish: Minor blemishes are only accepted (limited on the defects which can be induced by the concrete mix)
- Provisional actions in case of failure in meeting the intended performance: left to the assessment and decision of the client

**Prescriptive Specifications**



**Performance Specifications**



**THANK YOU**

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