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Achieving concrete sustainability using an integrated precast and admixture strategy

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INTRODUCTION

Sustainable Structure, also known as "**Green Building**" or "**Green Architecture**", is a general term that describes environmentally-conscious design techniques in the field of architecture.

Like all manufactured products, the production and use of **precast** concrete building systems

1. Imposes environmental demands.
2. Offers a dramatic range of colors, finishes and unlimited design possibilities difficult to match with any other material.
3. Provide superior environmental and energy performance from a life cycle perspective.; while creating structures .
4. Offers a competitive building solution based on first cost, long-term economic benefits, energy efficiency, lower maintenance and overall operating costs as well as opportunities for future reuse when the occupancy of a building changes.

BENEFITS OF PRECAST CONCRETE SYSTEM

A. Economical Benefits:

1. Precast concrete is made using local materials - aggregates, sand and cement, and to some extent the reinforcement steel. can help owners to reach as many as 21 of the 26 points needed to achieve LEED certification.
2. Low transportation costs - precast concrete is produced locally. Structures weigh less than those built using cast-in-place concrete.
3. Precast concrete is a cost-effective and competitive building material.
4. Precast concrete system is a low maintenance building system.

BENEFITS OF PRECAST CONCRETE SYSTEM Cont…

5. Precast concrete structure is a 100% recyclable structure .
6. Precast concrete has a high quality finish - The reflectance of precast concrete surfaces can lower interior lighting costs; with 78 or more SRI (Solar Reflectance Index) .
7. Precast concrete is durable - buildings last longer, and are resistant to wear and tear, severe weather, rot, insects and fire.

BENEFITS OF PRECAST CONCRETE SYSTEM Cont…

B. Environmental and Social Benefits:

1. Excellent indoor air quality - precast concrete contains no VOCs (Volatile Organic Compounds) to contribute to sick building syndrome, and that is because precast concrete generally require no coatings or finishes for external applications and minimses the use of renders and plasters for internal applications.
2. Safety - precast concrete offers superior fire, wind, vibration, and seismic resistance. The use of precast concrete system reduces potential for accidents.
3. Sound - precast concrete walls and floors have excellent Sound Transmission Class (STC) ratings to protect occupants from unwanted noise.

BENEFITS OF PRECAST CONCRETE SYSTEM Cont…

4. Precast concrete sandwich wall panels - the desired R-value can be obtained by specifying the appropriate type and thickness of incorporated insulation.
5. Made-to-order precast concrete means less on-site construction waste and improved quality control.
6. The use of DYNAMON SYSTEM for new technologies such as self-consolidating concrete (SCC) can significantly reduces noise and vibration in the production process.

MAPEI's LABORATORY TRIALS

Green Concrete for Pre-Cast

High Volume Fly Ash and Slag Concrete
Using DYNAMON ADMIXTURE SYSTEM

DYNAMON's PRODUCTS DISCRIPTION

DYNAMON NRG is a concrete admixture specially designed for the precast concrete industry and wherever there is the need for a significant water reduction and relatively high level of workability and mechanical strengths, in difference consistency classes.

DYNAMON NRG meets the requirements of consistency class S4 or S5 according to EN 206-1.

DYNAMON NRG characteristics make it particularly suitable for manufacturing self-compacting precast concrete, by ensuring high workability and the accelerated development of mechanical strength.

DYNAMON's PRODUCTS APPLICATIONS

1. To produce precast concrete with a high level of workability for manufacturing precast reinforced elements while achieving the high early levels of compressive strength requirements.
2. To produce precast reinforced concrete with a high level of workability containing a high percent of supplementary materials (PFA , GGBS). for manufacturing elements with an excellent appearance and workability retention (30 – 45) min's even in hot climates.
3. To produce concrete with a high level of workability for manufacturing cladding panels while a high level of appearance is essential.

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CASE STUDY

- The case study objectives were to reduce cement content in the concrete mix design, by the extensive using of fly ash & GGBS and reduce the total quantity of cementitious materials. Moreover to achieve the normal requirements of precast concrete, as early strength for early demolding, reduces man power, saves energy by decreasing temperature or time of steam curing.

- To achieve the above by using DYNAMON NRG new technology admixtures for high volume fly ash and Slag concrete.

SCOPE OF WORKS

1. Different precast concrete mix designs were done using different ratio's of fly ash and slag with cement.

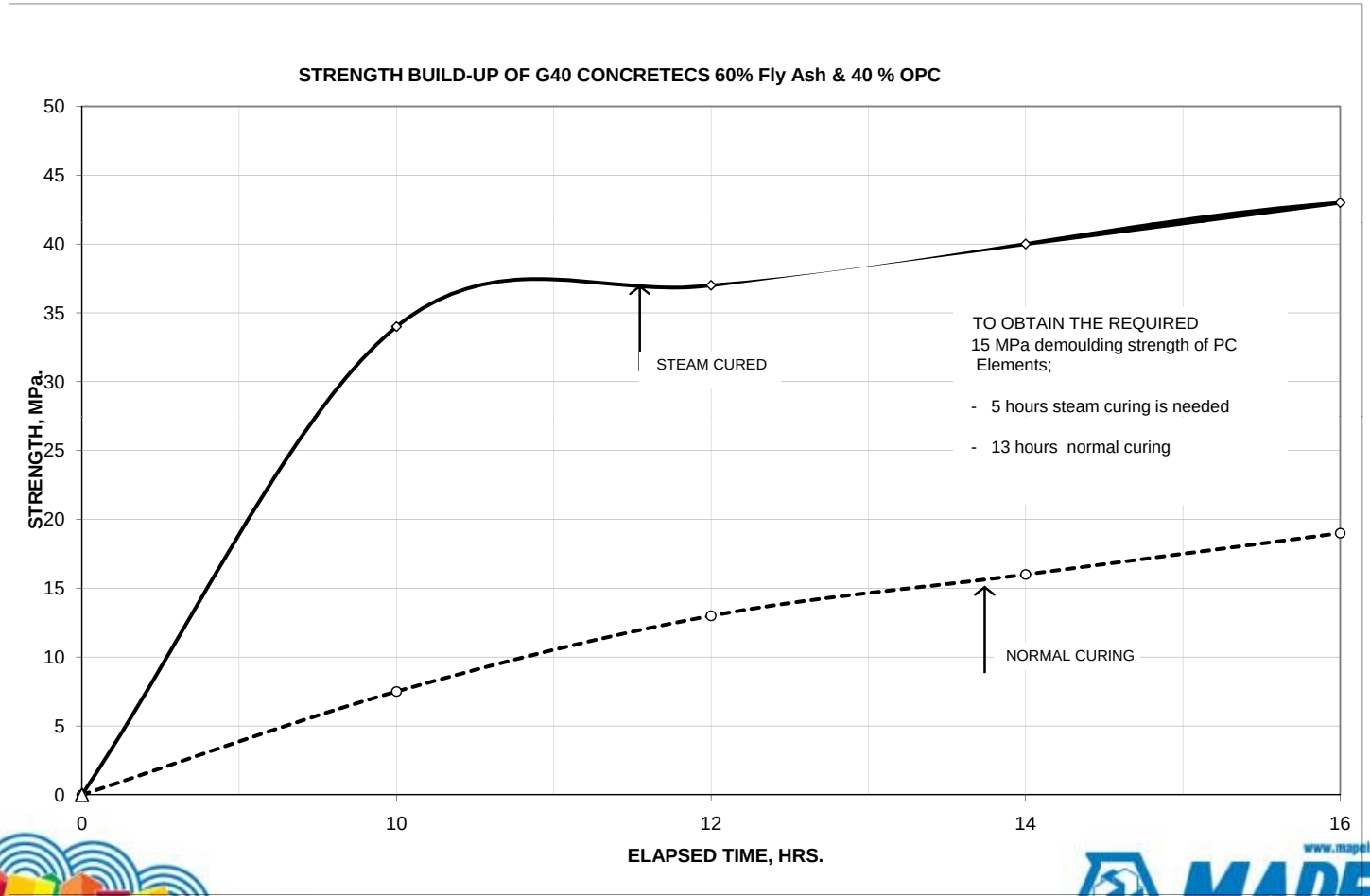
2. To maintain as low as possible the cement content, accordingly all the trials were done using 380 - 400 Kg total cementitious content.

3. To achieve 10 to 15 Mpa strength as early as possible i.e. 8, 10, 12, or 14 hours; for demoulding purposes.

TRIALS AND RESULTS

- Case Study (A): 400 Kg total cementitious content,
- 60% Fly ash and 40% cement.
- W/C : 0.28
- Admixture used DYNAMON NRG dosage: 3.5 Liters.

TRIALS AND RESULTS



TRIALS AND RESULTS

- <u>Summary:</u>

- The concrete was observed to be homogenous and flow-able.
- Strength results were seen to have improved early strength characteristic.

Casting of precast element

precast element – after demoulding

TRIALS AND RESULTS

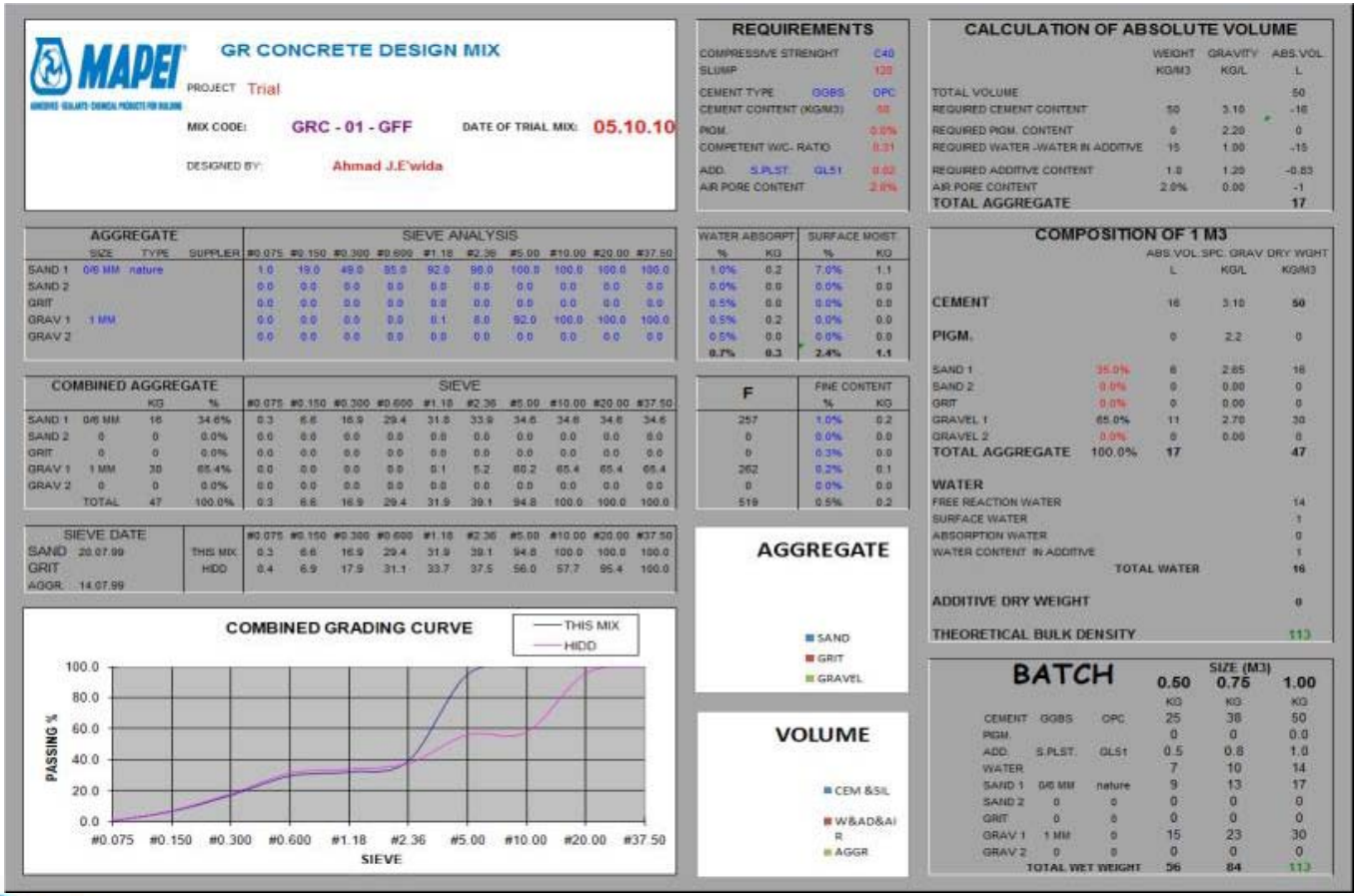
- Case Study (B) – GRC : 400 Kg total cementitious content,
- 70% GGBS, 30% cement.
- W/C: 0.30.
- Fiber Glass : 4.5 %
- Admixture used DYNAMON NRG, dosage: 4.0 Liters.

TRIALS AND RESULTS

- <u>Summary:</u>

- The concrete was very nice consistency, homogenous and flow-able.
- Strength results @ 24 hrs = 26 MPa.
- Strength results @ 7 days = 45 Mpa
- Strength results @ 28 days = 64 MPa

TRIALS AND RESULTS



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GR CONCRETE DESIGN MIX

PROJECT Trial

MIX CODE: GRC - 01 - GFF DATE OF TRIAL MIX: 05.10.10

DESIGNED BY: Ahmad J.E'wida

REQUIREMENTS

COMPRESSIVE STRENGHT	C40	
SLUMP	120	
CEMENT TYPE	GGBS	OPC
CEMENT CONTENT (KG/M3)	50	
PIGM.	0.0%	
COMPETENT W/C- RATIO	0.31	
ADD. S.PLST	GLS1	0.02
AIR PORE CONTENT	2.0%	

CALCULATION OF ABSOLUTE VOLUME

	WEIGHT KG/M3	GRAVITY KG/L	ABS.VOL L
TOTAL VOLUME			50
REQUIRED CEMENT CONTENT	50	3.10	-16
REQUIRED PIGM. CONTENT	0	2.20	0
REQUIRED WATER -WATER IN ADDITIVE	15	1.00	-15
REQUIRED ADDITIVE CONTENT	1.0	1.20	-0.83
AIR PORE CONTENT	2.0%	0.00	-1
TOTAL AGGREGATE			17

AGGREGATE

	SIZE	TYPE	SUPPLIER
SAND 1	0/6 MM	nature	
SAND 2			
GRIT			
GRAV 1	1 MM		
GRAV 2			

SIEVE ANALYSIS

	#0.075	#0.150	#0.300	#0.600	#1.18	#2.36	#5.00	#10.00	#20.00	#37.50
SAND 1	1.0	19.0	49.0	85.0	92.0	98.0	100.0	100.0	100.0	100.0
SAND 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GRIT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GRAV 1	0.0	0.0	0.0	0.0	0.1	8.0	92.0	100.0	100.0	100.0
GRAV 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

WATER ABSORPT %	WATER ABSORPT KG	SURFACE MOIST %	SURFACE MOIST KG
1.0%	0.2	7.0%	1.1
0.0%	0.0	0.0%	0.0
0.5%	0.0	0.0%	0.0
0.5%	0.2	0.0%	0.0
0.5%	0.0	0.0%	0.0
0.7%	0.3	2.4%	1.1

COMPOSITION OF 1 M3

		ABS.VOL L	SPC. GRAV KG/L	DRY WGHT KG/M3
CEMENT		16	3.10	50
PIGM.		0	2.2	0
SAND 1	35.0%	6	2.65	16
SAND 2	0.0%	0	0.00	0
GRIT	0.0%	0	0.00	0
GRAVEL 1	65.0%	11	2.70	30
GRAVEL 2	0.0%	0	0.00	0
TOTAL AGGREGATE	100.0%	17		47
WATER				
FREE REACTION WATER				14
SURFACE WATER				1
ABSORPTION WATER				0
WATER CONTENT IN ADDITIVE				1
TOTAL WATER				16
ADDITIVE DRY WEIGHT				0
THEORETICAL BULK DENSITY				113

COMBINED AGGREGATE

		KG	%
SAND 1	0/6 MM	16	34.6%
SAND 2	0	0	0.0%
GRIT	0	0	0.0%
GRAV 1	1 MM	30	65.4%
GRAV 2	0	0	0.0%
	TOTAL	47	100.0%

SIEVE

	#0.075	#0.150	#0.300	#0.600	#1.18	#2.36	#5.00	#10.00	#20.00	#37.50
SAND 1	0.3	6.6	16.9	29.4	31.8	33.9	34.6	34.6	34.6	34.6
SAND 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GRIT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GRAV 1	0.0	0.0	0.0	0.0	0.1	5.2	60.2	65.4	65.4	65.4
GRAV 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	0.3	6.6	16.9	29.4	31.9	39.1	94.8	100.0	100.0	100.0

F	FINE CONTENT %	FINE CONTENT KG
257	1.0%	0.2
0	0.0%	0.0
0	0.3%	0.0
262	0.2%	0.1
0	0.0%	0.0
519	0.5%	0.2

SIEVE DATE

			#0.075	#0.150	#0.300	#0.600	#1.18	#2.36	#5.00	#10.00	#20.00	#37.50
SAND	20.07.99	THIS MIX	0.3	6.6	16.9	29.4	31.9	39.1	94.8	100.0	100.0	100.0
GRIT		HIDD	0.4	6.9	17.9	31.1	33.7	37.5	56.0	57.7	95.4	100.0
AGGR.	14.07.99											

COMBINED GRADING CURVE

AGGREGATE

VOLUME

BATCH

			SIZE (M3) 0.50 KG	0.75 KG	1.00 KG
CEMENT	GGBS	OPC	25	38	50
PIGM.			0	0	0.0
ADD.	S.PLST.	GLS1	0.5	0.8	1.0
WATER			7	10	14
SAND 1	0/6 MM	nature	9	13	17
SAND 2	0	0	0	0	0
GRIT	0	0	0	0	0
GRAV 1	1 MM	0	15	23	30
GRAV 2	0	0	0	0	0
TOTAL WET WEIGHT			56	84	113

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TRIALS AND RESULTS

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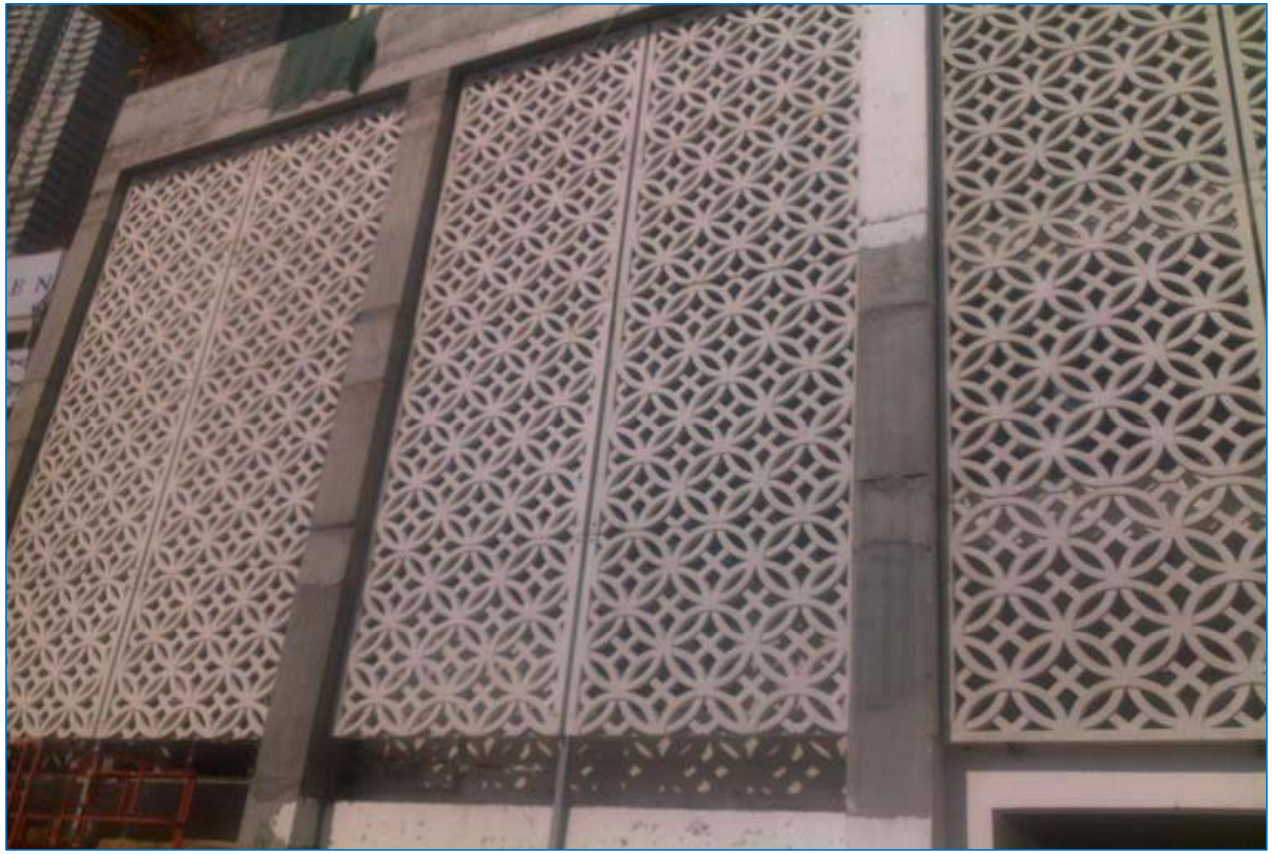

CONCLUSION & SUMMARY

- Precast concrete can be considered a very efficient and effective method of construction in particular while achieving a green, sustainable project espacially when working to a rating system such as LEED or ESTIDAMA.
- Precasting allows optimized concrete mix designs. Mixes are usually designed to reach 15 MPa in 12-16 hours for precasting a new element each day.
- According to our study and usage of our special formulated admixture DYNAMON NRG we were able to achieve 14 Mpa after 12 hours, under lab conditions (ambient temperature 25C) without steam curing. By using only 150 Kg of cement and 250 Kg of fly ash and Silica Fume, the total cementitious content was kept at 400 Kg.

CONCLUSION & SUMMARY

- Generally improve the workability and finishing of fresh concrete.
- Reduce bleeding and segregation of fresh concrete
- Improve the long term strength gain.
- Reduce permeability and absorption (especially silica fume)
- Reduce alkali-aggregate reactivity
- The effect of replacing cement with supplementary cementitious materials on the embodied energy of concrete is appreciable. For example, a 1% replacement of cement with fly ash results in an approximately 0.7% reduction in energy consumption per unit of concrete.
- The additional benefit of reducing cement is to reduce the carbon footprint of the structure (1 ton of cement is the equivalent if 1 ton of CO2)

Thank you for your kind attention

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