7th

أسبوع المياه العربي

MARWAN A. ALKURDI&PARTNERS Co. Ltd.

شركة مروان أحمد الكردي و شركاه ذ.م.م

Marwan Ahmad Alkurdi & Part. Co. Ltd

Marwan Ahmad Alkurdi & Partners Co. Ltd is a regional firm established in 1981 For over four decades, our company has specialized in the construction of **Dams, Deep Well Drilling, Bridges**, **Tunnels, Highways, Mining and Viaduct**, reinforcing our position as a trusted partner for complex infrastructure projects.

Our expertise extends beyond Jordan, with a robust track record in Saudi Arabia, Iraq, and cooperations in Syria and Kuwait.

DAMS

Al Wehda Dam


Mujib Dam

Wala Dam

Deep Well Drilling


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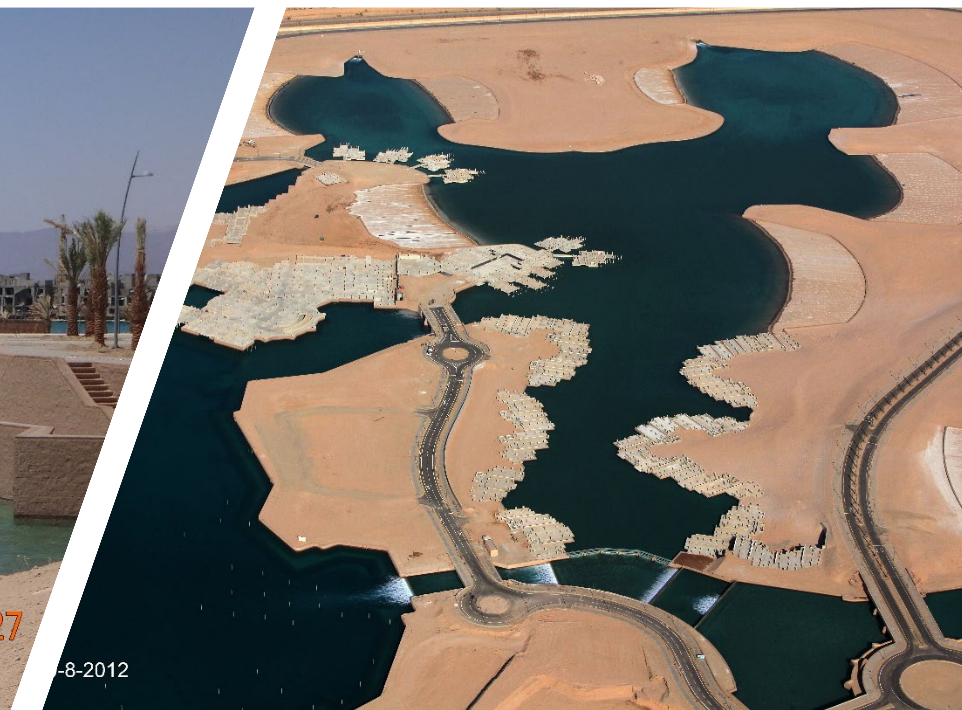
ACAR

Highways
Bridges
Tunnels

Amman Ring Road

Ayla



Dead Sea Parkway

Jamarat Bridges

Karak Entrance Bridge

King Hussein Bridge

Mujib Protection Works

Alquds-Sweimeh-Alzara Highway

Ibn Hammad Dam
Combined Roller Compacted Concrete Dam

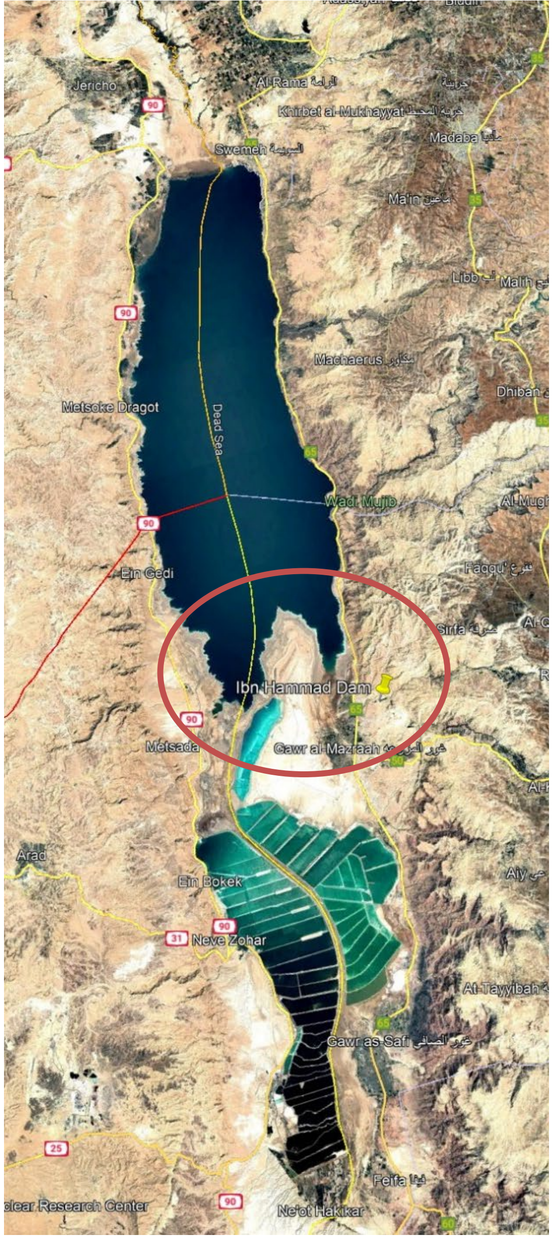
Breaking Barriers

How Jordan's Ibn Hammad Dam Redefines RCC Technology in Extreme Conditions

Introduction

Ibn Hammad Dam is located in Wadi IBN HAMMAD in the West part of Jordan, close to the Dead Sea area.

Year 1985



Year 2024

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Lisan Peninsula Area 1973

Lisan Peninsula Area 2000

Over the past 50 years, the level of the Dead Sea has dropped by 45 meters, and the rate of decline is increasing. From 1930 to 1973, the sea declined 17 centimeters per year. From 1974 to 1979, it dropped 62 centimeters per year, and from 1981 to 1990, 79 centimeters per year. From 1994 to 2001, the sea declined 100 centimeters per year. Current rate of decline is **1.2 meters per year.**

Lisan Peninsula Area 2024

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The purpose of the Dam is to trap floods through the Wadi. Once the flood is retained, the natural permeability of the reservoir will allow the water to percolate underground and recharge the aquifer.

The dam scheme is composed of a Rolled-Compacted Concrete (RCC) dam and a clay core rock-fill dam to be constructed on the right and left abutments. The dam average height above the foundation is 55.5 meters and the crest length is about 300 meters.

Ibn Hammad Dam

Location	Karak , Wadi Ibn Hammad
Owner	Jordan Valley Authority
Fund	Arab Potash Company Ltd.
Construction	February- 2022
Total Cost	52.5 M - JOD
Height	60 m (-209.5 mbsl)
Crest Length	340 m
Storage Capacity	4.0 MCM
Purpose	Recharge Dam

What is the Roller Compacted Concrete (RCC)?

Roller-Compacted Concrete

(1) concrete compacted by roller compaction;

(2) concrete that, in its unhardened state, will support a roller while being compacted.

ACI Concrete Terminology , ACI CT-13

RCC is usually mixed using high-capacity continuous mixing or batching equipment, delivered with trucks or conveyors, and spread with bulldozers in layers prior to compaction with vibratory rollers. Because of RCC's zero-slump consistency, subsequent lifts can be placed immediately after compaction of the previous lift. RCC can use a broader range of materials than conventional concrete, and derives its strength and durability from a mixture philosophy that relies on using just enough paste volume to fill the aggregate voids and no more water content than what is needed for proper workability.

Report on Roller-Compacted Mass Concrete
Reported by ACI Committee 207

An overview of the Dam RCC footprint before RCC and fill works

An overview of the RCC Dam


09.11.2017

22.01.2018 16:43






Project Specification requirements for the Roller Compacted Concrete (RCC):

1. Maximum size of aggregate 37mm
2. Passing #200 in the crushed fine sand to be in range of 8-12% in order to have good paste / **workability** (the advantage of rock flour).
3. Use the dolomitic limestone quarry area on the right bank of the dam, **later on and after a series of tests this have been eliminated due to high alkali silica reaction**.
4. The primary RCC mix shall be a low cement content mix containing approximately 120 kg of cementitous material (60kg cement+60kg fly ash), **but Fly ash was confirmed to be banned when the Contractor started the RCC mix design**

Approved RCC mix design parameters

60 Flyash
+ 60 OPC

Content	Unit	Quantity	Percentage
Cementitious Material	Kg/m^3	130	
Coarse Aggregate 19-37mm	Kg/m^3	380	16%
Coarse Aggregate 05-19mm	Kg/m^3	930	40%
Fine Aggregate (crushed)	Kg/m^3	549	23%
Silica Sand 0-5mm	Kg/m^3	253	11%
Admixture (Master Pozzolith 383NT)	Lit/m^3	1.04	

RCC mix trials– Mixing process in the laboratory

RCC mix Trials – manual re-mixing

RCC mix trials – VeBe Time Testing

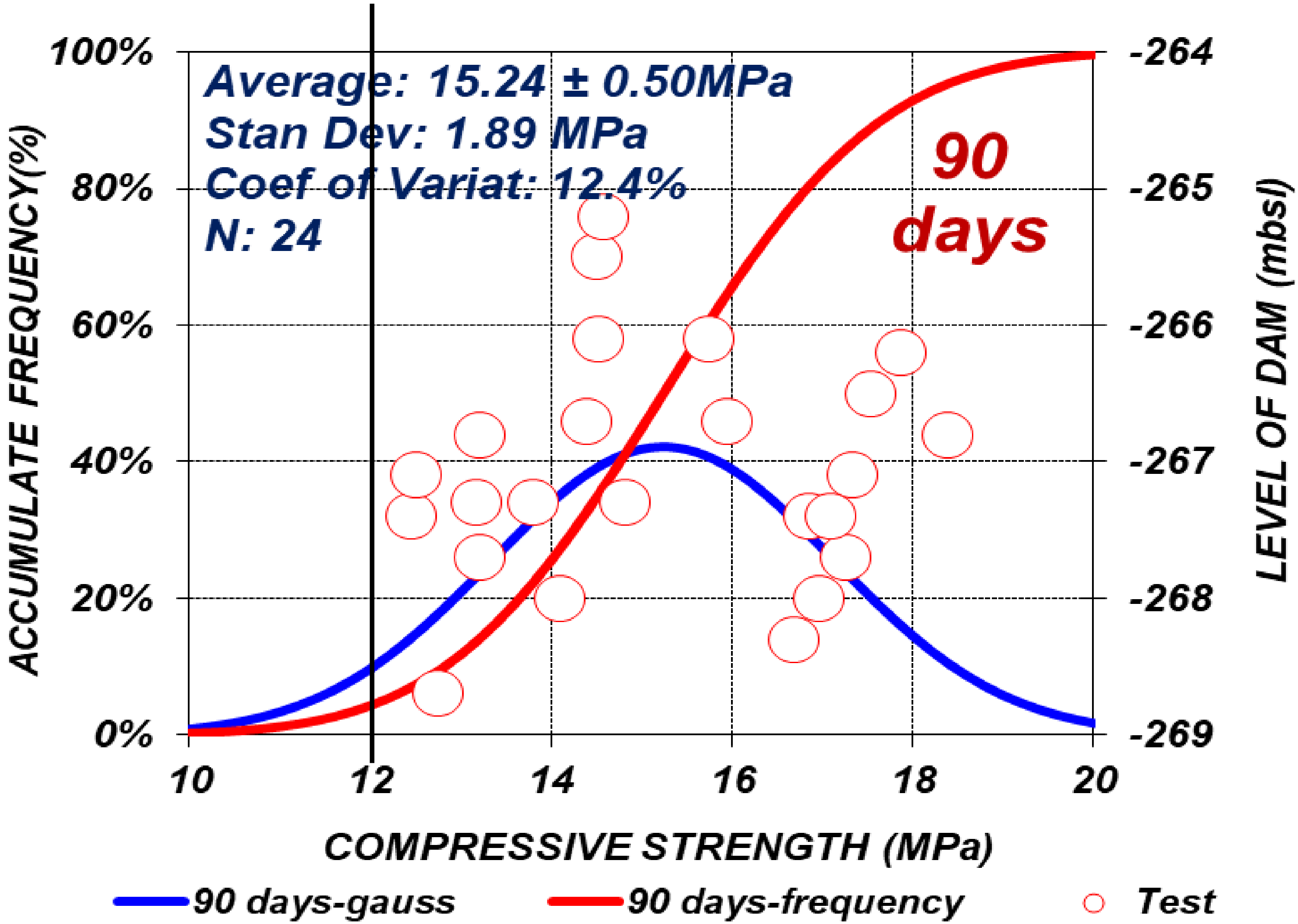
RCC mix design – Sampling using hammer

Curing tanks and RCC compressive cylinder strength testing

12 MPa @ 360 days

Indirect Tensile Strength Testing

10% of Compressive Strength


Average: 15.24 ± 0.50MPa
Stan Dev: 1.89 MPa
Coef of Variat: 12.4%
N: 24
90 days
100%
80%
60%
40%
20%
0%
ACCUMULATE FREQUENCY(%)
-264
-265
-266
-267
-268
-269
LEVEL OF DAM (mbsl)
10
12
14
16
18
20
COMPRESSIVE STRENGTH (MPa)
90 days-gauss
90 days-frequency
Test

Measuring Degree of Compaction &

Density of RCC Layer - Non-destructive testing

Sample extraction from RCC dam body-destructive testing

RCC extracted cores' inspection and preparation for testing in Site Laboratory

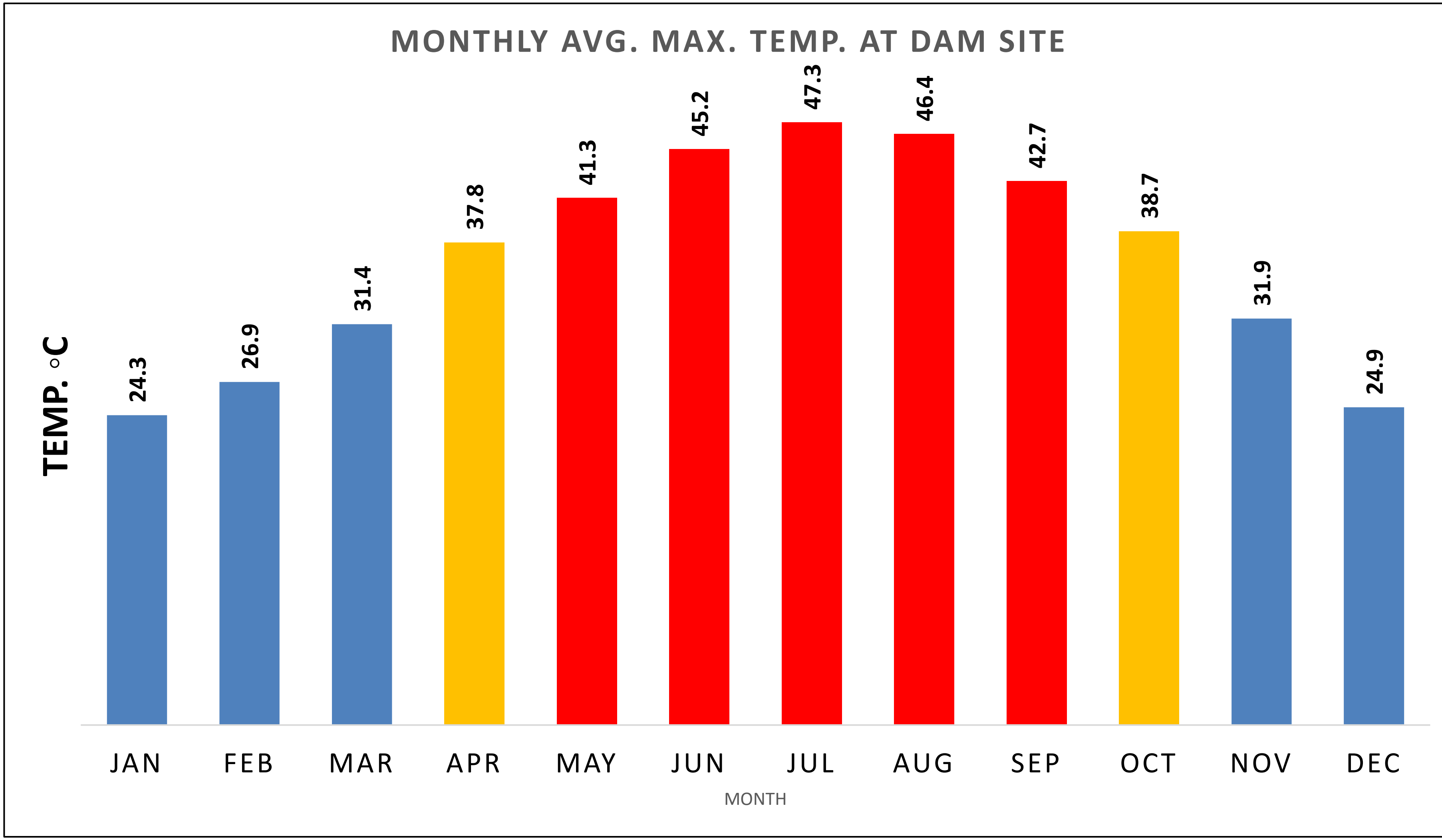
Instruments used for testing and control of concrete temperature

Plant and Equipment

RCC batch plant Layout

Crusher plant layout

Temperature Restrictions and Selection of Cooling Method


MONTHLY AVG. MAX. TEMP. AT DAM SITE
TEMP. ○C
24.3
26.9
31.4
37.8
41.3
45.2
47.3
46.4
42.7
38.7
31.9
24.9
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
MONTH

Effect of Temperature of Materials on Concrete Temperatures

$$T = \frac{0.22(T_aM_a + T_cM_c) + T_wM_w + T_{wa}M_{wa}}{0.22(M_a + M_c) + M_w + M_{wa}}$$

T = temperature of the freshly mixed concrete, °C (°F)

T_a, T_c, T_w, and T_{wa} = temperature in °C (°F) of aggregates, cement, added mixing water, and free water on aggregates, respectively

M_a, M_c, M_w, and M_{wa} = mass, kg (lb), of aggregates, cementing materials, added mixing water, and free water on aggregates, respectively

Table 1 : RCC mix design –without any cooling !

Material	Temp. (^{o}C)	Quantity (kg)
Cement	55	130
Aggregate 19-37mm	38	380
Aggregate 5-19mm	39	930
Crushed fine 0-5mm	40	549
Natural Silica Sand	40	253
Water	32	102
Admixture	32	1.3
T1 =	38.71 ^{o}C	>23.0-26.0 ^{o}C Not Ok

Table 2 : RCC mix design –using chilled water !

Material	Temp. (°C)	Quantity (kg)
Cement	55	130
Aggregate 19-37mm	38	380
Aggregate 5-19mm	39	930
Crushed fine 0-5mm	40	549
Natural Silica Sand	40	253
Water	3	102
Admixture	32	1.3
T1 =	33.75 °C >23.0 & 26.0 °C Not Ok	

Table 2 : RCC mix design –chilled water and air cooling

Material	Temp. (°C)	Quantity (kg)
Cement	55	130
Aggregate 19-37mm	16	380
Aggregate 5-19mm	16	930
Crushed fine 0-5mm	40	549
Natural Silica Sand	40	253
Water	4	102
Admixture	32	1.3
T1 =	23.0 °C OK	

In order to produce RCC with a maximum temperature of 23 ^{o}C at mixer discharge and 26 ^{o}C at placement point

- **Aggregate cooling using Air cooling method was adopted**

The required volume of cold air and temperature of the air were designed based on :

1. **aggregate size and volume to feed into the mixer in each batching cycle.**
2. **Size of each aggregate bins.**
3. **Batch plant mixing capacity per hour.**

Additional measures adopted:

1. Deploying the necessary resources to spread and compact the RCC in timely manner,
2. Provide shelter for the trucks to protect from direct sun light and wind,
3. Avoid the RCC placement during the high temperature peak hours.
4. Adopt aggregate Stockpiles precooling using water sprinklers,
5. Exercise strict quality control for the mix properties and temperature before the starting mixing, during placement, and
6. Installation of thermocouples and temperature monitoring devices after placement of RCC.
7. Start water curing (fog) immediately after the compaction is competed

Containerized Air-Cooling system

Refrigerating system and control panel-Automated system

Air pipes inside the coarse aggregate bins

Water sprinkling of aggregate stockpiles

Thank You