DESIGN AND ANALYSIS OF FOUR IN ONE SCHOOL COMPLEX

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Abstract – The paper deals with the construction of school complex, which is comprised of four schools, namely: - Kindergarten, primary, intermediate and secondary. Total built up area of this project is 40000 sq.m. With 2 Basement and 3 upper floors. Advanced facilities and Green Building principles in construction is adopted.

Concrete mix used for the RCC members is M30 & M40 and steel used is high yield strength deformed bars of grade Fe500. Limit State Method (LSM) is adopted for the design of all structural members in the building. Safe bearing capacity of soil is taken as 100kN/m2. Foundation is designed as Raft foundation. Construction methods and tests adopted in this project are enclosed in this report.

Key Words: schools, RCC, foundation, LSM, tests

1. INTRODUCTION

The project is construction of School Complex, which is comprised of four Schools, namely: Kindergarten, Primary, Intermediate and Secondary. It is located on Jeddah-Makka Expressway, Makkah – Kingdom of Saudi Arabia.The total built up area of the project is 40,000 sq. m. with 2 Basements and 3 upper floors. The total cost is budgeted to be 100 million Saudi Riyals. It includes advanced facilities and also applies Green Building principles in construction. The activites during the visit are covered in this report which is as follows:

1. Erection of Columns

2. Laying of Beams

3. Formwork for Slabs

4. Concreting and

5. Block work

The above mentioned activites gave a thorough insight of materials used in construction, which

include, Concrete, various Reinforcement Bars, Blocks, etc., The materials and activites are further elaborated below.

1.2 REINFORCEMENT BARS

Reinforcement Bars are also known as Rebar, which is a steel bar or mesh of steel wires used as a tension device in reinforced concrete and reinforced masonry structures to strengthened hold the concrete in tension.

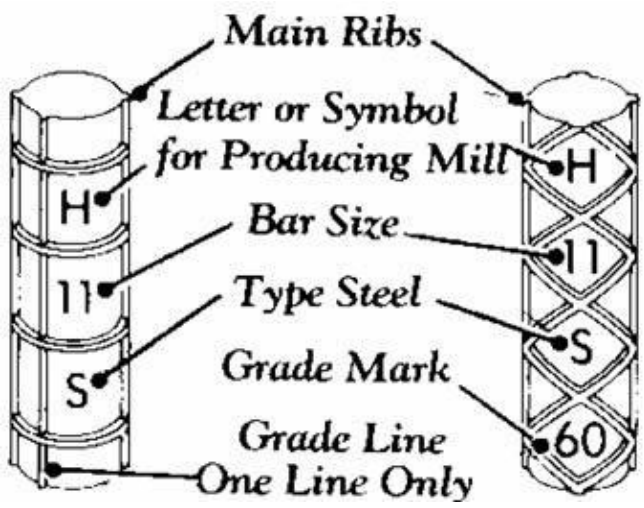


FIGURE : *Figure*: Rebar Markings

a) **Weight of Rebar:**

To calculate the weight of the rebar, the formula is

W ht o R = $d^2/162$ k/m

Table: Rebar Weights

Diameter (MM)	Cross Sectional Area (MM2)	Theorectical Weight (KG/M)	Weight of 12M Bar (KG)	A Ton Contains 12M Bars (PCS)
6	28.27	0.222	2.664	375.38
8	50.27	0.395	4.74	210.97
10	78.54	0.617	7.404	135.06
12	113.1	0.888	10.656	93.84
14	153.9	1.21	14.52	68.87
16	201.1	1.58	18.96	52.74
18	254.5	2	24	41.67
20	314.2	2.47	29.64	33.74
22	380.1	2.98	35.76	27.96
25	490.9	3.85	46.2	21.65
28	615.8	4.83	57.96	17.25
32	804.2	6.31	75.72	13.21
36	1018	7.99	98.88	10.43
40	1257	9.87	118.44	8.44

b) Sizes of Rebar used at the project:

Diameter	Areas
10	Stirrups
12	Slabs / Stirrup
16	Slabs / Columns
20	Columns / Beams
25	Columns / Beams
32	Frames

2. CONCRETE:

Concrete is a composite material composed of coarse aggregate bonded together with a fluid cement. When aggregate is mixed together with dry Portland cement and water, the mixture forms a fluid slurry that is easily poured and molded into shape. The cement reacts chemically with the water and other ingredients to form a hard matrix that binds the materials together into a durable stone-like material that has many uses.

Figure: Concrete

a) Types of Concrete:

i. High-strength concrete

It has Low W/C ratios and the use of silica fume make concrete mixes significantly less workable, which is particularly likely to be a problem in high-strength concrete applications where dense rebar cages are likely to be used.

ii. High-performance concrete

It is a relatively new term for concrete that conforms to a set of standards above those of the most common applications, but not limited to strength.

iii. Self-consolidating concrete

It is extreme fluid as measured by flow, typically between 650–750 mm on a flow table It does not need vibrators to compact the concrete. It is easily placed and no bleeding, or aggregate segregation

iv. Shotcrete

It is uses compressed air to shoot concrete in to a frame or structure. The greatest advantage of the process is that shotcrete can be applied overhead or on vertical surfaces without formwork

b) Grade of Concrete:

Table: Concrete Grades

Grade of Concrete	Specified Compressive Strength at 28 Days (N/mm^2)
M10	10
M15	15
M20	20
M25	25
M30	30
M35	35
M40	40

In the classification of concrete mix, the letter M denotes the Mix and the numbers 10, 15, 20, 25, 30, 35, 40 represent the predetermined works cube strength of 15 cm cubes after curing of 28 days in N/mm2.

c) Concrete used at the project:

There are two grades of concrete used at the project, a) M30 for all the structural members and b) M40 for large frames.

d) Concrete Pouring:

The concrete before placing / pouring undergoes various tests as follows

1. Temperature Check: As the concrete arrives from the batching plant, the temperature is checked to verify if it is the applicable limit (< 30 ⍰C). The concrete loses its **strength** and **durability** if the temperature is higher

Figure: Concrete Temperature Check

2. SLUMP TEST: Concrete slump test is to determine the workability or consistency of concrete mix prepared at the laboratory or the construction site during the progress of the work. Concrete slump test is carried out from batch to batch to check the uniform quality of concrete during construction. At measurement, the height of the concrete has to be between 18-20 cm to have good workability.

Figure(a) Removing Cone (b) Height Measurement

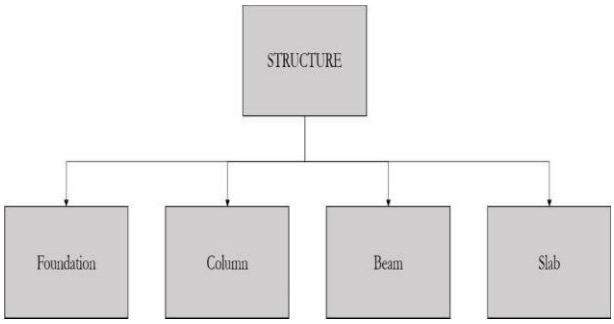
Compressive strength:

The other test is Concrete compression test. It is done to know the concrete compressive strength. It is one of two well-known concrete tests, other being slump cone test.For this purpose, either concrete cube or cylinder specimens are tested in the laboratory. Six concrete specimens are generally made and cured for 28 days at site and then sent to laboratory for testing.

Figure: casts of cylinders for compressive test

2.1 Elements Of Concrete Structure

There are four main elements of concrete structure as follows:



a) Foundation:

A foundation is a lower portion of building structure that transfers its gravity loads to the earth.

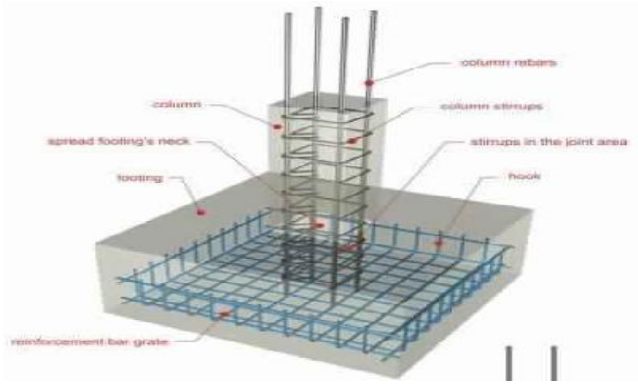


Figure: Typical Foundation

2.1.1. Types of Foundation:

- Shallow Foundations.
- Individual Footings
- Strip footings.
- Raft or Mat foundations
- Pile Foundations (deep foundations).

Foundation at the project: This project has a huge Raft Foundation since the area is large. Typically, raft foundations are formed by reinforced concrete slabs that cover a wide area, often the entire footprint of a building. They spread the load imposed by a number of columns or walls over a large area, and can be considered to 'float' on the ground as a raft floats on water.

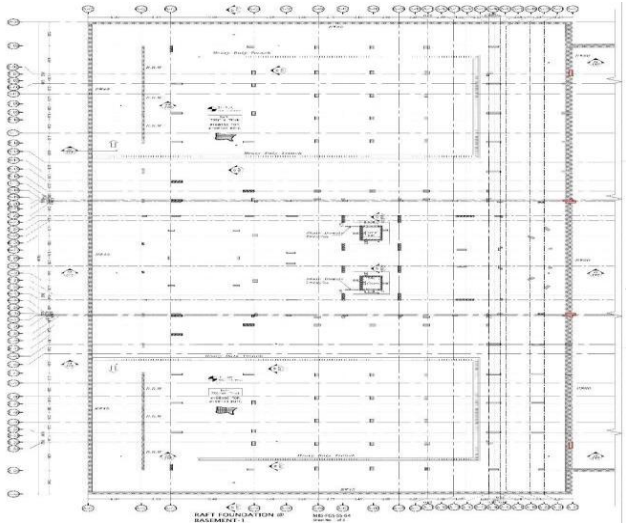


Figure: Foundation Plan of the Project

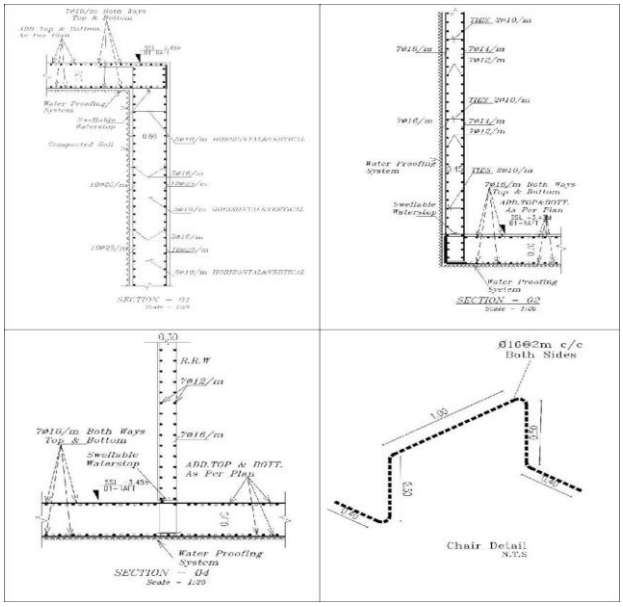


Figure: Sectional Details of the Raft Foundation

b) Column: The column is essential part of a structure. It is the vertical support which is free from all sides taking the load of beams, slabs etc., and transfers the load to the earth.

Figure: Typical Column

Column erection procedure at the project:

1. The surveyor marks the location of column with the help of total station and other surveying instrument.

2. The Labors take the details from the plan and make required lengths of bars and stirrups.

3. The rebars are tied-up with required lapping to the started bar which comes from the foundation or respective location

4. A small piece of required cover blocks are placed before doing the formwork

5. Three sides of the column are covered with the formwork.

6. One side is left open for inspection and changes.

7. The fourth side is closed and concrete is poured.

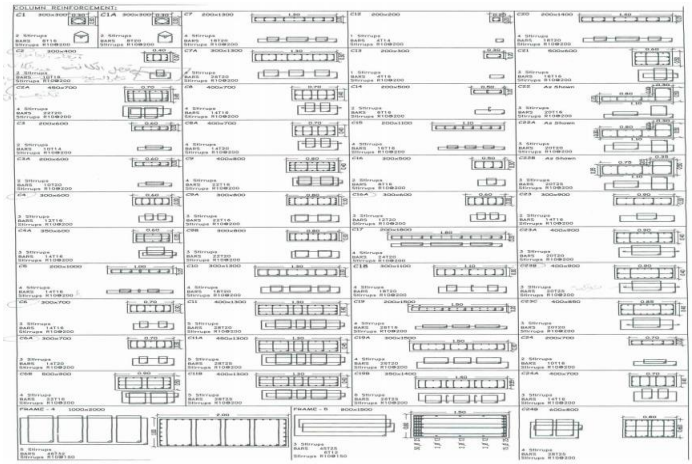


Figure: Column Rebar details

Special Practices in Columns

Alternate to Absence of lapping length

If there is no required lapping length of rebar or if the lapping of large diameter barsmake the column denser in the column member, Couplers are used. The following are pictures of Couplers.

Figure: Coupler

Figure: Testing of a coupler

Figure joining of a coupler to Rebar

c) Beam:

A concrete beam is a horizontal load-bearing unit that can be used to carry both horizontal and vertical loads. These beams are made by encasing steel bars within the concrete. Such steel reinforcing increases the beam strength, and allows the beam to cope with tensile stresses and resist bending.

Figure: Beams at different Floors

Special Practices in Beams / Column

Alternate to Absence of Starter Bar

In the absence of Starter bars, new holes are drilled in the structural component and new dowels are inserted with the help of HILTI RE-500 post install rebar joining.

Below are the pictures showing the details of it

Figure: New holes drilled.

Figure: HILTI RE-500

Figure: New Dowels placed

Figure: New Dowels Placed

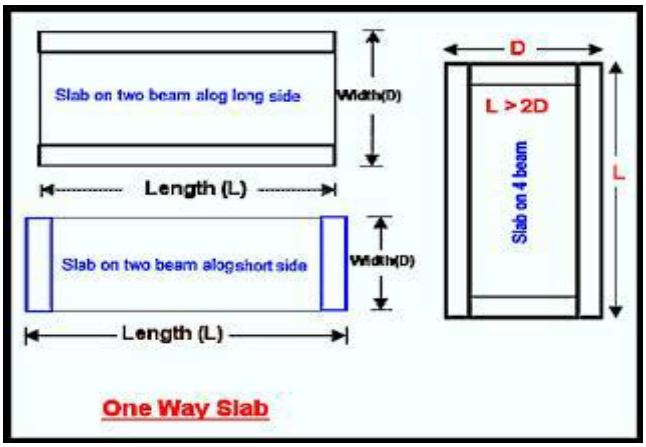
d) Slabs:

Structural Slabs are constructed to provide flat horizontal surfaces, in building floors, roofs, bridges, and other types of structures.

i. Types of Slabs:

One -way slab:

The slab can be rested on four beams but the long-span of slab should be greater than two times of short-span. See the image below "One Way Slab".



Two- way slab:

When a Solid RCC slab rests on four beams but long-span of slab is less than or equal to two times of short-span then we can call that slab a "two-way slab".

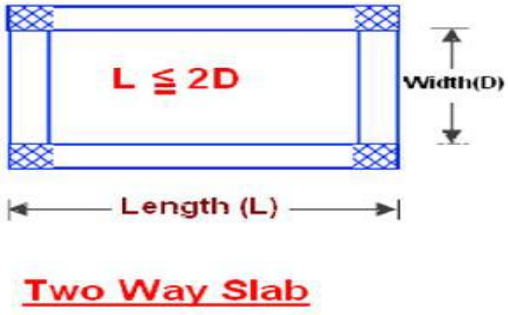


Figure: Reinforcement of Slab

E) Block Works

Blocks are components of durable masonry construction in which uniformly shaped individual units are laid in courses with mortar as the bed and binding material.

Types of Concrete Blocks:

Solid concrete blocks.

Hollow concrete Blocks.

Figure: SOLID BLOCK

Figure HALLOW BLOCK

3. RESULTS

The test has to be done as per as ASTM C140 standards .The compressive strength test results for blocks are as

MTL
Modern Technology laboratory
Construction Materials Laboratory and Engineering Services

REPORT ON TESTING OF COMPRESSIVE STRENGTH OF LOAD BEARING BLOCK SPECIMENS

CLIENT	MANSOUR BIN SAED	WORK ORDER NO.	3897
PROJECT	FAKWWH GIRLS SCHOOL	REPORT NO.	3897
LOCATION	JEDDAH	REPORT DATE	30-07-2017
TEST METHOD	ASTM C140	DATE RECEIVED	30-07-2017
LAB NO.	CR-1,3	SAMPLED BY	CLIENT
SAMPLE DESCRIPTION	HOLLOW BLOCK (400X200X200) THREE VOIDS	DATE TESTED	30-07-2017
		AIR TEMPERATURE (°C)	24
SOURCE	NAMLA	RELATIVE HUMIDITY (%)	48
SAMPLE ID	-	TESTING MACHINE	SANS (0-1000kN)

SPECIMEN MEASUREMENTS

LAB NO.	WIDTH (mm)	LENGTH (mm)	HEIGHT (mm)	WEIGHT (kg)	HOLLOW AREA (mm^2)	GROSS CROSS-SECTIONAL AREA (mm^2)	NET CROSS SECTIONAL AREA (mm^2)
CR-1	200	400	200	20.11	37260.0	80000.00	42740.0
CR-2	200	400	200	20.43	37260.0	80000.00	42740.0
CR-3	200	400	200	19.02	37260.0	80000.00	42740.0

COMPRESSIVE STRENGTH TESTING RESULTS OF HOLLOW BLOCKS (ASTM C140)

ID	DATE CASTED	DATE TESTED	DENSITY (kg/m^3)	LOAD (kN)	COMPRESSIVE (NET AREA)STRENGTH (MPa)	'AVERAGE OF COMPRESSIVE STRENGTH (MPa)
CR-1	N/G	30-07-2017	2353	338.4	7.9	5.1
CR-2	N/G	30-07-2017	2390	144.70	3.4	
CR-3	N/G	30-07-2017	2225	169.40	4.0	

AVERAGE DENSITY (kg/m3)	3322
REMARKS	

TESTED BY SIGNATURE		CHECKED BY SIGNATURE		VERIFIED BY SIGNATURE	

☐ SAMPLE PREPARED BY MTL
☑ RESULTS RELATE ONLY TO THE SAMPLE AS RECEIVED

MTL MANAGEMENT IS NOT RESPONSIBLE OF CUSTOMER SAMPLE 15 DAYS AFTER THE TEST DATE
THE TEST REPORT SHALL NOT BE REPRODUCED WITHOUT APPROVAL FROM THE MTL MANAGEMENT

Figure: TEST REPORT

4. CONCLUSION

In this paper we had briefly discussed about the design as well as analysis aspects of the school complex. Base on the above results the average compressive strength of the hallow blocks is 5.1MPa and the average density is 2322 kg/m^3

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