# Equipment for Production and Transportation of Concrete

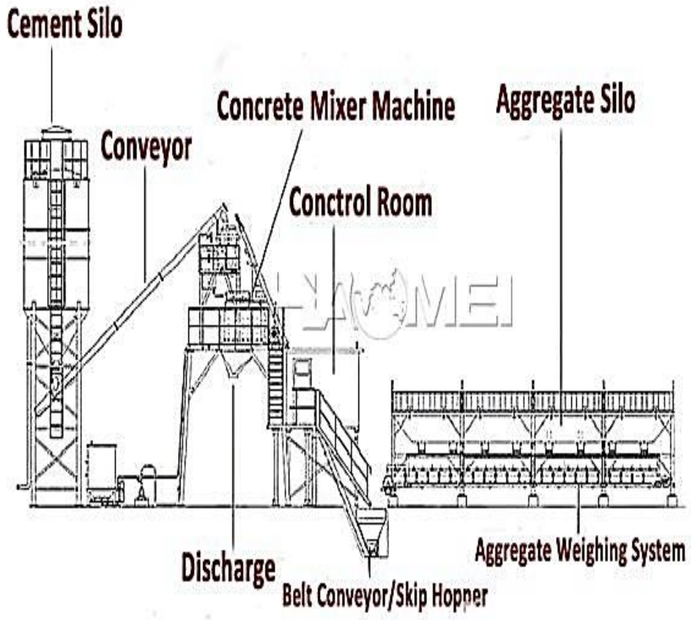
Concrete is basically cement, aggregate, and water have been mixed together, deposited, and permitted to solidify. Some admixtures are used for various purposes, such as to produce a desired concrete.

## Concrete is produced in two ways:

- ***On-site*** using construction site mixers of various sizes and capacities,
- ***Off-site*** using concrete batching plants, which consist of *standardized central units designed to perform specific functions* and then transported to the construction sites.
- These plants are available in *various sizes and production capacities* that are usually located off-site, but sometimes, they are installed on construction sites *for large-scale* construction projects.

## Ready mixed concrete (RMC) production plants:

### Components of a concrete production plant:




***Cement Silos:*** These are vertical cylindrical tanks used for temporary storage of cement intended for use in concrete mixes.

***Aggregate holding hoppers (Aggregate Silo):*** These are open, square, horizontal tanks with a conical end used for grading aggregates used in the mixes. At the bottom of these tanks are scales used to control the weight of the aggregate.

***Control room:*** This is where the weight ratios of the mixes and other specifications are controlled.

***Central mixer body (Concrete Mixer Machine):*** This is where the concrete components, whether dry or wet, are mixed.

***Conveyor:*** It is a mechanical system that uses an endless belt and rollers to automatically transport materials, products, or goods from one location to another.



Machinery used in the production and transportation of RMC

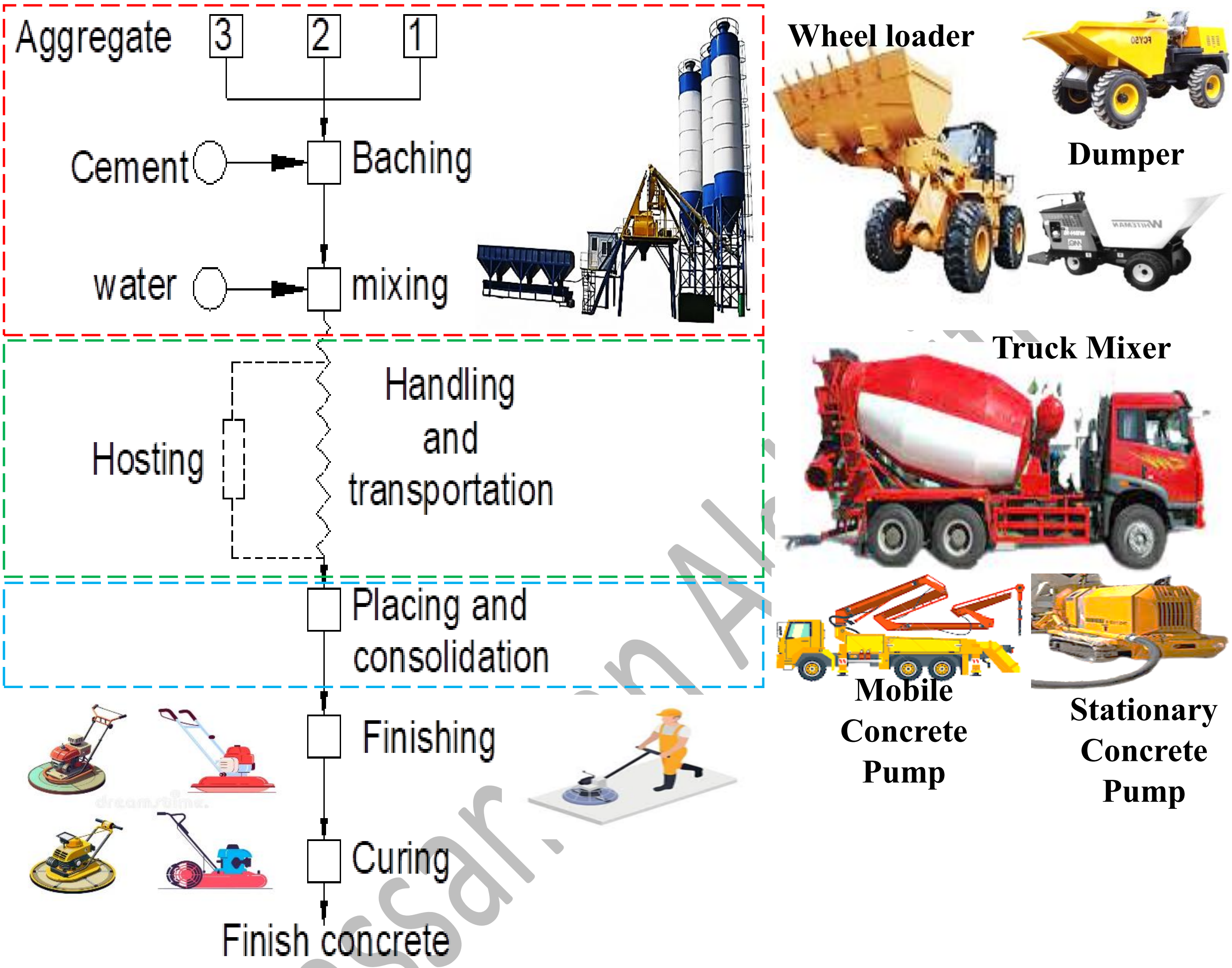



Figure 10.1: Flow chart diagram showing the operations performed from production to end casting of concrete in construction project.

***Step to produce concrete mixes:***

- Batching.
- Mixing.
- Handling and transformation.
- Placing and consolidation.
- Finishing.
- Curing.

**Batching of materials:**

***i.*** Cement

***a.*** Packing (50 kg per pack)

***b.*** Loose (transport in silo, storage in container)

***ii.*** Aggregate: different sizes and types

*Gravel*; ***a.*** uncrushed

***b.*** crushed

*Sand*; ***a.*** fine sand

***b.*** coarse sand

**Concrete mixers:**

***i.*** Construction mixers.

***ii.*** Paving mixers.

***iii.*** Transit mixers.

**Output of mixer:**

$$\textbf{Output of mixer } (m^3/hr) = Vol.\,of\ mixer\,(m^3) * No.\,of\ trips$$

$$\textbf{Time of mixer trip} = Time\ of\ filling\ mixer + mixing\ time + dumping\ time + lost\ time$$

**Handling and transporting concrete:**

- *Buggies.*
- *Dumpers.*
- *Skips or boxes.*
- *Chutes.*
- *Pipes and pumps.*
- *Belt conveyors.*
- *Transit-mix.*



## *The purpose of using RMC:*

*Recently, the use of RMC has increased in the construction sector in developing countries in general, and in Iraq in particular, for several reasons, the most important of which are:*

- *High control over the specifications of the concrete produced.*
- *High quality control over concrete pouring operations.*
- *Reducing waste in raw materials used.*
- *Reducing incidental waste from concrete works.*
- *High control over the planned pouring time.*
- *Ensuring a consistent flow of concrete supplies throughout the pouring process.*

## *Basic principles for selecting the optimal number of appropriate mechanisms:*

The basic principles for selecting the optimal number of suitable machines to complete RMC operations, after fulfilling the main criteria for selecting a supplier (i.e., source), can be summarized in two points:

**1)** *Concrete batch plant productivity* < *Productivity of the selected conveyors* < *Productivity of concrete pumping and pouring equipment*.

**2)** *<u>Waiting time</u> for concrete truck mixers fleet <u>should be minimized</u>.*



## Case Study No. 10-1:

Find the materials quantity for each mix of 0.452 $m^3$ mixers, its output trip having the following times [loading time 0.25 min, damping time 0.25 min, mixing time 1.0 min, lost time 0.1 min], operating factor 50min/hr. The quantities for 1$m^3$ concrete is:

| Cement (*pack*) | Sand (*kg*) | Gravel (*kg*) | Water (*L*) |
|---|---|---|---|
| 7.32 | 853 | 1093 | 193 |

## Solution:

$$Vol. of\ cement = 0.452 * 7.32 = 3.31\ pack$$

$$use\ 3\ pack\ of\ cement$$

$$\therefore Vol. of\ mix = 0.452 * \frac{3}{3.31} = 0.41\ m^3$$

$$Sand = 0.41 * 853 = 349.7 \cong 350\ kg$$

$$gravel = 0.41 * 1095 = 449\ kg$$

$$water = 0.41 * 193 = 79.1 \cong 79\ l$$

$$Time\ of\ output\ trip = 0.25 + 1 + 0.25 + 0.1 = 1.6\ min.$$

$$No. of\ trips = \frac{50}{1.6} = 31.25\ trip/hr$$

$$Out\ put = 0.41 * 31.25 = 12.813\ m^3/\text{hr}$$

$$Output\ per\ day = 12.813 * 8 = 102.5\ m^3/\text{day}$$

## Case Study No. 10-2:

It is required to cast a raft foundation of volume 340 $m^3$ by using the following methods, decide which of them is more economical, and find the cost of 1 $m^3$ concrete (work only).

- ***First method:*** Using central mixing plant, with distance of 15 km from the project, and has the following;

***a.*** Central mixer volume 0.5 $m^3$, time of its trip 1.6 $min$, time factor 45 min/hr, daily rent $500 * 10^3\ IQD$. Operating hours 8 *hour per day*.



**b.** Truck mixers of volume 5 $m^3$, the no. of truck mixers available in plant 6 trucks, transportation velocity 40 $km/hr$, return velocity 60 $km/hr$, lost time 6 $min$, daily rent $200 * 10^3\ IQD/day$ (for each).

**c.** Concrete pump of output 0.5 $m^3/min.$, daily rent $300 * 10^3 IQD/day$.

- ***Second method:*** Using a construction mixer of vol. 0.2 $m^3$, its trip time 90 $sec$, time factor 50 $min/hr$, daily operating hours 8 $hr$, daily rent $400 * 10^3\ IQD/day\ including\ wages\ of\ workers.$

***Solution:*** ***First method:***

$$Output\ of\ central\ plant\ mixer\ = 0.5 * \frac{45}{1.6} * 8 = 112.5\ m^3/day$$

$$Period\ required\ to\ do\ project\ = \frac{340}{112.5} = 3\ days$$

$$Time\ required\ to\ load\ truck\ mixers\ = \frac{5}{0.5} * 1.6 = 16\ min.$$

$$Time\ of\ truck\ trip = 16 + \frac{15}{\frac{40}{60}} + \frac{15}{\frac{60}{60}} + 6 = 59.5\ min.$$

$\therefore No.of\ truck\ required\ = \frac{59.5}{16} = 3.72$, use 4 trucks for 3 days

$$output\ of\ truck\ mixers\ = \frac{45}{59.5} * 5 * 8 = 30.25\ m^3/day$$

$output\ of\ 4\ truck\ mixers\ = 4 * 30.25 = 121\ m^3$ **Ok**

Output of truck mixers > Output of central mixer

$$output\ of\ pump\ = 0.5 * 60 * 8 = 240\ m^3/day$$

Ok > Output of truck mixers & central mixer

$$Total\ cost\ = 3 * [500 * 10^3 + (4 * 200 * 10^3) + 300 * 10^3] = 4800000\ IQD$$

$$Cost\ per\ 1\ m^3\ concrete\ = \frac{4800000}{340} = 14118\ IQD$$

***Second method:***

$$\text{Output of construction mixers} = 0.2 * \frac{50}{\frac{90}{60}} * 8 = 53.34\ m^3/day$$

$$\text{Period to do the job} = \frac{340}{53.34} = 6.4 \cong 7\ days$$

$$\therefore Total\ cost = 7 * 400000 = 2800000\ IQD$$

$$\therefore Cost\ per\ 1\ m^3\ of\ concrete = \frac{2800000}{340} = 8235\ IQD$$

$$\therefore The\ second\ method\ is\ more\ economical.$$

# *Asphalt mixing plant*

Asphalt is basically asphalt, aggregate, and filler which have been mixed together at a specified temperature, deposited, separated, and compacted at site.

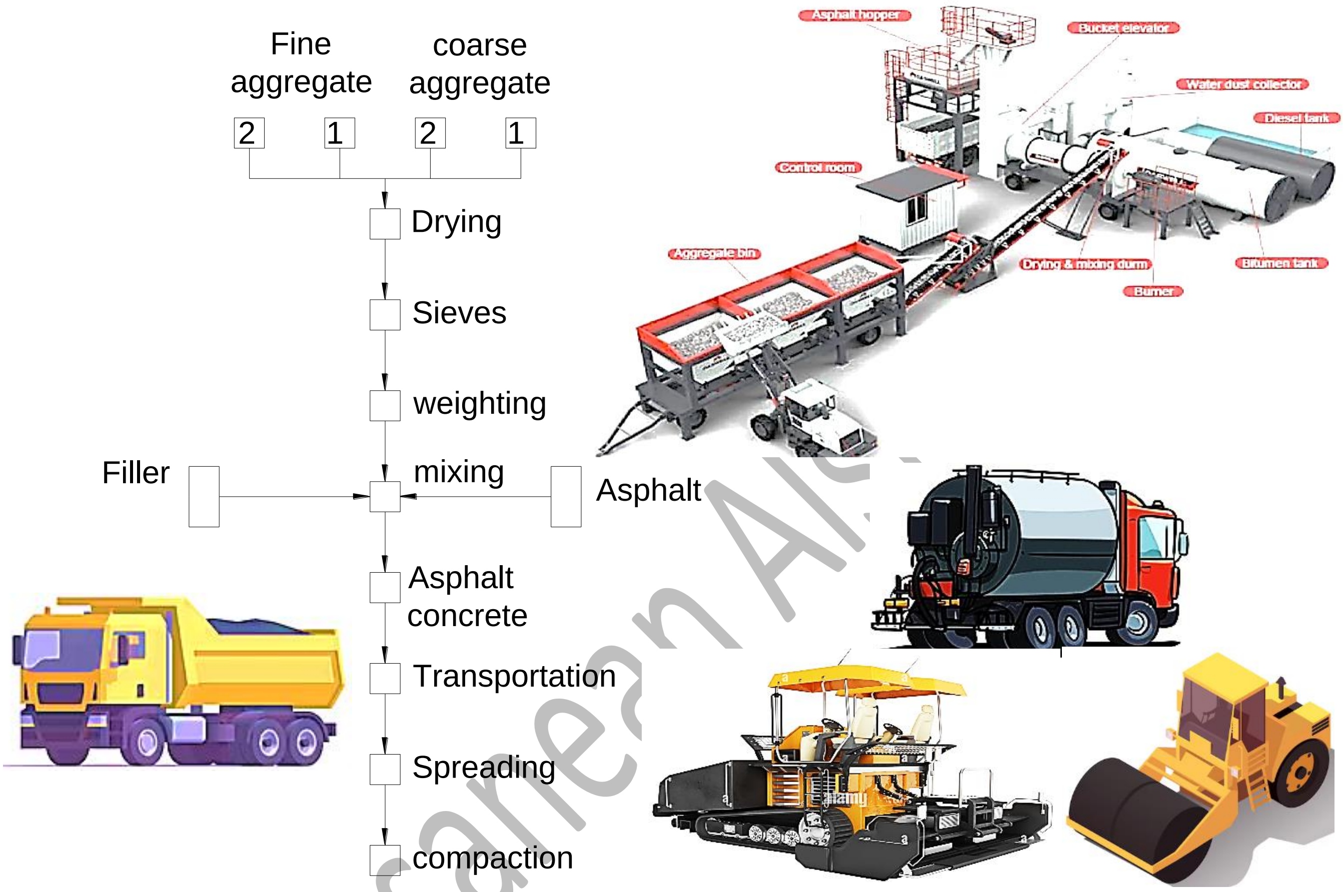



Figure 10.2: Flow chart diagram showing the operations performed in asphalt mixing plant till asphalt compaction stage.

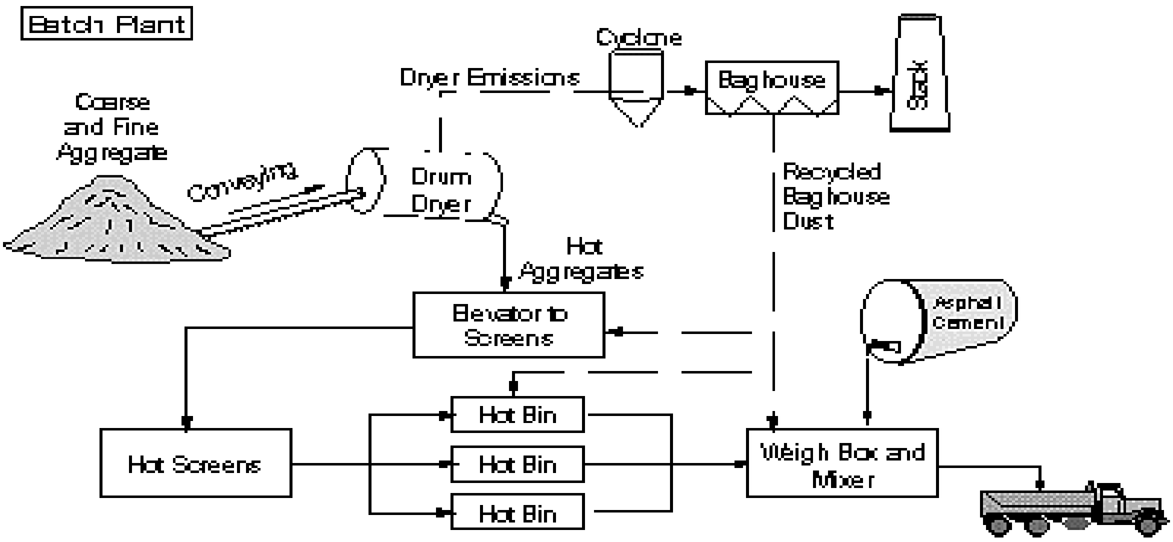



Figure 5.3: The workflow in asphalt mixing plant

### *Steps to produce asphalt concrete:*

- Batching of materials.
- Heating of materials.
- Classification of materials according to asphalt mixes.
- Weighting the materials.
- Mixing.
- Transportation.
- Spreading.
- Compaction.

### *Asphalt concrete produced in the following steps:*

**a.** ***Central asphalt concrete plant***: Materials batched and mixed after heat drying, the output of these plant ranged between (50-250) ton/hr.

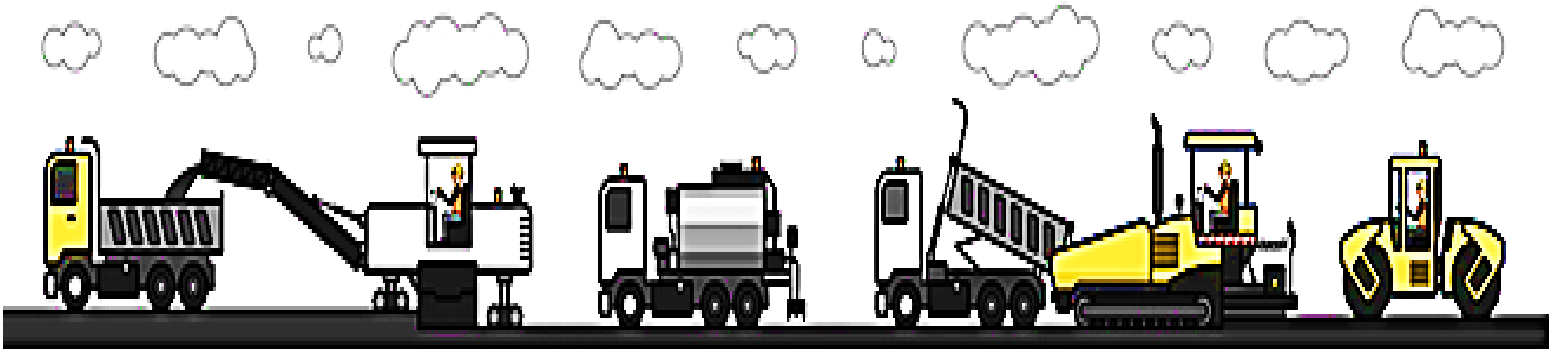
**b.** ***Transportation***: Asphalt transported by trucks with capacity (16-24) $m^3$.

**c.** ***Separating***: Asphalt separation by using especial equipment at a temperature (120 $c^o$), the output of this equipment (30-50)$m^3/hr$, width of asphalt (2-8) m, and thickness of lift (5-20) cm.

**d.** ***Compaction***:

- *Smooth wheel roller.*
- *Pneumatic-wheel roller.*







## Case Study No. 10-3:

Find the total cost of paving a yard (work only) by asphalt, if the dimension of the yard is (425*24*0.1) m, the loose due to compaction is 15%. Asphalt brought from central plant 18 km far from the project, use the following information:

***i.*** Central asphalt plant mixer with vol. of 1.3 $m^3$, its trip time = 3 $min.$, operating factor= 45 $min./hr$. Cost of operating the plant = $400 * 10^3$ $IQD/day$.

***ii.*** Trucks used to transport asphalt, with capacity of 18 $m^3$, there are enough no. in the plant, time for each truck (transport, return, and lost time) = 35 $min.$, daily rent = $150 * 10^3$ $IQD/day$ for each truck.

***iii.*** Asphalt spreader of capacity 40 $m^3/hr$, and its daily rent $200 * 10^3$ $IQD$.



## Solution:

$$\text{Output of centeral plant mixer} = 1.3 \times \frac{45}{3} \times 8 = 156\ \text{m}^3/\text{day}$$

$$\text{Volume of asphalt required to pave the yard} = (425 \times 24 \times 0.1) \times 1.15 = 1173\ \text{m}^3$$

$$\text{Period required to pave the yard} = \frac{1173}{156} = 7.52\ \text{day; use 8 days}$$

$$\text{Time required to load truck} = \frac{18}{1.3} \times 3 = 41.54\ \text{min}$$

$$\text{Time of truck trip} = 35 + 41.54 = 76.54\ \text{min}$$

$$\text{Number of trucks} = \frac{76.54}{41.54} = 1.8 \quad \equiv\equiv\equiv> \text{use 2 trucks}$$

$$\text{Output of trucks} = \frac{45}{76.54} \times 18 \times 8 \times 2 = 169\ \text{m}^3/\text{day}$$

$$\text{Output of trucks} > \text{Output of centeral plant mixer} \ \therefore \text{OK}$$

$$\text{Output of sperader} = 40 \times 8 = 320\ \text{m}^3/\text{day} > \text{Output of centeral plant mixer} \ \therefore \text{OK}$$

$$\text{Total cost} = 8 \times [400 \times 10^3 + 2 \times 150 \times 10^3 + 200 \times 10^3] = 7200000\ \text{IQD}$$

$$\text{Cost of 1 m}^2 = \frac{7200000}{425 \times 24} = 706\ \text{IQD/m}^2$$