Quality Control of Concrete in Less Technically Developed Sites: Cast Study

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Some Observations

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See how beautiful the sky is

Repair of a column

The dirty column!

Repair of a column

Mix water with something, say cement

The final nice product!

NOBODY SAW THE DIRTY ONE

Foundations
Or like that

Foundations
Filling and embankment

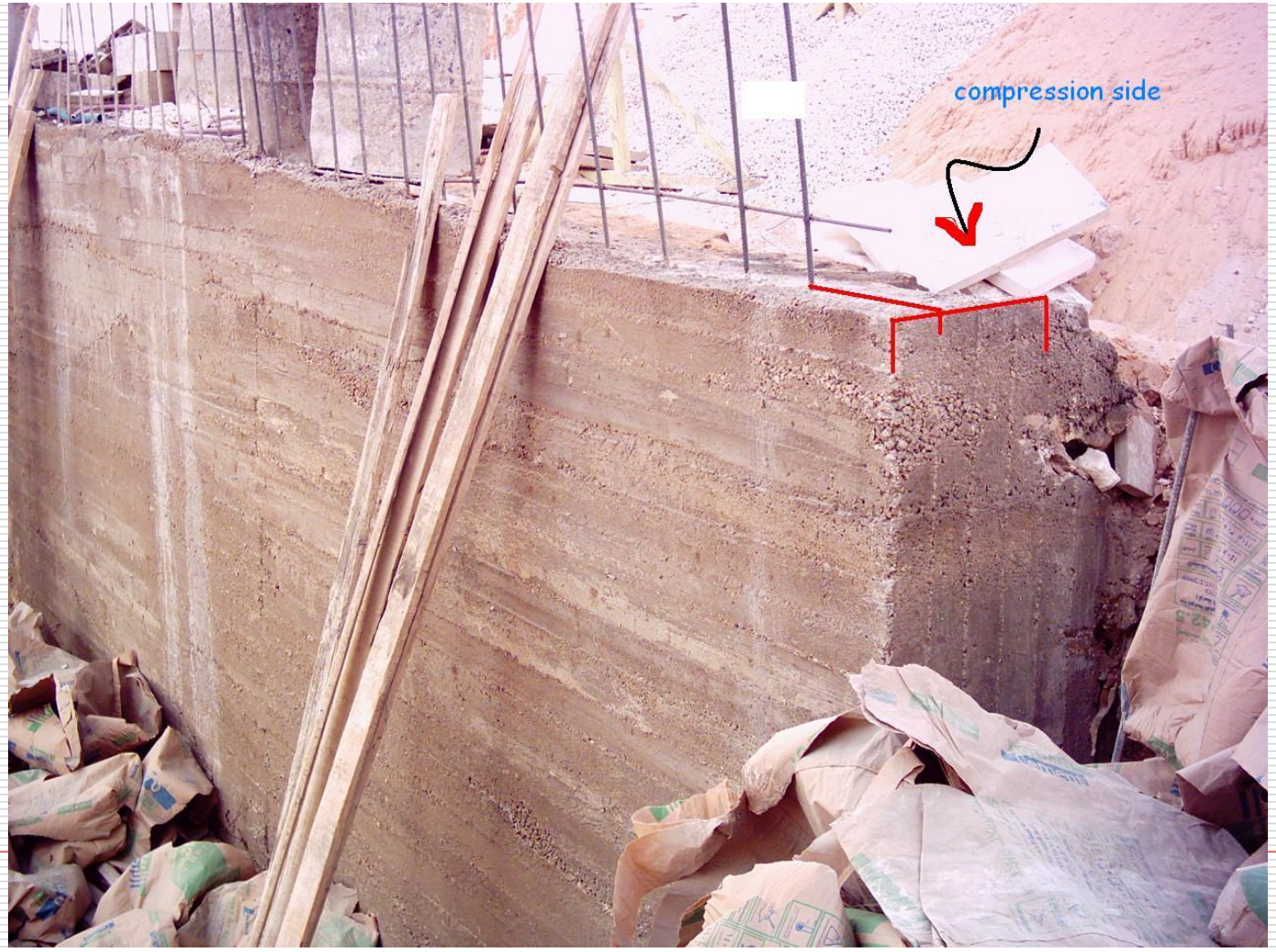
Materials

Don’t bother, the worker uses the correct size

Slabs

Nice sun beneath slab formwork

Retaining walls
Some reinforcement!

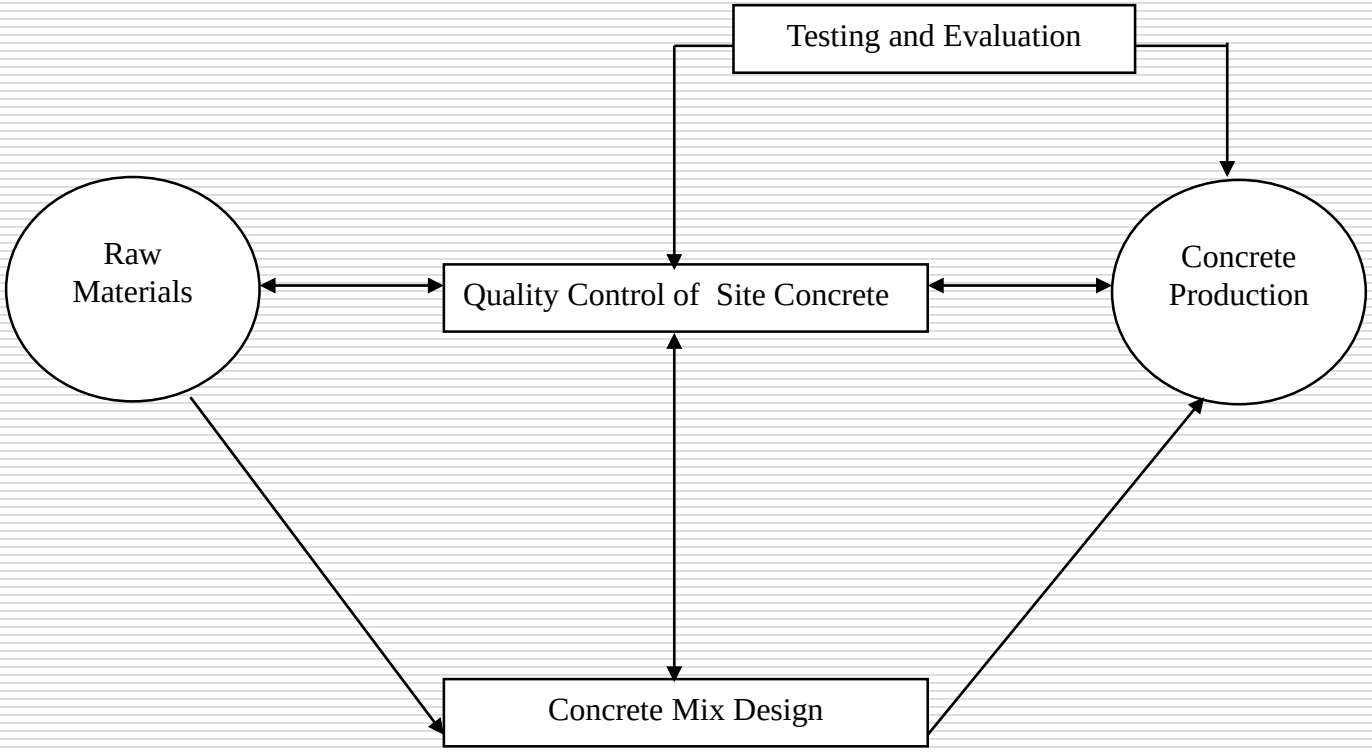


Retaining walls
More stones!

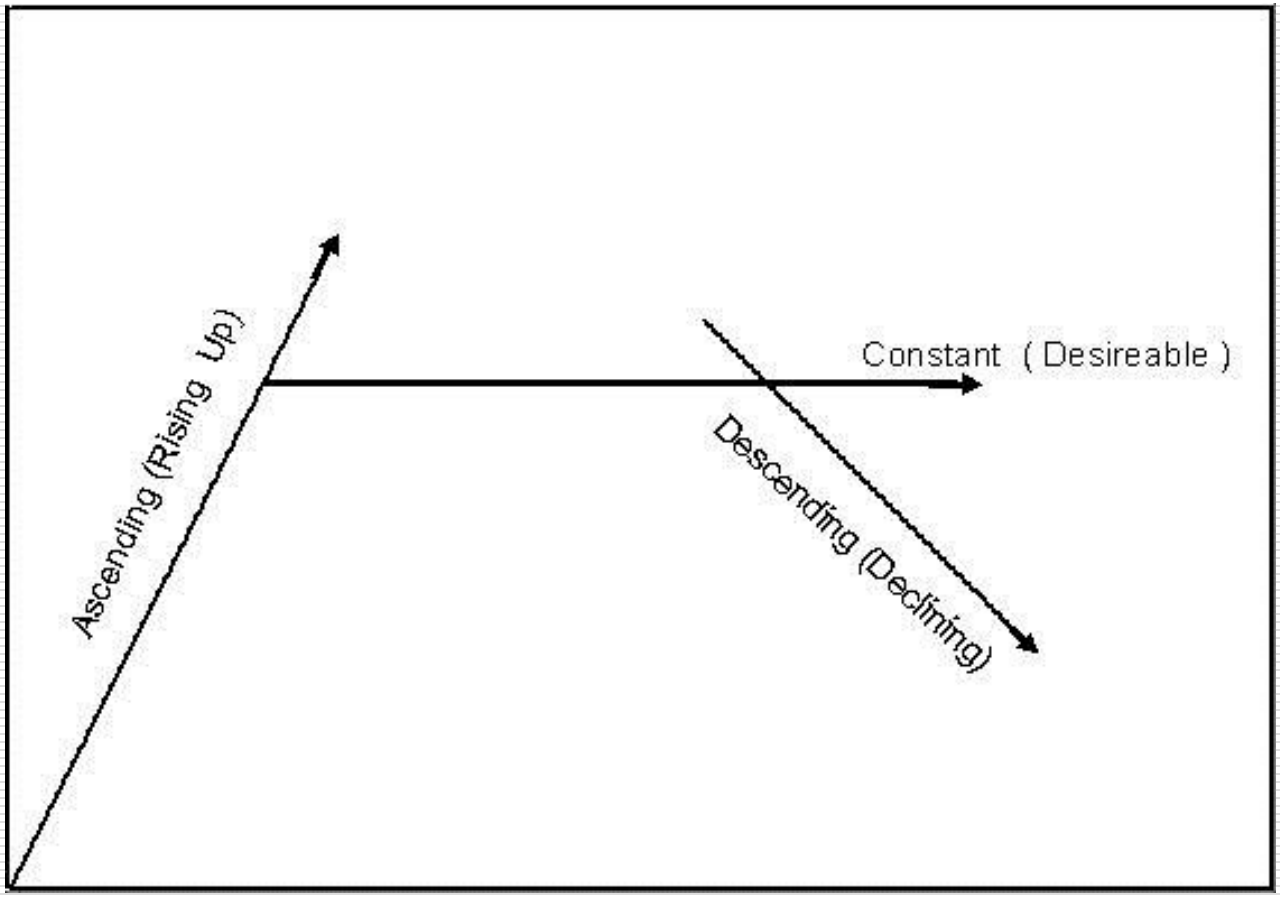
Columns
Don’t know what to say!

Introduction to Quality Control

- Strength, durability and serviceability



Major Process of Quality Control



Major Process of Quality Control

- The ascending period, in which concrete strength increases and this indicates **higher** values than required and **economy** may not be attained.
- The constant period which indicates **constant** quality control. This is the behavior the engineer should **aim to**.
- The declining period which indicates **lower** quality control and possibly **failure** to attain the required quality.

Major Problems of Quality Control in Less Developed Countries

- Lack of Genuine Specifications and Standards
- Lack of communication between Academic Institutions and the Industry
- Lack of Technology
- Lack of Well-Trained and Experienced Workmanship

Major Problems of Quality Control in Less Developed Countries

- Lack of Supervision
- Incorrect Production Practices
- Lack of Testing and Evaluation
- The Role of the Consultant and the Contractor
- Competition, Tendering, Costs and Benefits

Examples

Results of Strength Testing During the Progress of Work

Time of Sampling	During First Hour	After Three Hours	During Last Hour
Compressive Strength	27.4 MPa	29.1 MPa	33.7 MPa
Standard Deviation	3.34 MPa	4.27 MPa	5.97 MPa
Range (Max. - Min.)	30.7 – 24.6 MPa	34.7 – 25.2 MPa	40.8 – 29.3 MPa

Quality Control During Construction Workability

Degree of Workability	Slump (mm) tested as to ASTM C134	Compliance Requirements (Author)
Very low	<20	Needs further testeng Example (V.B. test)
Low	30 - 50	- 20 to +30 mm
Medium	80 - 100	± 30 mm
High	120 - 150	- 40 mm to + 30 mm
Very high	>180	Needs testeng for segregation Example (flow table)

Quality Control During Construction Density

- Fresh Density
  - ± 2.5 % for ready mixed concrete and
  - ± 3.5 % for cast on-place concrete
- Hardened Density
  - ± 4 % of the average measured density for ready mixed concrete and
  - ± 6 % of the average measured density for concrete mixed in-situ

Quality Control During Construction Air Content

- Non-air Entrained
  - ± 1 % apart of the expected value.
- Air Entrained
  - ± 1 % apart of the expected value, but depends on the severity of the frost effect.

Example (Case Study)
Mix Design

- Plasticizer is used
- Water was checked for workability and min. possible was used

Slump	Cement (min)	Free w/c ratio	Required strength	Design Strength
100mm	350kg/m^3	0.48	25MPa	38MPa.

Strength

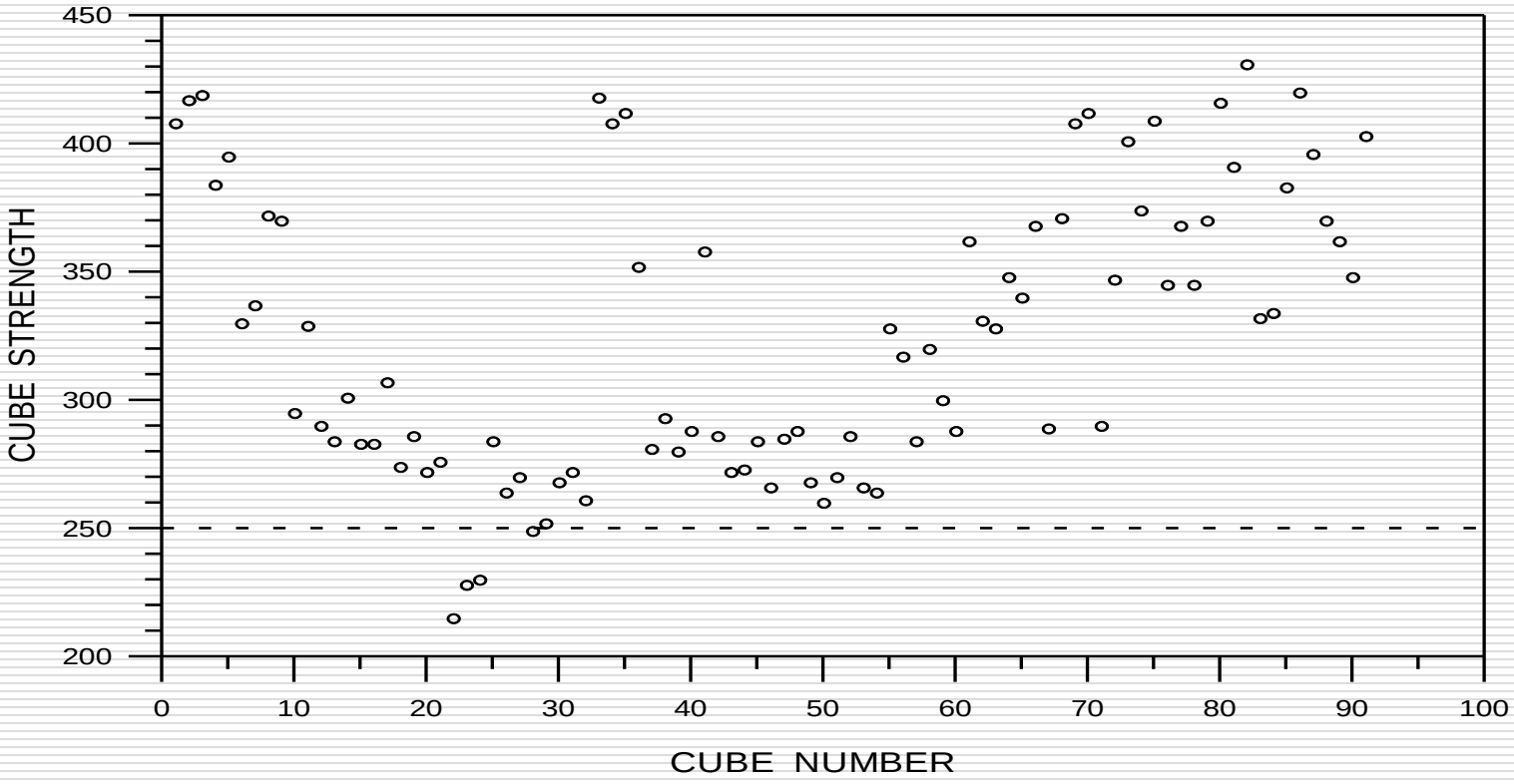


FIGURE (4): INDIVISUAL CUBE STRENGTH

Strength

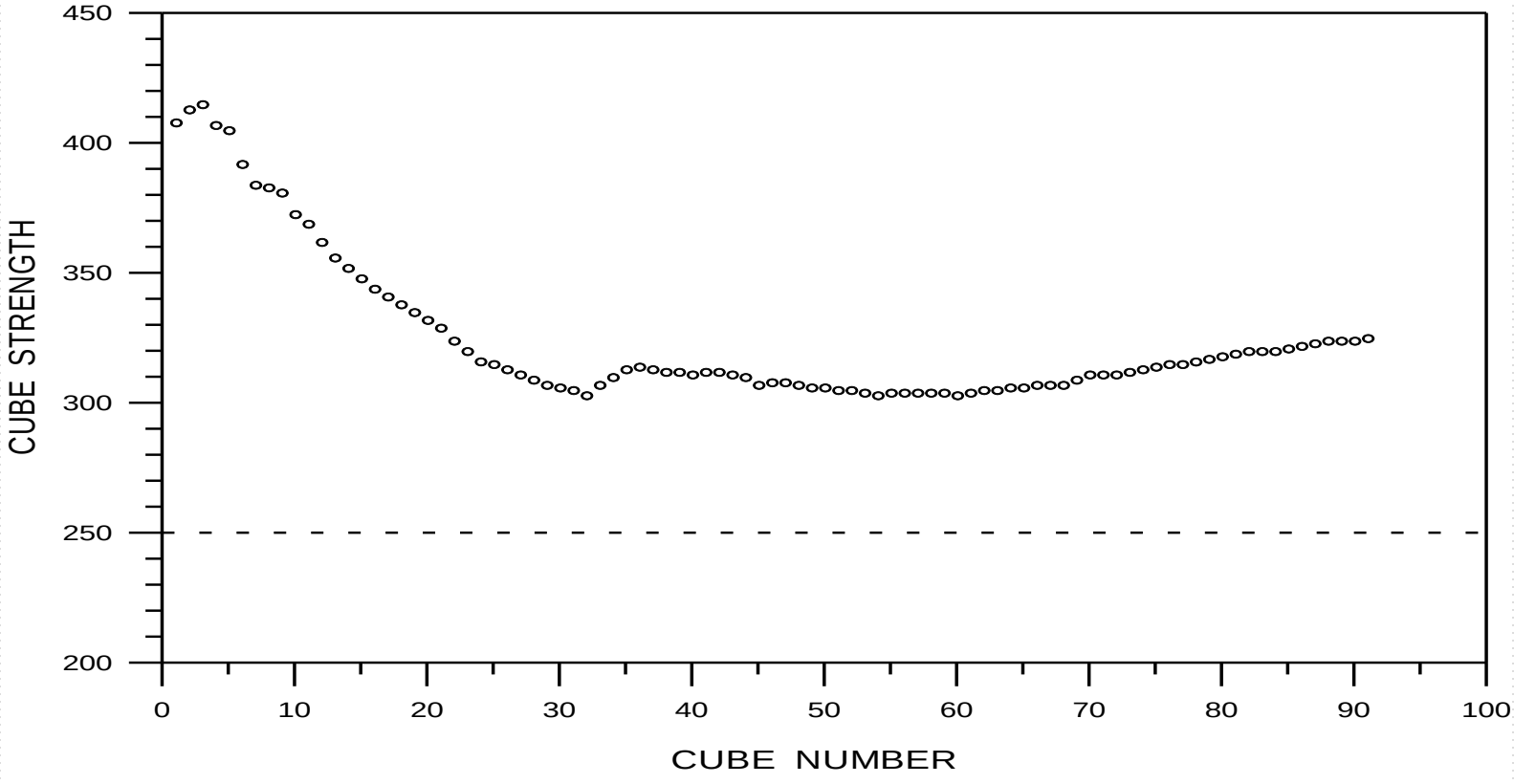


FIGURE (5): MOVING AVERAGE OF THE STRENGTH OF CUBES

Strength

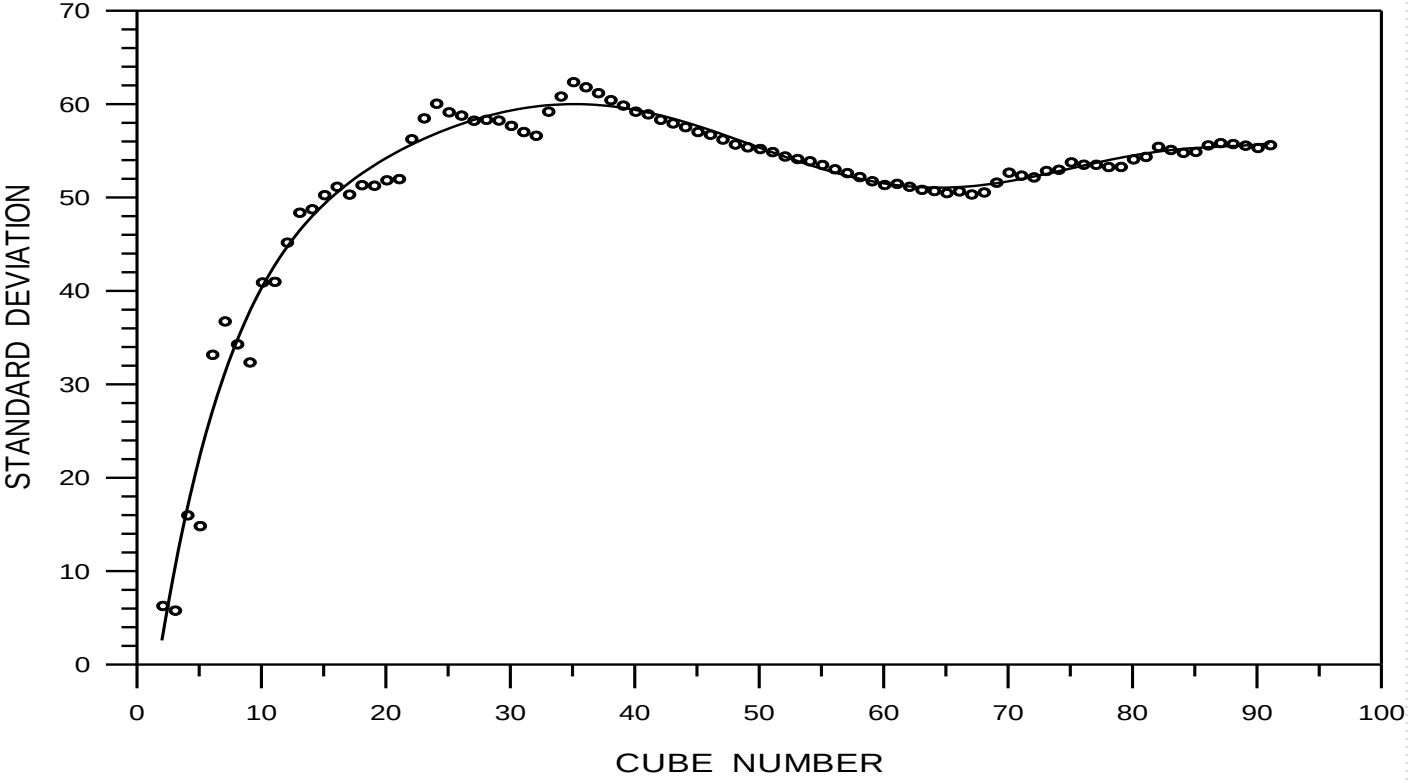


FIGURE (6a): VARIATION OF STANDARD DEVIATION

Recommendations

- Suggested Degree of Quality Control as Assessed from Standard Deviation (Ready Mixed Concrete and Batch Plant Concrete)

Quality Control	Excellent	Very Good	Good	Fair	Bad	Unacceptable
Standard Deviation	< 2.5 MPa	2.5 – 3.5 MPa	3.5 – 4.5 MPa	4.5 – 5.5 MPa	5.5 – 6.5 MPa	> 6.5 MPa
Coefficient of Varaiation (%)	< 8.5	8.5 – 11.5	11.5 – 15	15 – 18.5	18.5 – 22	> 22

Recommendations

Suggested Degree of Quality Control as Assessed from Standard Deviation (Concrete Mixed and Cast at Site)

Quality Control	Expected Site Description and Condition of Work	Expected Standard Deviation
Excellent	Graded aggregate from different sizes mixed properly according to spesifications, experienced engineers, continuous supervision, testing and evaluation, experienced workmanship, (weight batching).	< 3.5 MPa
Very Good	Graded aggregate from different sizes, continuous supervision, experienced workmanship, frequent testing and evaluation, (weight batching).	3.5 - 4.5 MPa
Good	Graded aggregate from different sizes, intermittent supervision or less experienced workmanship and less equipment.	4.5 – 5.5 MPa
Fair	Graded aggregate from at least two sizes, intermittent supervision, less experienced workmanship, volume batching.	5.5 – 7.0 MPa
Bad	Volume batching, no supervision, water is left to the technicians, unexperienced workmanship.	7.0 – 8.5 MPa
Unacceptable	Volume batching, no supervision, water is left to the technicians, unexperienced workmanship.	> 8.5 MPa