Quality Control & Quality Assurance In Road Construction

By

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BBMP Quality Control :

- Several lakhs of rupees being spent for Infrastructure and other Improvement works in BBMP.
- In order to ensure quality of works a full fledged, well equipped in house laboratory is necessary.
- Presently the BBMP has a quality control wing constituting EE's , AEE's & AE's.
- The quality control lab is equipped for testing cement, sand, metal, bitumen, bituminous mix, etc.,
- The field Engineers shall make use of BBMP quality control lab to ensure good quality works.

Emplaned Laboratories in BBMP

- The BBMP has empanelled consultants / firms having material testing laboratories.

- The agency has to make its own arrangement to convey the samples to the laboratories for testing .

❖ Quality Control

- Tests Necessary to Control a Product
- Determine Quality of Product being Produced
- Performed by Contractor

❖ Quality Assurance

- Tests Necessary to Make a Decision on Acceptance
- Ensure Product being Evaluated is What the owner Specified
- Performed by Owner

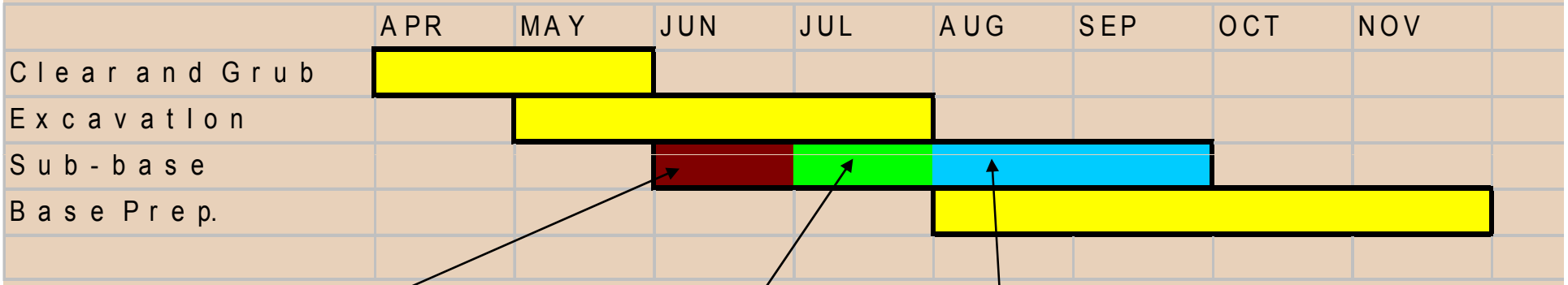
Quality Control vs. Quality Assurance

- Quality Control (QC) = The contractors system in place during the construction to manage, control and document his activities in order to comply with contract requirements

- Quality Assurance (QA) = The Governments system in place to monitor the Quality Control efforts of the contractor

QC + QA = **High Quality Finished Road**

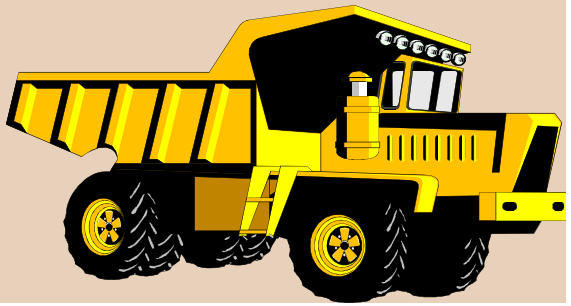
3 Phases of Contractor Quality Control



Preparatory Phase

Start-up Phase

Production Phase

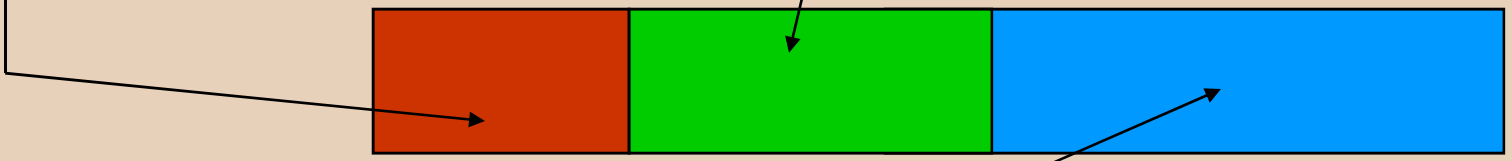


3 Phases of Contractor Quality Control

What is involved?

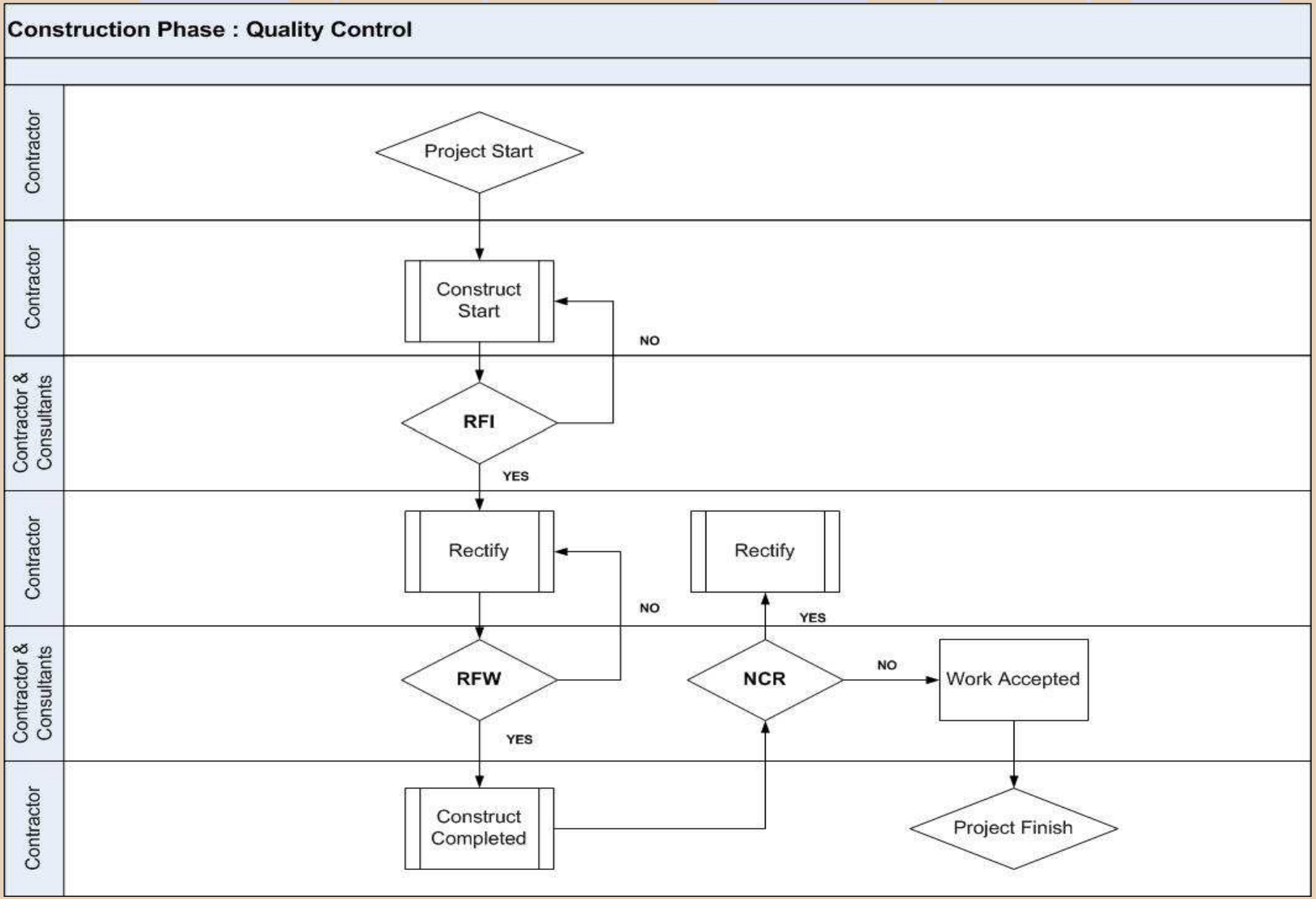
Preparatory Phase
- Review Plans and Specs
- Verify submittal approval
- Check preliminary work
- Examine materials
- Discuss construction methods
- Review Safety
- Coordinate surveying and staking work

Start-up Phase
- Establish quality required
- Resolve conflicts
- Ensure testing is performed
- Establish detailed testing schedule based on production schedule
- Review Safety



Production Phase
- Ensure Contract Compliance
- Conduct intermittent or continuous inspections to identify and correct deficiencies
- Inspect completed phases before scheduled Government acceptance
- Ensure Testing reports are submitted
- Ensure rework is completed

❖ CONSTRUCTION PHASE-Quality Control



❖ Requirements

- Ensure Quality
- Create Durable National Assets
- Grossly Inadequate for Present day Needs

❖ Advantages

- Improved Quality
- Uniformity
- Economic Utilisation of Materials
- Reduction in User Cost
- Extra Cost – Fraction of Resulting Benefits
- ½ to 1% of Construction Cost
- Economic Return – 5 – 10% of Total Construction Cost

❖ Pre-requisites

- Provision for Quality Control in Construction, Specification and Estimates
- Adequately Trained Staff
- Adequate Equipment
- Periodic Appraisal of the QC Data
- Updating of Knowledge by On-job Training

❖ Quality Control In Road Construction

- Control of Materials
- Test Procedure
- Frequency and Extent of Testing
- Acceptance Criteria
- Equipment Type & its Calibration
- Recording of Test Results
- Training for QC

❖ Quality Control Test

- **Individual Materials**
  - Soil, Gravel, Aggregate, Binder
- **Mixes**
  - Gradation of Aggregates, Mix Proportion, Mixed Design Properties
- **During Construction Process**
  - Spreading
  - Segregation
  - Temperature – Mixing, Laying, Rolling

❖ Quality Control Test

- **Test on Compacted Layer**
  - Mixed Proportion (Unbound Layers)
  - Density
  - Mix proportion and Gradation (bound layers after extraction)

- **Finished Surface**
  - Longitudinal Profile
  - Transverse Profile
  - Cross Slope
  - Texture

❖Tests On Borrow Materials Of embankment/subgrade

Test	Min. Desirable Frequency
Gradation/ Sand Content	1-2 Tests per 8000 m^3 of Soil
Plasticity Index	1-2 Tests per 8000 m^3 of Soil
Standard Proctor Test	1-2 Tests per 8000 m^3 of Soil
CBR on a set of 3 Specimens	One Test per 3000 m^3
Deleterious Constituents	As Required
Natural Moisture Content	One Test per 250 m^3 of Soil

❖ Density Requirements Of Embankments And Subgrade

Embankments upto 3 metres height, not subjected to extensive flooding	Not less than 15.2 kN/cu.m
Embankments exceeding 3 metres height or embankments of any height subject to long periods of inundation	Not less than 16.0 kN/cu.m
Subgrade and earthern shoulders/ verges/backfill	Not less than 17.5 kN/cu.m

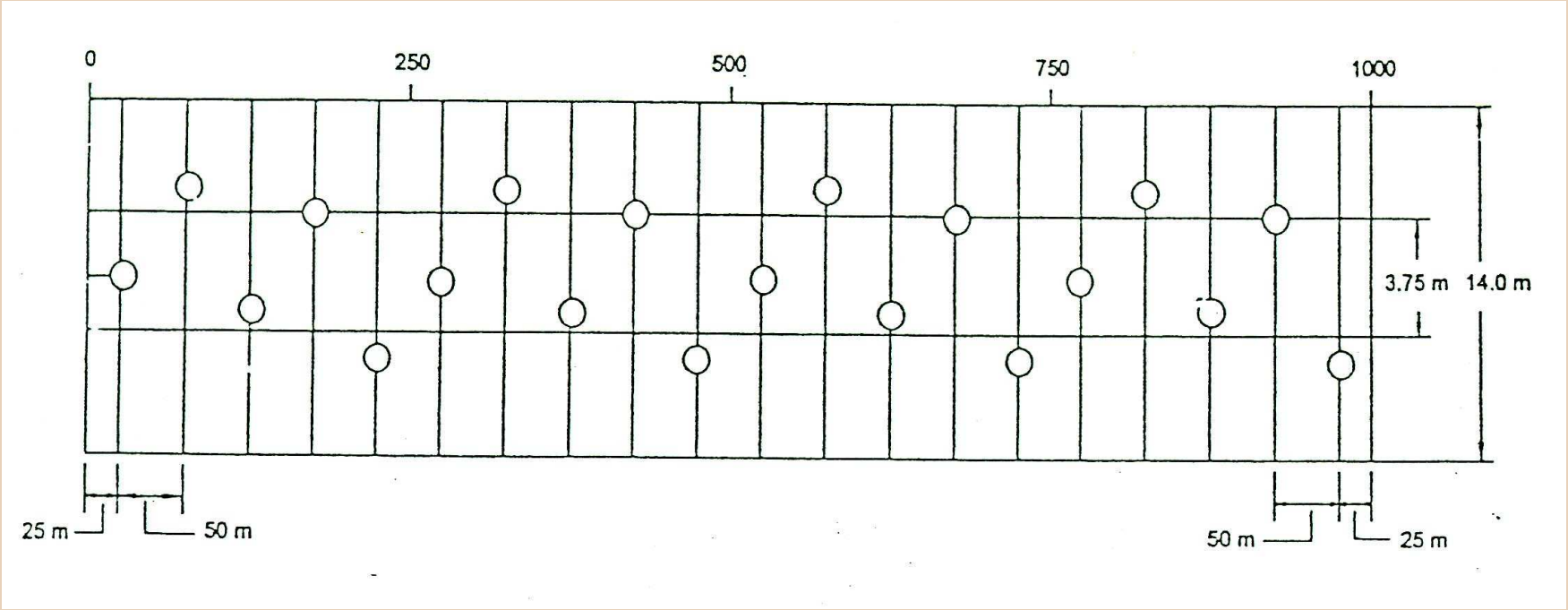
❖ Compaction Requirements For Embankment And Subgrade

Type of Work/ Material	Relative Compaction as % of MDD
Subgrade and Earthen Shoulders	Not less than 97
Embankments	Not less than 95
Expansive Clays:	
Subgrade and 500 mm portion just below the subgrade	Not Allowed
Remaining Portion of Embankment	Not Less than 90

❖ Frequency of Compaction Tests

Particulars	Frequency (min)
Moisture Content prior to compaction	One test for every 250 m^3 of soil subject to min. of 4 tests/day
Thickness of layer	Regularly
Degree of compaction	
(a) Body of embankment	At least one test per 1,000 m^2 for each layer
(b) Subgrade and shoulders	At least one test per 500 m^2 for each layer

❖ Location Of Density Test Points For Earth Work



❖ Acceptance Criteria

Control should be based on the mean value of a set of 5-10 density measurement.

The criteria for acceptance shall be subject to the condition that the MEAN DENSITY is not less than the specified density plus:

$$\left[1.65 - \frac{1.65}{(\text{No. of samples})^{0.5}}\right] \text{times the standard deviation}$$

❖ Granular Sub-base

Gradation	One test per 200 m^3
Atternberg limits	One test per 200 m^3
Moisture Content prior to Compaction	One test per 250 m^3
Density of Compacted Layer	One test per 500 m^2
Deleterious Constituents	As Required
CBR	As Required

❖ Lime/ Cement Stabilised Soil Sub-base

Quality of Lime/ Cement	One Test for Each Consignment Subject to a Minimum of one Test per 5 Tonnes
Lime/Cement Content	Regularly, through Procedural Checks
Degree of Pulverisation	1-2 Tests per 8000 m^3 of Soil
CBR or UCC	As Required
Density	One Test per 500 m^2

❖ Physical Requirements Of Coarse Aggregates For Water Bound Macadam For Sub-base/base Courses

Test	Requirements
Los Angeles Abrasion Value	40 percent (Max.)
or Aggregate Impact Value	30 percent (Max.)
Combined Flakiness and Elongation Indices	30 percent (Max.)

❖ Water Bound Macadam

Aggregate Impact Value	One Test per 200 m^3 of Aggregate
Grading	One Test per 100 m^3
Flakiness Index and Elongation Index	One Test per 200 m^3 of Aggregate
Attenberg Limits of Binding Material	One Test per 25 m^3 of Binding Material
Attenberg Limits of Portion of Aggregate passing 425 micron sieve	One Test per 100 cubic Metre of Aggregate

❖ Wet Mix Macadam

Aggregate Impact Value	One Test per 200 m^3 of Aggregate
Grading	One Test per 100 m^3 of Aggregate
Flakiness and Elongation Index	One Test per 200 m^3 of Aggregate
Attenberg Limits of Portion of Aggregate passing 425 micron sieve	One Test per 100 m^3 of Aggregate
Density of Compacted Layer	One Test per 500 m^3

❖ Prime Coat / Tack Coat

Quality of Binder	Two Samples lot to be subjected to all or some Tests as Directed by the Engineer
Binder Temperature for Application	At Regular Close Intervals
Rate of Spread of Binder	Two Tests per Day

❖ Surface Dressing

Quality of Binder	Two Samples per lot
Aggregate Impact Value	One Test per 50 m^3 of Aggregate
Flakiness Index and Elongation Index	- do -
Stripping Value of Aggregates	3 specimens per source
Water Absorption of Aggregates	- do -
Grading of Aggregates	One Test per 25 m^3 of Aggregates

❖ Open-graded Premix Carpet/ Mix-seal Surfacing

Quality of Binder	**Two Samples per lot to be Subjected to all or some tests as Directed by Engineer**
Aggregate Impact Value	**One test per 50 m^3 of Aggregates**
FI and EI of Aggregates	**- do -**
Stripping value	**3 specimens per source**
Water Absorption of Aggregates	**- do -**
Grading of Aggregates	**One Test per 25 m^3 of Aggregates**

❖ Physical Requirements Of Aggregates For Bituminous Macadam

Test	Requirement
Los Angeles Abrasion Value	40 % Max.
FI and EI	30 % Max.
Coating and Stripping of Bitumen Aggregate Mixtures	30 % Max.
Soundness	12 % Max.
Water Absorption	2 % Max.

❖ Bituminous Macadam

Quality of Binder	**Two Samples per lot to be subjected to all or some tests as directed by the Engineer**
Aggregate Impact Value	**One Test per 50 m^3 of Aggregate**
FI and EI of Aggregates	**- do -**
Stripping Value	**3 specimens per source**
Grading of Aggregates	**Two Tests per day per plant both on the individual constituents and mixed aggregates from the dryer**

❖ Bituminous Penetration Macadam/ Built-up Spray Grout

Quality of Binder	**Two Samples per lot to be subjected to all or some tests as directed by the Engineer**
Aggregate Impact Value	**One Test per 200 m^3 of Aggregate**
FI and EI of Aggregates	**- do -**
Stripping Value	**3 specimens per source**
Aggregate Grading	**One Test per 100 m^3 of aggregate**
Temp. of Binder at Application	**At regular Close Intervals**

Requirements For Semi-dense Bituminous Concrete Mix

Marshall Stability	820 kg (1800 lbs) Min.
Marshall Flow	2-4
Percent Air Voids in Mix	3-5
Percent Air Voids in Mineral Aggregate (VMA) Minimum	13-15
Percentage Air Voids in Mineral aggregates filled with Bitumen (VFB)	65-75
Binder Content, percent by weight of mix	Not less than 4.0 percent

❖ Dense Bituminous Madacam/ Semi Dense Bituminous Concrete/ Bituminous Concrete

Quality of Binder	**Two Samples per lot to be subjected to all or some tests as directed by the Engineer**
Aggregate Impact Value	**One Test per 50 m^3 of Aggregate**
F I and E I of Aggregates	**One Test per 50 m^3 of Aggregate**
Stripping Value	**3 Specimens per Source**
Water Absorption of Aggregates	**- do -**
Water Sensitivity of mix	**As Required for BC**

❖Requirements Of Bituminous Concrete Mix

Marshall Stability	900 kg Min.
Marshall Flow	2 - 4
Percent Air voids in Mix	3-5
Min. VMA Percent related to Design Air Voids, %	3.0 - 10-14 % 4.0 - 11-15% 5.0 - 12-16 %
Percent Airvoids in Mineral Aggregates filled by Bitumen (VFB)	65 - 75
Binder content percent by weight of total mix	5- 6 (50-65 mm thick) 5 - 7 (30-45 mm thick)
Water Sensitivity	Min. 75 % Retained Strength
Swell Test	1.5 % Max. LAV

❖ Testing Of Asphalt Mixes

- Aggregate gradation
- Asphalt content
- Temperature
- Theoretical maximum density
- In-place density
- Smoothness
- Visual inspection

❖ Aggregate Gradation

- SAMPLING
  - STOCK PILE
  - COLD FEEDER BELT
  - HOT BINS
  - EXTRACTED ASPHALT MIXTURE (END PRODUCT)

❖ Trouble Shooting

- Sampling stock pile
- Check gradation of new material added
- Segregation in feeder belt
- Improper loading of cold bins
- Improper setting of individual bins

❖ Asphalt Content

- Important for satisfactory performance
- Low asphalt content- less durable mix
- More asphalt content- not stable mix
- Affects film thickness, voids, stability and flow

❖ Temperature

- High enough to provide good coating on aggregates
- Allow satisfactory compaction
- More heating – additional oxidation, loss of volatiles, reduce mixture durability

❖ Temperature

Grade	Bitumen	Agg.	Mix	Rolling	Laying
65	150 - 165	150 - 170	165 Max	90 Min	125 Min
90	140 - 160	140 - 165	155 Max	80 Min	115 Min

❖ Compaction

- Commence From Edges And Progress Towards Centre
- Initial Breakdown Rolling – 8 To 10 T Smooth Wheel Roller
- Intermediate Rolling – 8-10 T Dead Wt. Or Vibratory Roller.Pneumatic Tyred Roller –12-15 T Wt. 5.6 Kg/Sq.Cm Pr.
- Finished Rolling – 6-8 T Smooth Wheel Tandem Roller

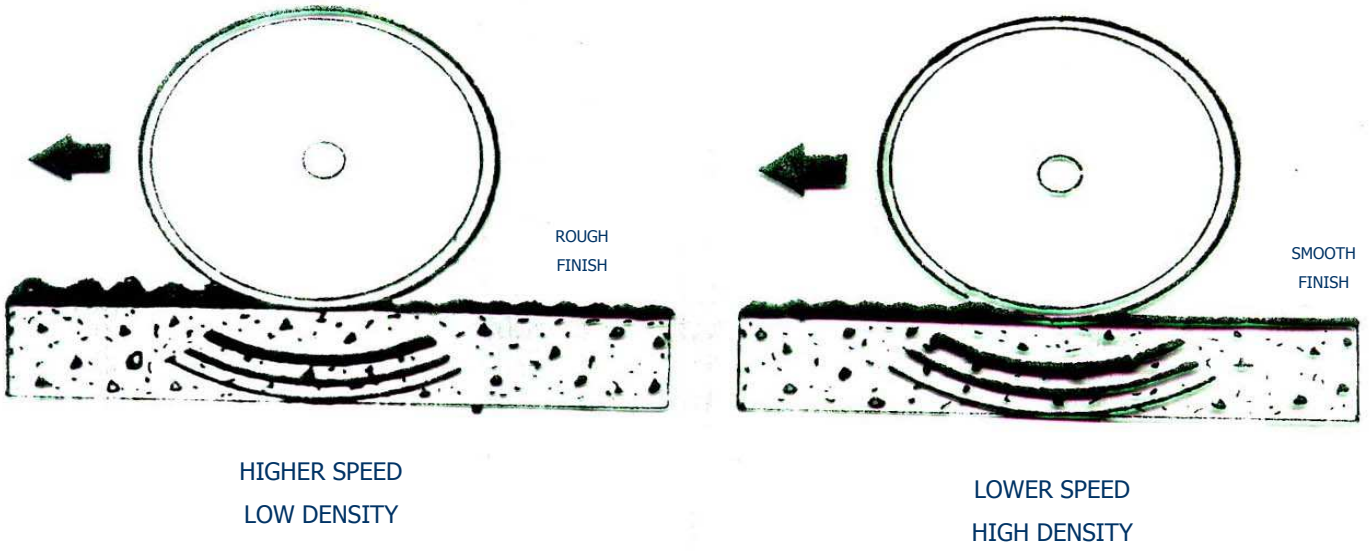
❖ Compaction

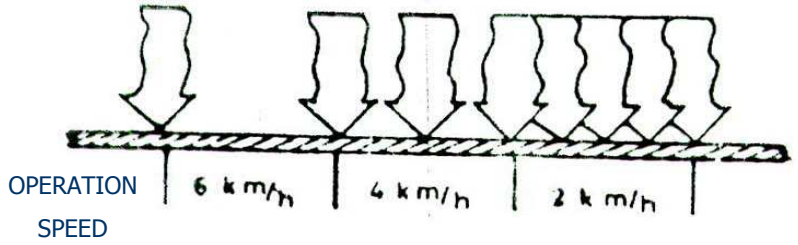
- Roller Speed Not More Than 5 Kmph
- Do Not Permit Rollers To Stand On Pavement
- Prevent Oil Drop
- Keep Wheels Just Moist Enough

Suggested Frequency And Amplitude For Vibratory Compaction

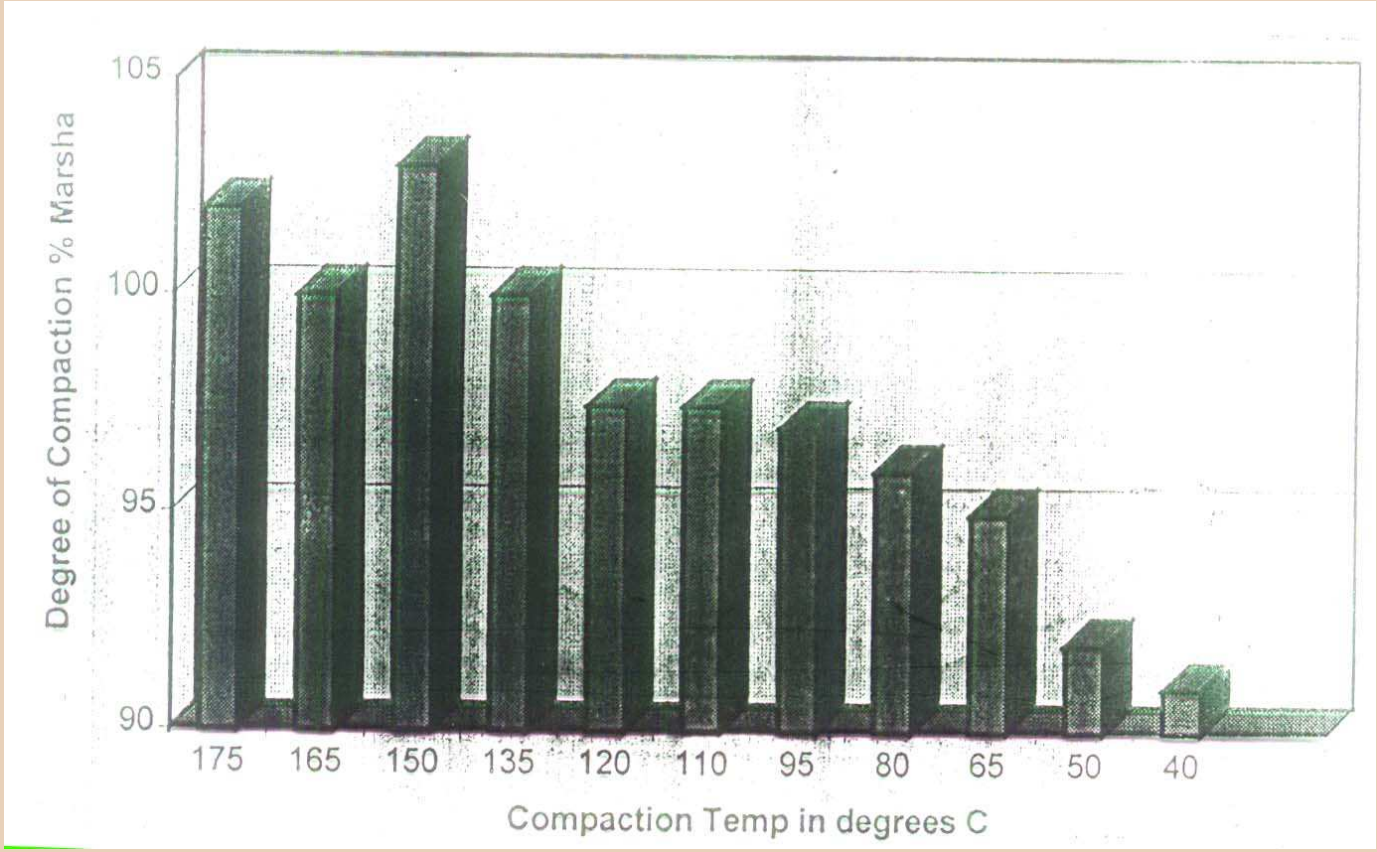
Nature of Soil/ Materials	Frequency (CPM)	Amplitude (mm)	Thickness of Compaction, mm
Rock	1800-2500	1.2 – 1.5	750
Sand/ Gravel	1800-2000	0.8 – 1.2	500
Sandy/clay /clayey	1600-2000	0.8 – 1.2	600
Clay	2000-2500	0.8 – 1.0	400
Asphalt	2500-3500	0.4 – 0.6	50 – 75

Effect Of Speed Of Roller In Density And Finish Surface





Relationship Between Compactability & Temperature



❖ TACK COATING BY SPRAYER

❖ Tack Coat Without Crack Sealing

❖ Overlay Over Severely Cracked

- **Inadequate Compaction And Excess Binding Material**

- WBM Surface Without Key Aggregates And Excess Binding Material

❖ Shoulders At Higher Elevation

❖ Poorly Widened WBM Carriageway

❖ POORLY WIDENED WBM CARRIAGEWAY

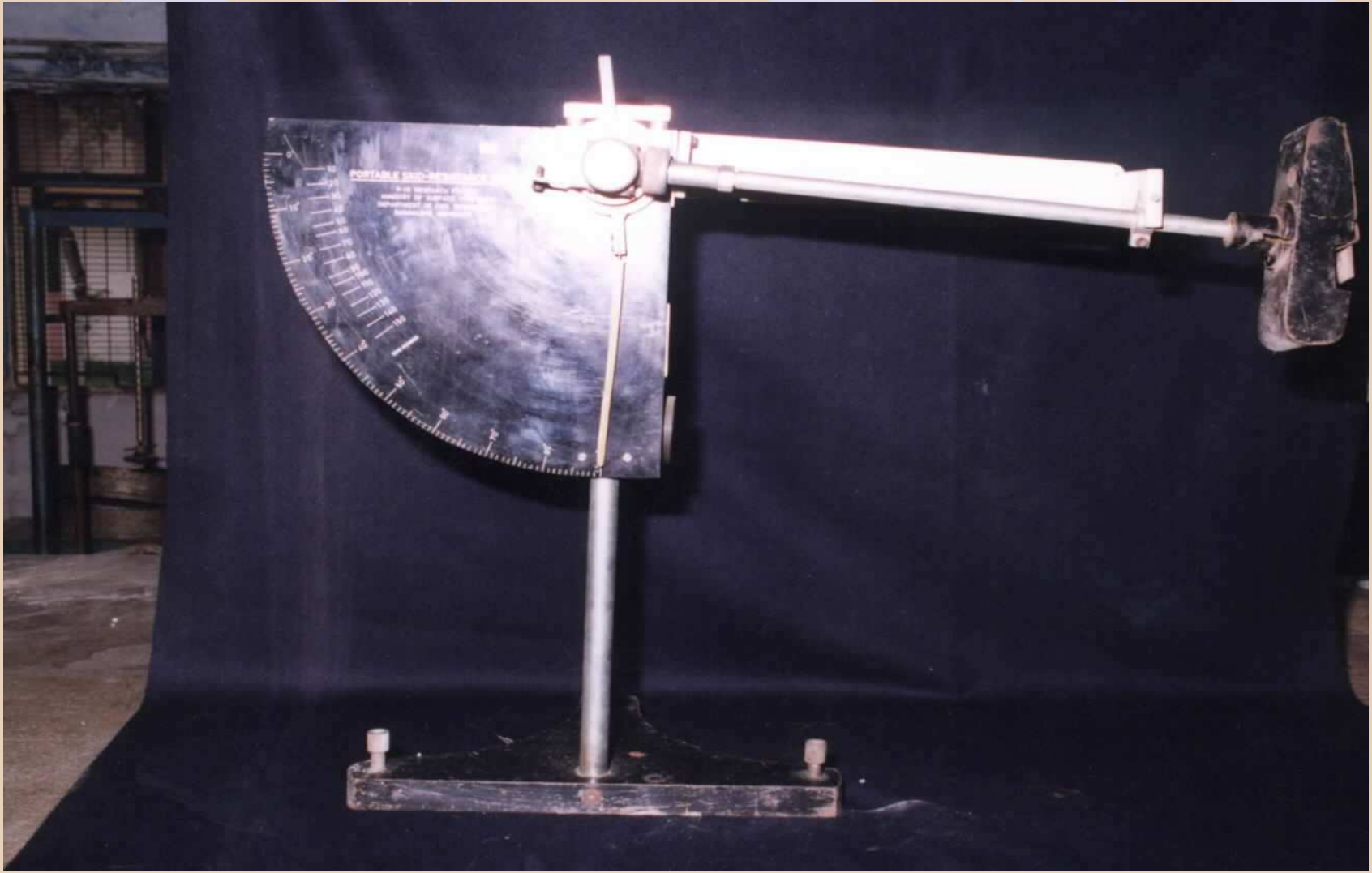
❖ Depressed Carriageway

❖ Tack Coat Surfaced WBM Layer

Modern Equipment For Quality Control Tests In Highways Construction

Asphalt Content Guage

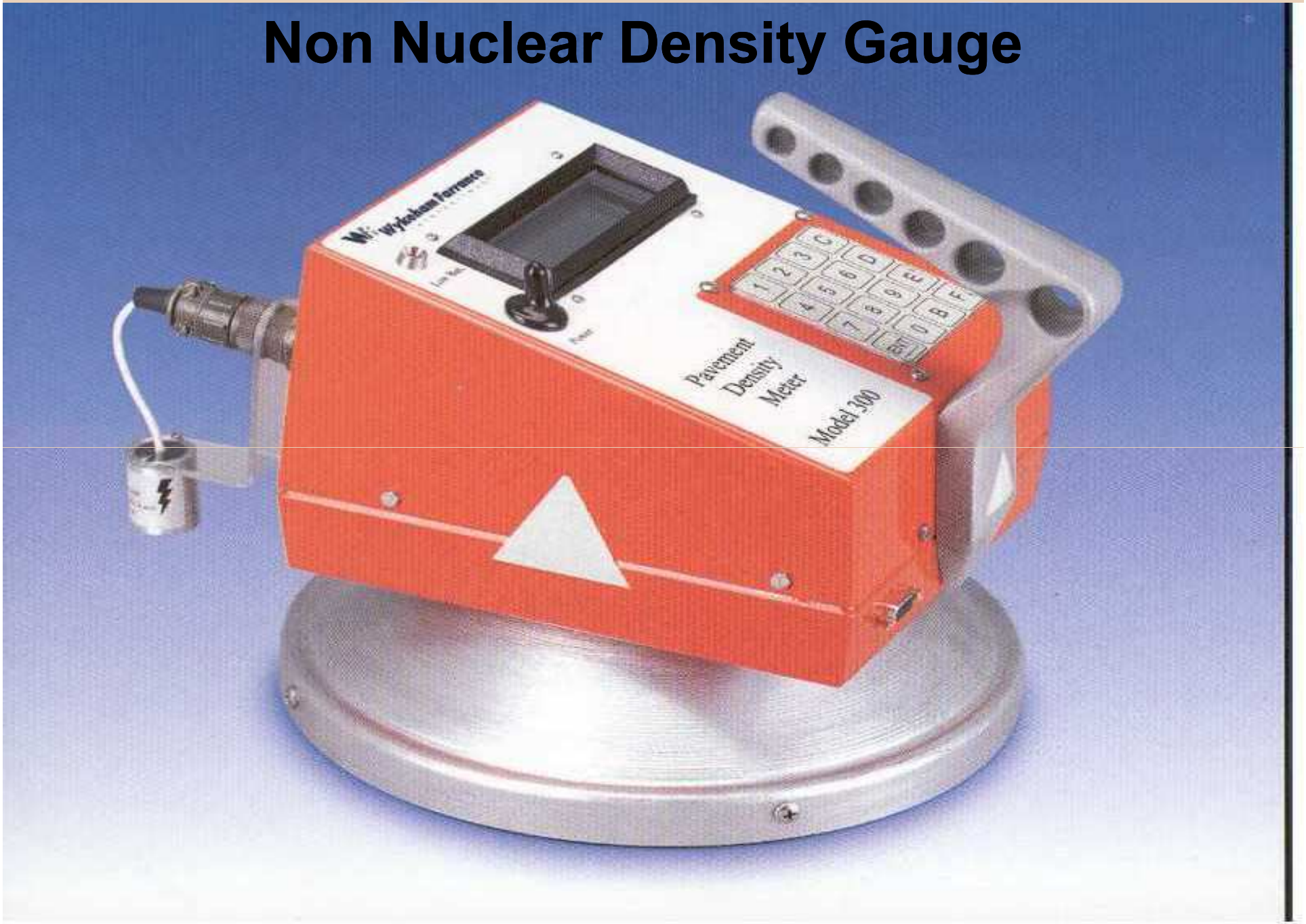
❖ Portable Pendulum Type Skid Resistance Tester



❖ Dynamic Skid Resistance Tester

❖Portable Asphalt Core Cutter

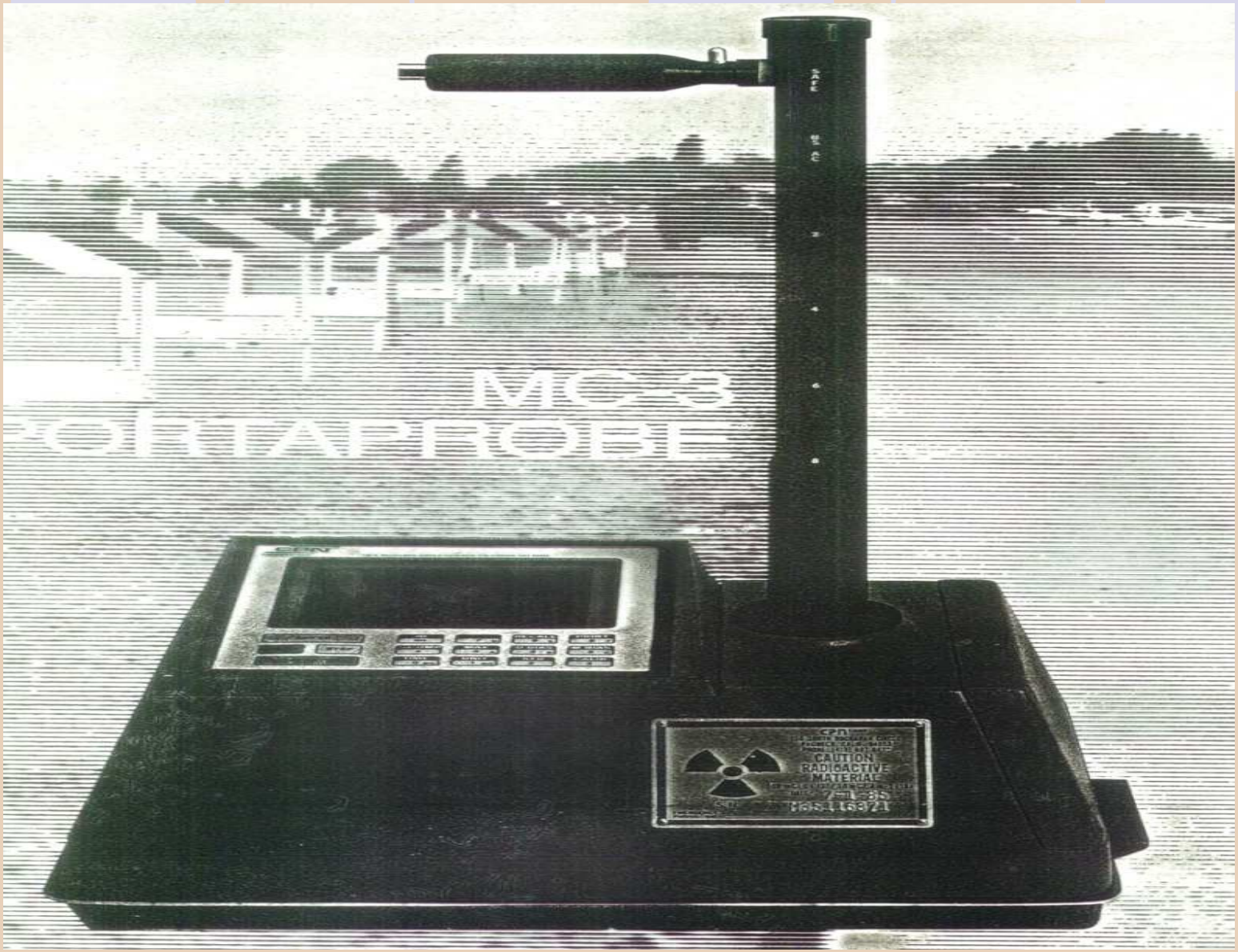
Non Nuclear Density Gauge



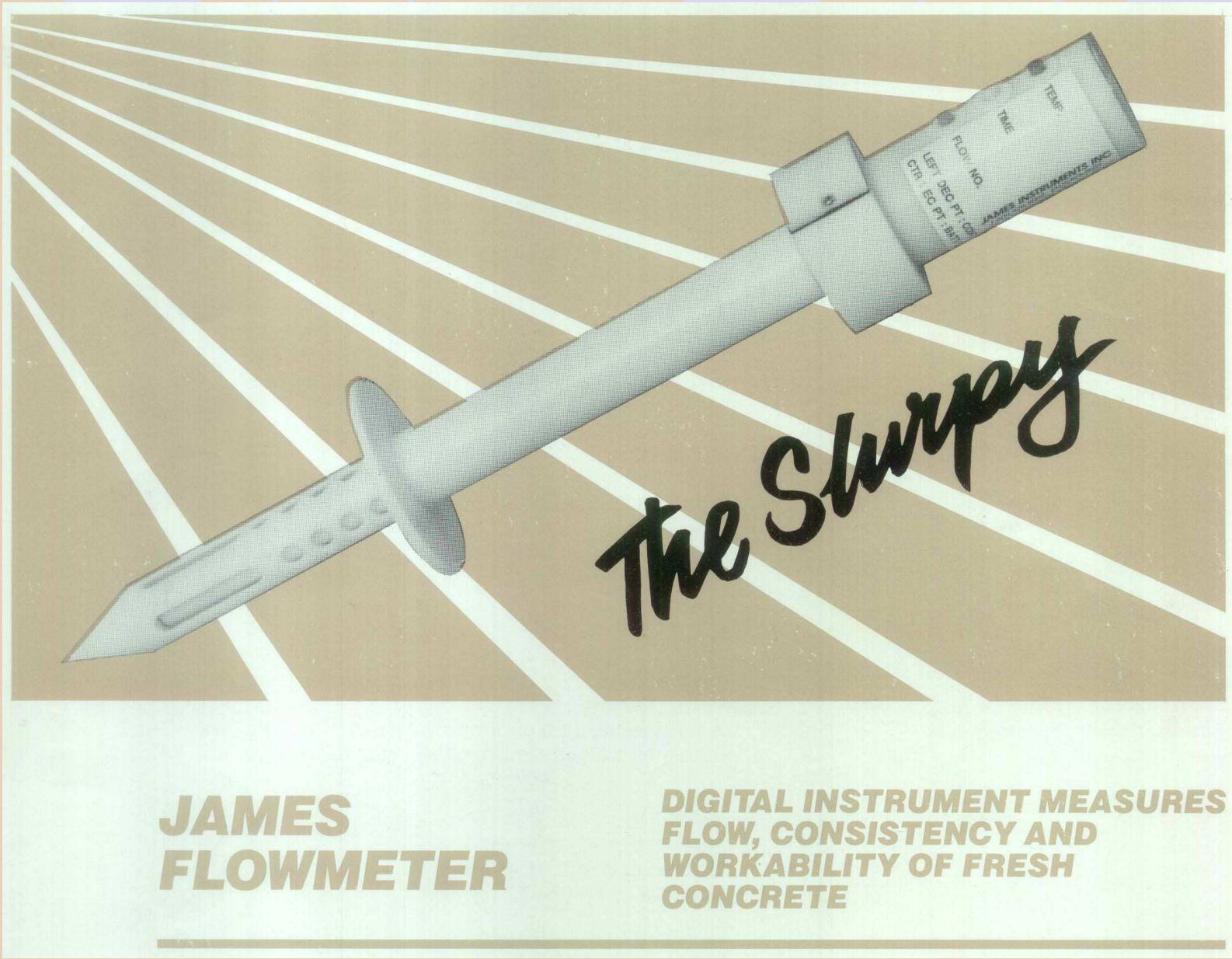
❖ Benkelmen Beam

❖ Fifth Wheel Bump Integrator (Roughometer)

❖ Nuclear Density Meter



Asphalt Content Guage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The Slurpy
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FLOW, CONSISTENCY AND
WORKABILITY OF FRESH
CONCRETE


Concrete Tester
Betonprüfer
Concrete Tester
DIGI SCHMIDT 2
MADE IN SWITZERLAND
ON
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START
RESET
MENU
END
PRINT
STORE
PROCEQ Testing Instruments
Original SCHMIDT
DIGI SCHMIDT
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Rebar Locator

❖ Falling Weight Deflectometer

Thank you....