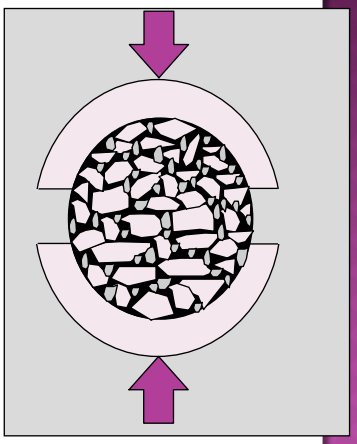
# MARSHALL MIX DESIGN



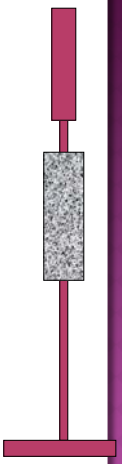


## REQUIREMENTS IN COMMON

- Sufficient asphalt to ensure a durable pavement
- Sufficient stability under traffic loads
- Sufficient air voids
  - Upper limit to prevent excessive environmental damage
  - Lower limit to allow room for initial densification due to traffic
- Sufficient workability

# MARSHALL MIX DESIGN

- Developed by Bruce Marshall for the Mississippi Highway Department in the late 30's
- WES began to study it in 1943 for WWII
  - Evaluated compaction effort
    - No. of blows, foot design, etc.
    - Decided on 10 lb.. Hammer, 50 blows/side
    - 4% voids after traffic
- Initial criteria were established and upgraded for increased tire pressures and loads





# AUTOMATIC MARSHALL HAMMER

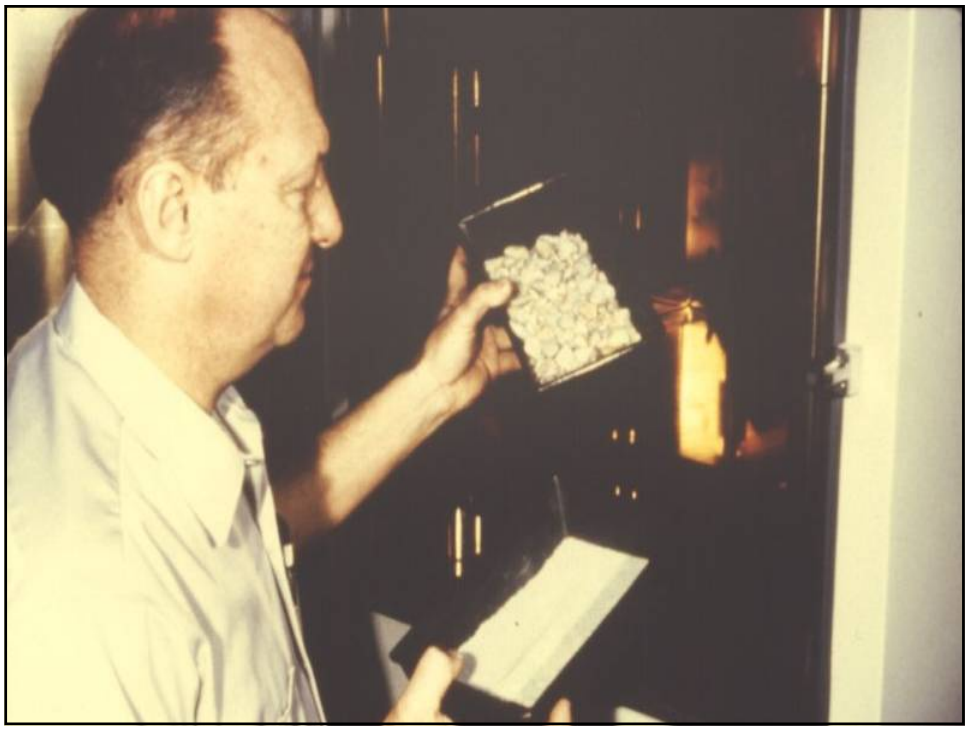
# MARSHALL MIX DESIGN

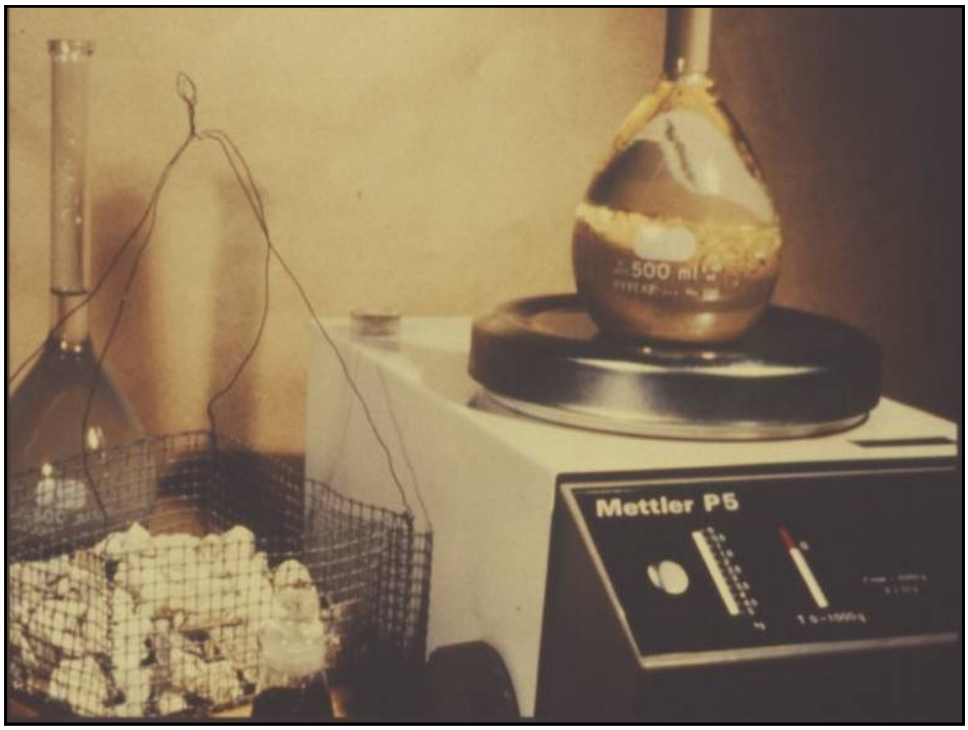
- Select and test aggregate
- Select and test asphalt cement
  - Establish mixing and compaction temperatures
- Develop trial blends
  - Heat and mix asphalt cement and aggregates
  - Compact specimen (100 mm diameter)

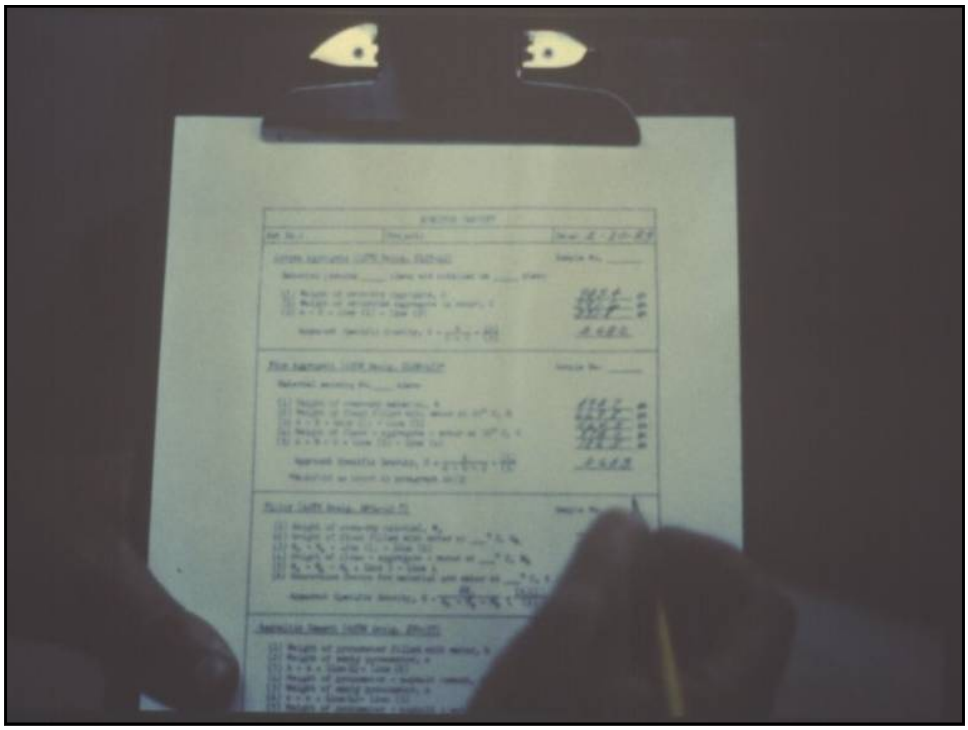


# Marshall Procedures

- Density & Voids Analysis
- Stability & Flow Test




500 ml
Mettler P5

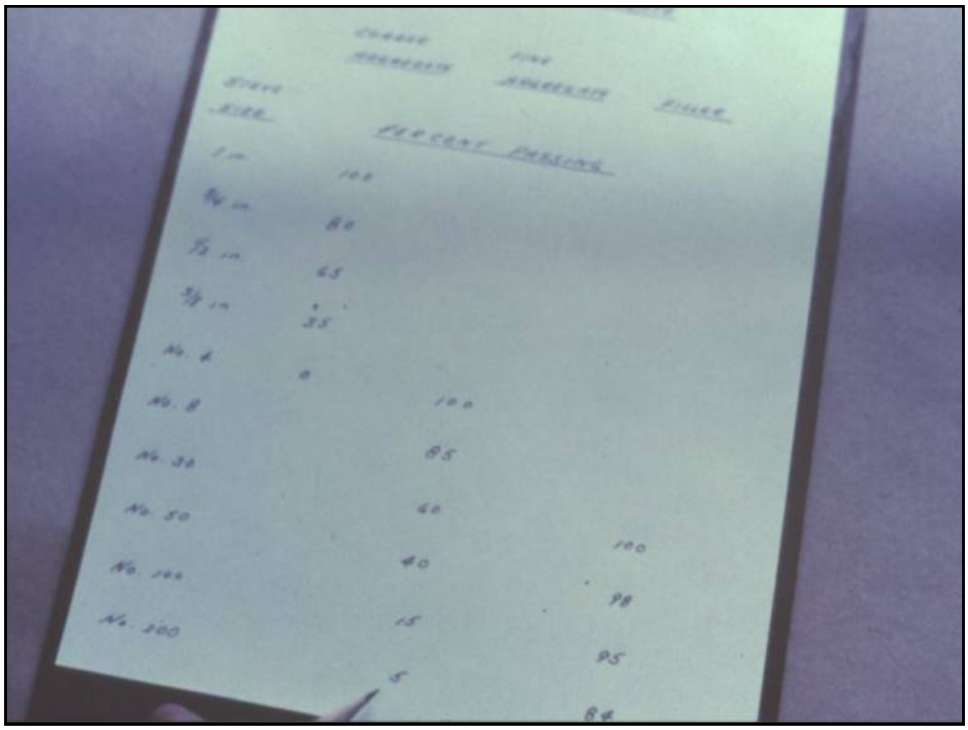


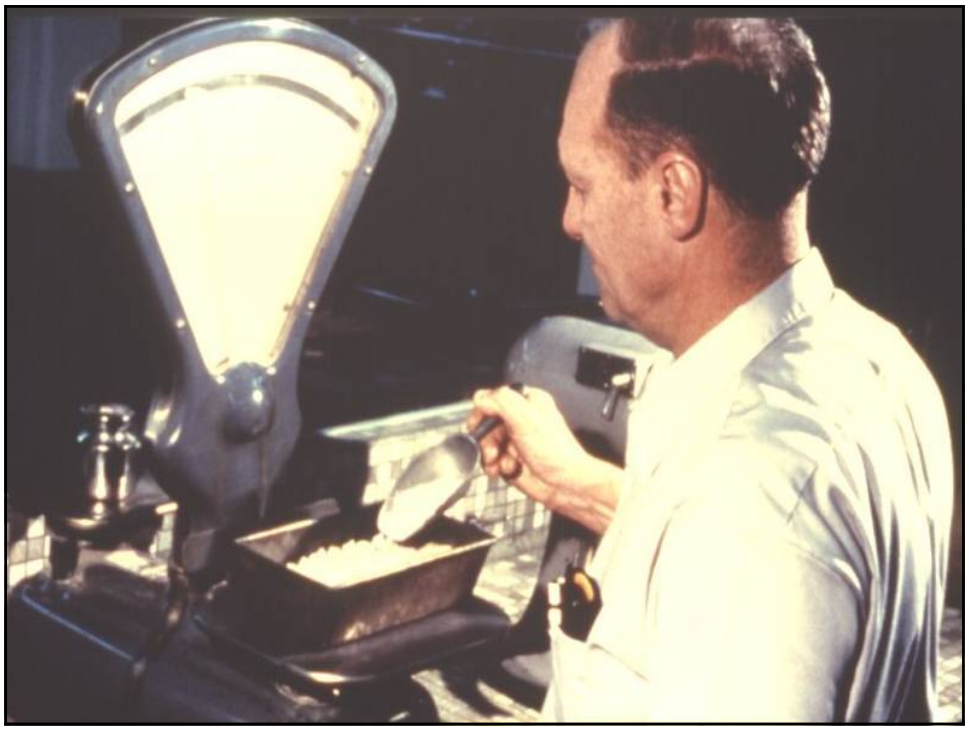
| | | | |
|---|---|---|---|
| -200 | 50.0 | 3.0 | 10.0 |
| Total | 50.0 | 5.0 | 5.0 |
| | 1000.0 | 5.0 (T) | |

(A) Weight original sample 1000 gm
(B) Weight after washed 950 gm
C) Wash loss (A - B) 50 gm
S) -200 from sieving 0 gm
) Total -200 C + S 50 gm
Use "T" to calculate percentages

Checked by:


Mettler PC

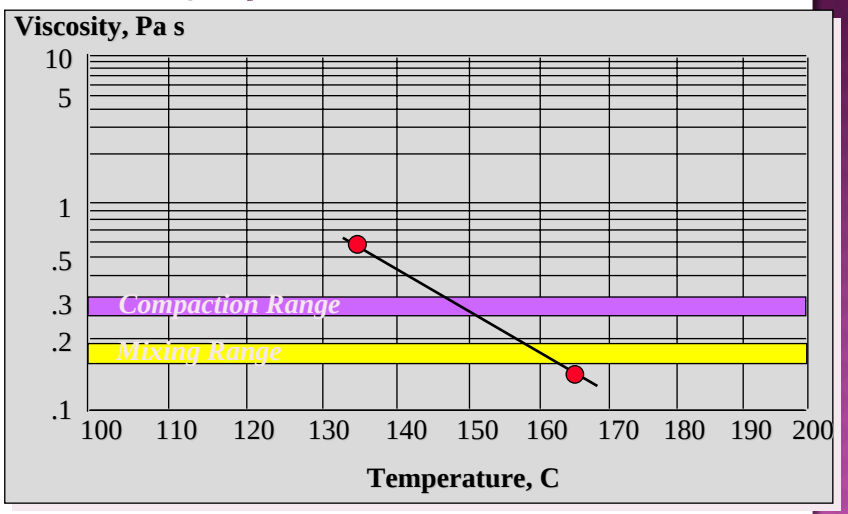

Sieve Size
Percent Passing
Fines
1 in
100
¾ in
80
½ in
65
⅜ in
35
No. 4
0
No. 8
100
No. 30
85
No. 50
60
No. 100
40
100
No. 200
15
98
No. 300
5
95
84

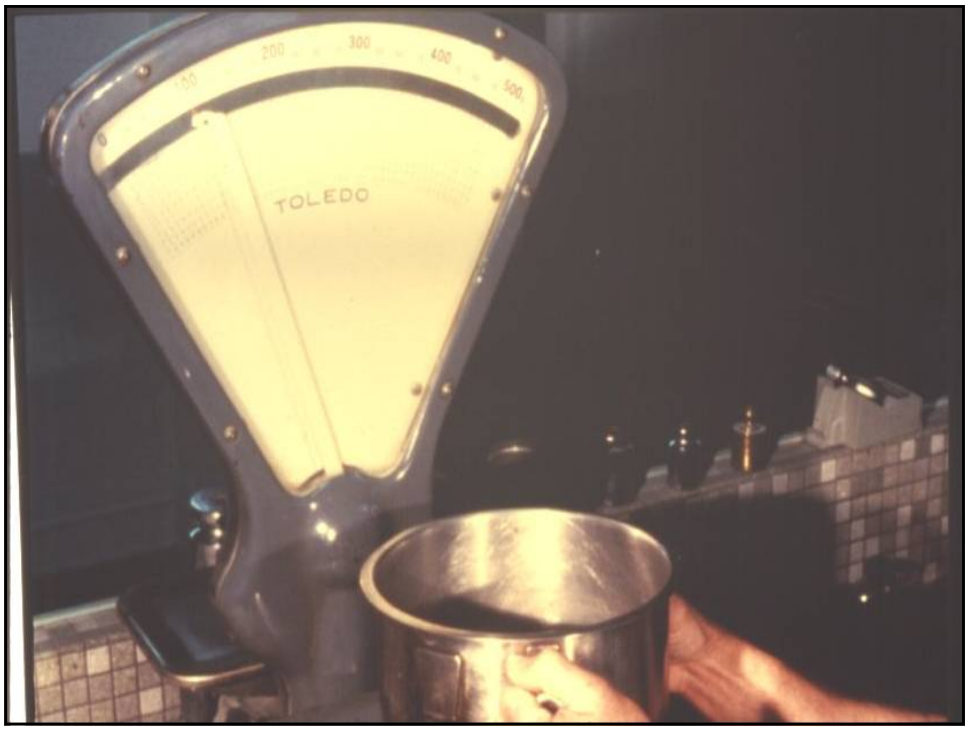


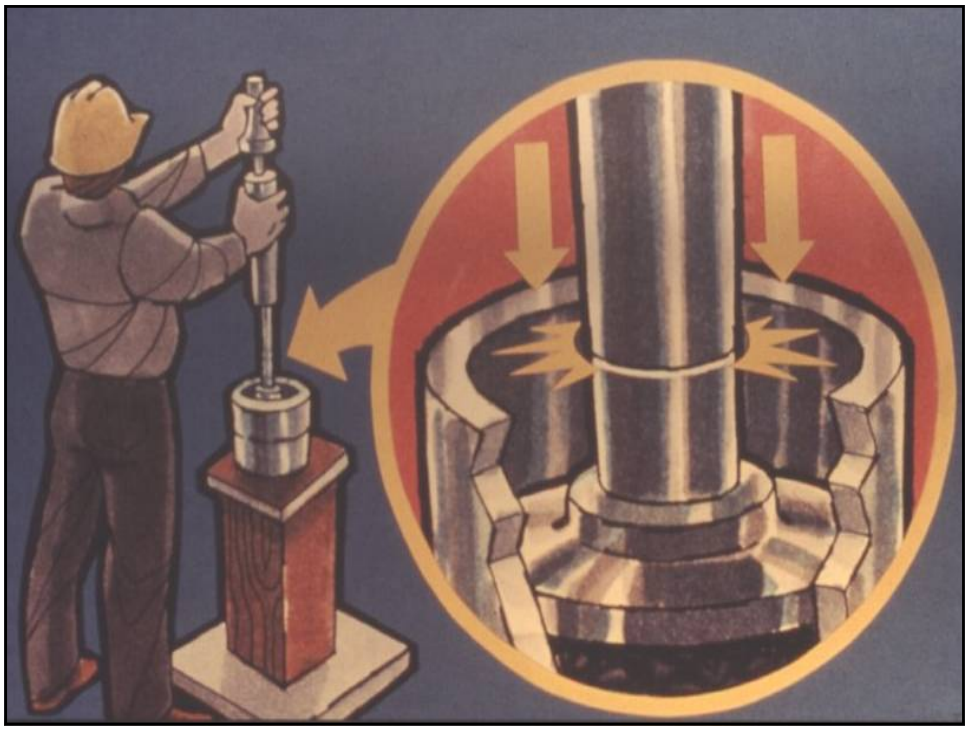
## Recommended Aggregate Fractions

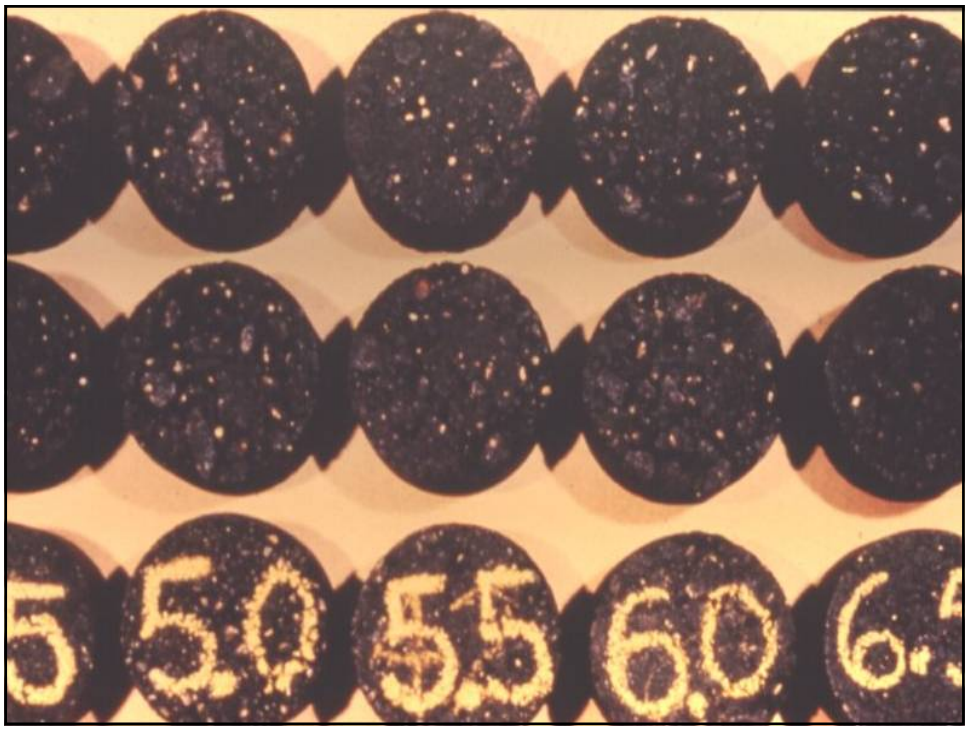
1 in – 3/4 in
3/4 in – 3/8 in
3/8 in – No.4
No.4 – No.8
Passing No.8

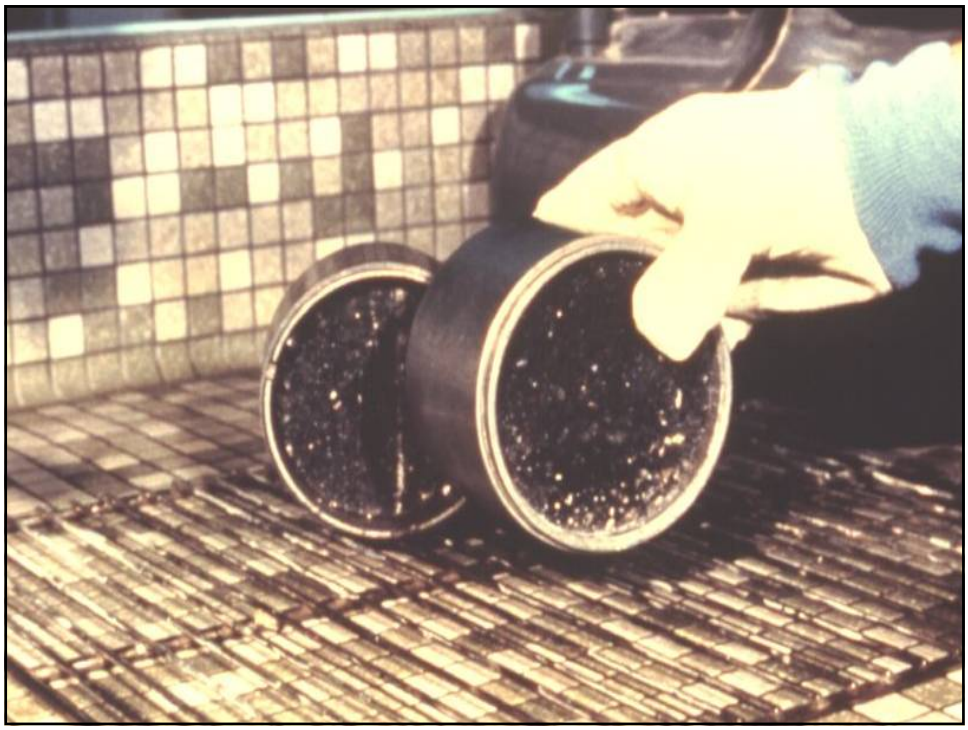
# MIXING/COMPACTION TEMPS





TOLEDO

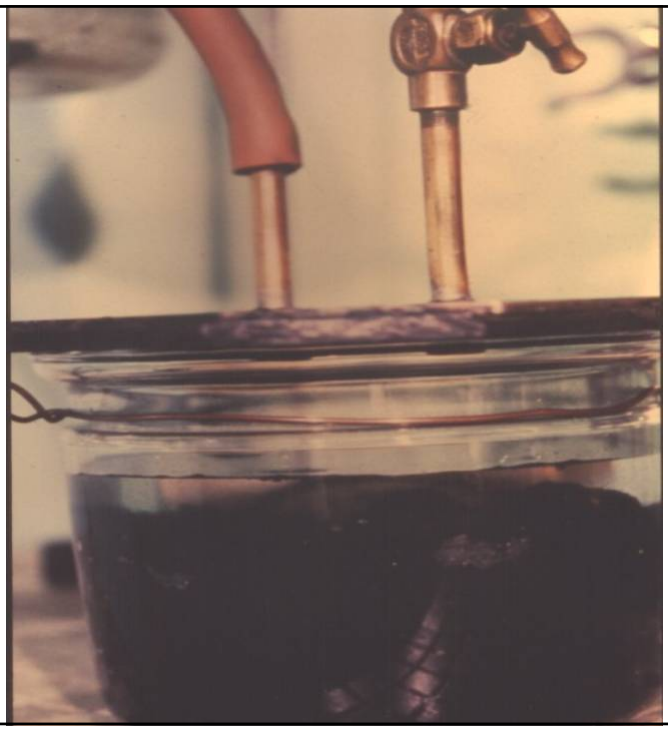



5
5.0
5.5
6.0
6.

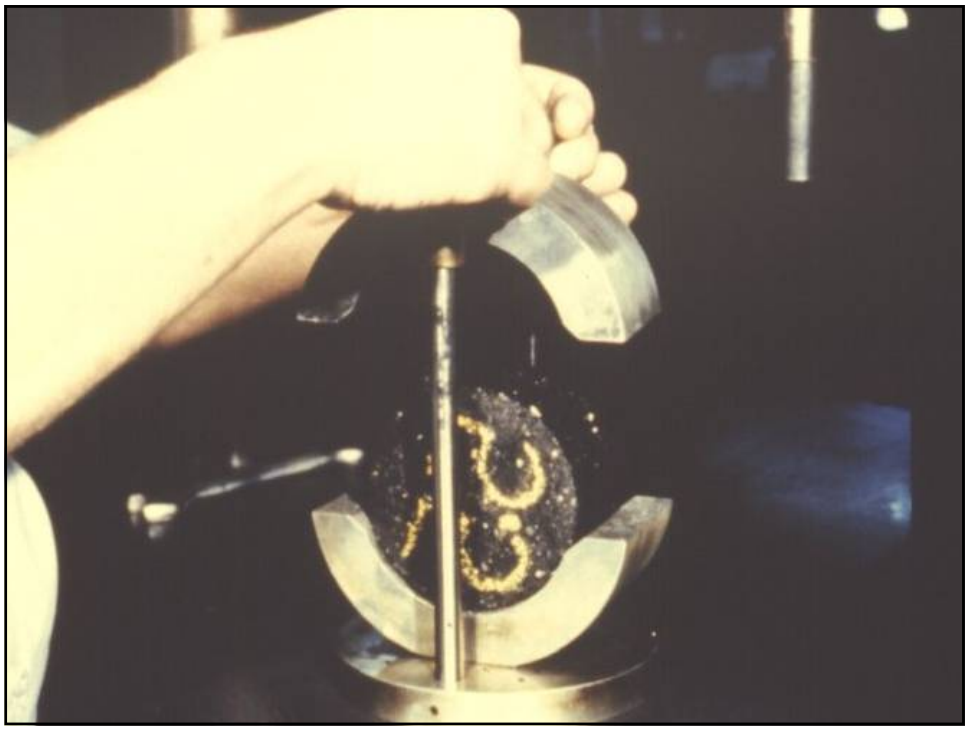


## MARSHALL MIX DESIGN TESTS

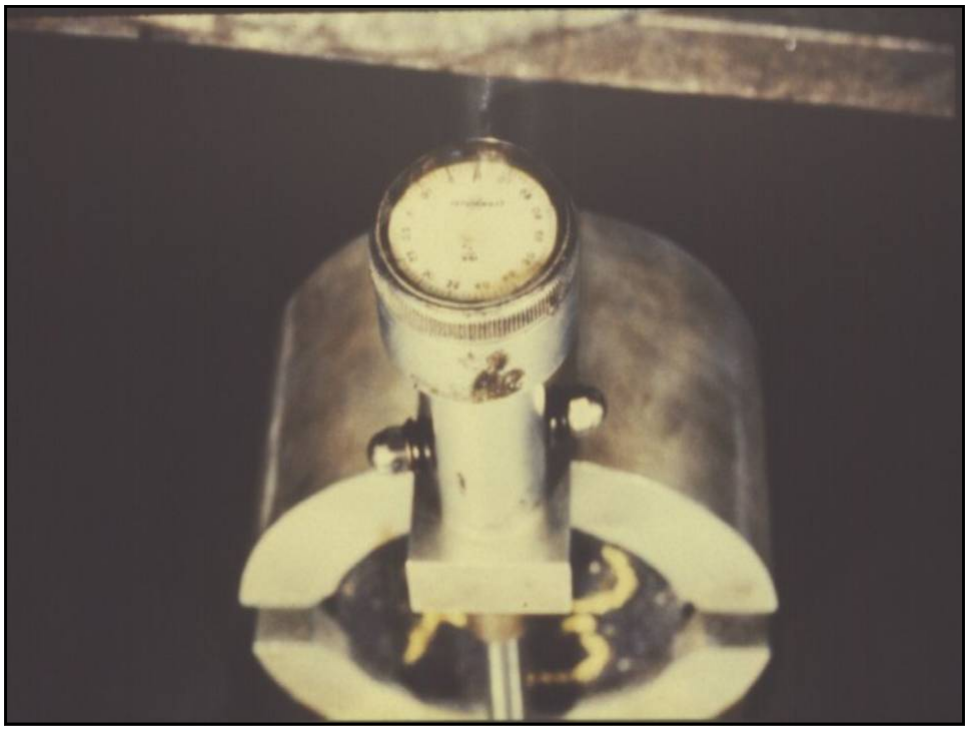
- Heights
  - Used to correct stability measurements
- Bulk specific gravity of compacted sample
- Maximum specific gravity of loose mix
- Stability and flow

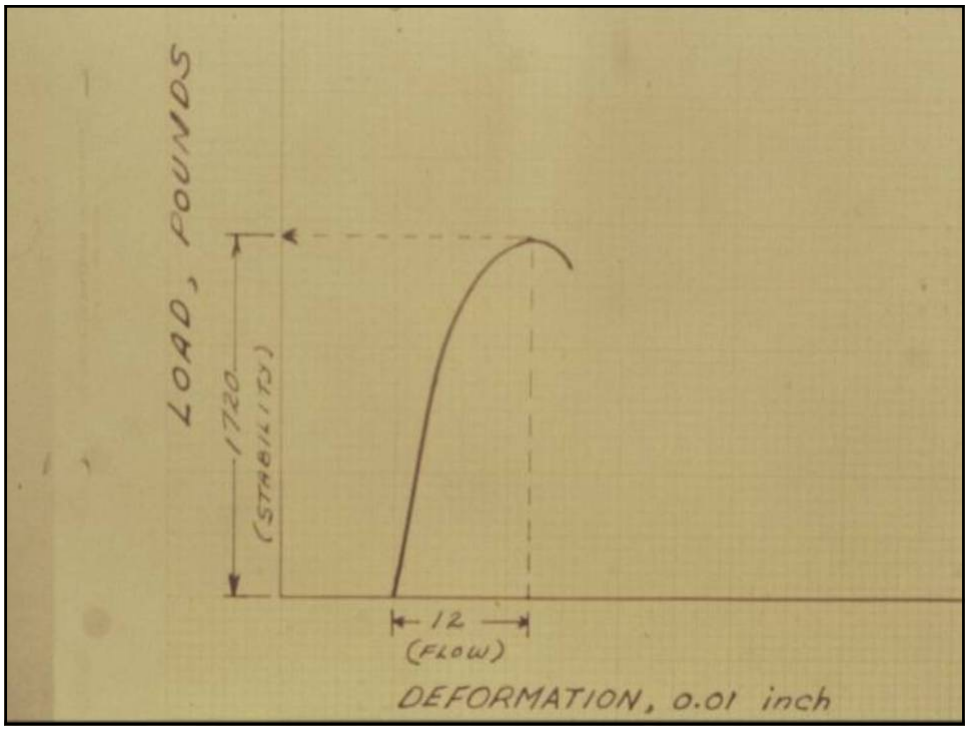


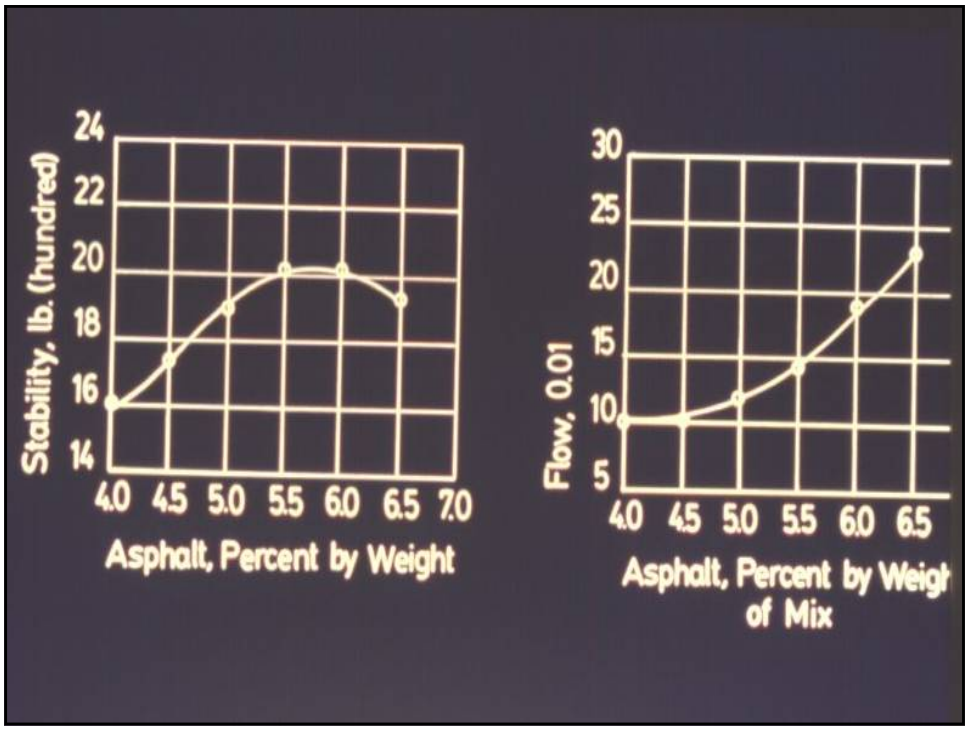

Mettler P5
T 0-1000g

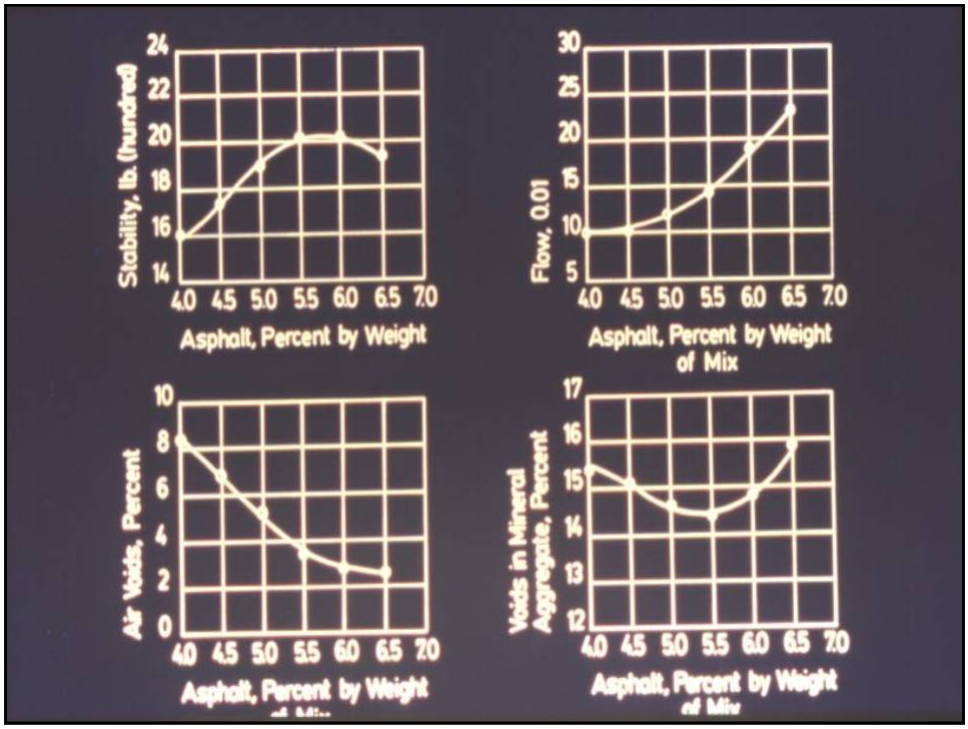


# MARSHALL STABILITY AND FLOW




LOAD, POUNDS
1720
(STABILITY)
12
(FLOW)
DEFORMATION, 0.01 inch

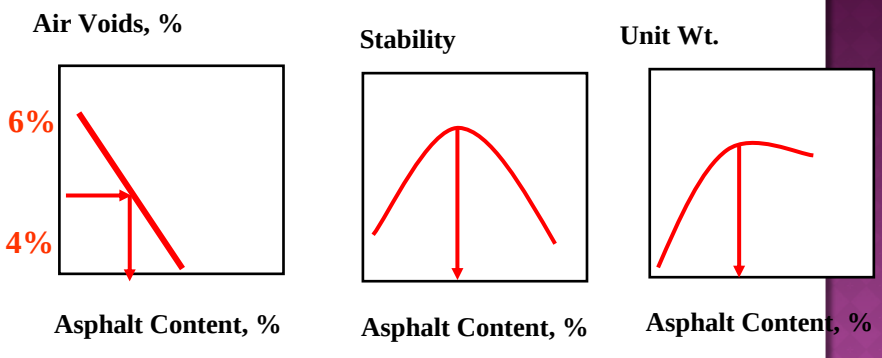

Stability, lb. (hundred)
24
22
20
18
16
14
4.0 4.5 5.0 5.5 6.0 6.5 7.0
Asphalt, Percent by Weight
Flow, 0.01
30
25
20
15
10
5
4.0 4.5 5.0 5.5 6.0 6.5
Asphalt, Percent by Weight of Mix


Stability, lb. (hundred)
24
22
20
18
16
14
4.0 4.5 5.0 5.5 6.0 6.5 7.0
Asphalt, Percent by Weight
Flow, 0.01
30
25
20
15
10
5
4.0 4.5 5.0 5.5 6.0 6.5 7.0
Asphalt, Percent by Weight of Mix
Air Voids, Percent
10
8
6
4
2
0
4.0 4.5 5.0 5.5 6.0 6.5 7.0
Asphalt, Percent by Weight
Voids in Mineral Aggregate, Percent
17
16
15
14
13
12
4.0 4.5 5.0 5.5 6.0 6.5 7.0
Asphalt, Percent by Weight

# Asphalt Content Criteria

- Highest Stability
- Highest Unit Weight
- Median Void Content

## MARSHALL DESIGN USE OF DATA ASPHALT INSTITUTE PROCEDURE

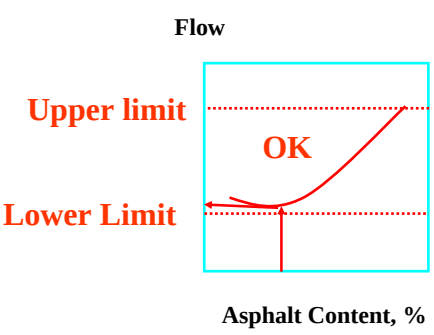


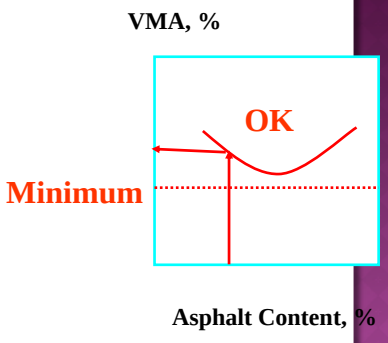

***Target optimum asphalt content = average***

## Summary

| Characteristic | % Asphalt |
|---|---|
| Highest Stability | 5.8 |
| Highest Unit Weight | 4.7 |
| Optimum Voids Content | 5.3 |

## MARSHALL DESIGN USE OF DATA
## ASPHALT INSTITUTE PROCEDURE

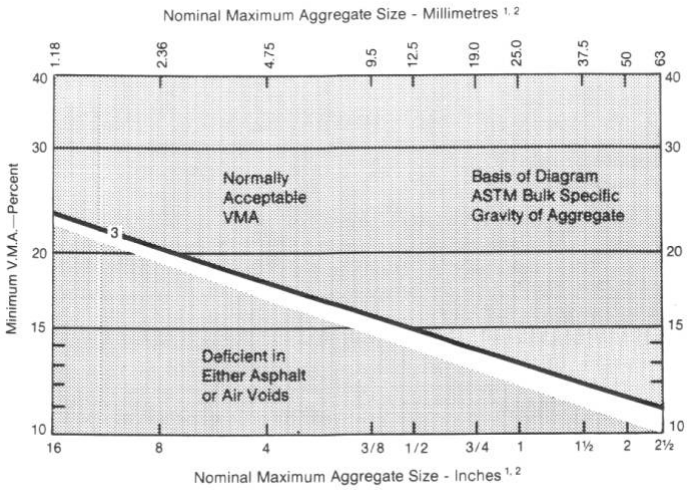



***Use target optimum asphalt content to check if these criteria are met***

| Characteristic | % Asphalt |
|---|---|
| Highest Stability | 5.8 |
| Highest Unit Weight | 4.7 |
| Optimum Voids Content | 5.3 |
| Total | 15.8 |
| | 3 |
| Average: | 5.3 % |

# MINIMUM VMA REQUIREMENTS



# MARSHALL DESIGN METHOD

- Advantages
  - Attention on voids, strength, durability
  - Inexpensive equipment
  - Easy to use in process control/acceptance
- Disadvantages
  - Impact method of compaction
  - Does not consider shear strength
  - Load perpendicular to compaction axis
  - Does not predict performance



# MARSHALL DESIGN CRITERIA

| | Light Traffic ESAL < $10^4$ | Medium Traffic $10^4$ < ESAL< $10^6$ | Heavy Traffic ESAL > $10^6$ |
|---|---|---|---|
| Compaction | 35 | 50 | 75 |
| Stability N (lb.) | 3336 (750) | 5338 (1200) | 8006 (1800) |
| Flow, 0.25 mm (0.1 in) | 8 to 18 | 8 to 16 | 8 to 14 |
| Air Voids, % | 3 to 5 | 3 to 5 | 3 to 5 |
| Voids in Mineral Agg. (VMA) | Varies with aggregate size | | |

| | Design Criteria (Heavy Traffic) | | Values at 5.3% Asphalt Content |
|---|---|---|---|
| | Min. | Max. | |
| Stability (lbs) | 1500 | – | 2080 |
| Flow (0.01") | 8 | 16 | 13 |
| % Air Voids | 3 | 5 | 4 |