



# “Comparative Study Of Regular Bitumen Mixture And Crumbrubber Modified Bitumen Mixture”

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## **Abstract:**

Crumb rubber modification has gained significant attention in the field of bituminous materials and asphalt mixtures. This abstract provides an overview of the key aspects related to regular bitumen (RM) and Crumb Rubber Modified Bituminous Mix (CRMB Mix). CRMB is a novel asphalt binder that incorporates recycled rubber particles, offering improved performance characteristics and sustainability. CR Mix, on the other hand, represents the use of CRMB in bitumen mixtures, which enhances their durability, resistance to cracking, and reduced environmental impact. This abstract discusses the composition, production methods, properties, benefits, and challenges associated with CRMB and CR Mix, highlighting their potential to revolutionize the road construction industry by promoting eco-friendly and high-performance pavement solutions.

## **I. INTRODUCTION**

India has a road network of over 6,215,797 kilometers in 2021, the second largest road network in the world. It has primarily flexible pavement design which constitutes more than 98% of the total road network. India being a very vast country has widely varying climates, terrains, construction materials and mixed traffic conditions both in terms of loads and volumes. Increased traffic factors such as heavier loads, higher traffic volume and higher tyre pressure demand higher performance pavements. So, to minimize the damage of pavement surface and increase durability of flexible pavement, the conventional bitumen needs to be improved. There are many modification processes and additives that are currently used in bitumen modifications such as styrene butadiene styrene (SBS), styrene-butadiene rubber (SBR), ethylene vinyl acetate (EVA) and crumb rubber modifier (CRM).

Crumb rubber is the term usually applied to recycled rubber from automotive and truck scrap tires. During the recycling process steel and fluff is removed leaving tire rubber with a granular consistency. Continued processing with a granulator and/or cracker mill, possibly with the aid of cryogenics or mechanical means, reduces the size of the particles. From physical and chemical interaction of crumb rubber with conventional bitumen Crumb Rubber Modified Bitumen (CRMB) is made. Its advantages are: Lower susceptibility to daily & seasonal temperature variations, higher resistance to deformation at elevated pavement temperature, better age

resistance properties, higher fatigue life of mixes, better adhesion between aggregate & binder. Prevention of cracking & reflective cracking, and overall improved performance in extreme climatic conditions & under heavy traffic con

## II. RESEARCH METHODOLOGY

### Marshall Stability Mix Design

Weight of the Aggregate (gm)	Sieve size (mm)
172	12.5
332	10
84	4.7
204	2.6
408	Filler
Total=1200gm	

Total weight of the aggregate + Filler material = 1200(gm)

➤ Bitumen content = 4.5%, 5%, 5.5% Bitumen content 4.5% =  $0.045 \times 1200 = 54\text{gm}$  Bitumen content 5% =  $0.050 \times 1200 = 60\text{gm}$  Bitumen content 5.5% =  $0.055 \times 1200 = 66\text{gm}$

➤ Crumb rubber content = 3%, 6%, 9%, 12%.

1) Crumb rubber content 3% =  $0.03 \times 1200 = 36\text{gm}$

2) Crumb rubber content 6% =  $0.06 \times 1200 = 72\text{gm}$

3) Crumb rubber content 9% =  $0.09 \times 1200 = 108\text{gm}$

4) Crumb rubber content 12% =  $0.12 \times 1200 = 144\text{gm}$  Crumb rubber content for 4.5% bitumen content = 552gm

Total Crumb rubber content for 4.5%, 5%, 5.5% bitumen content = 1656gm

Crumb rubber content	Bitumen content	No of specimen
3%	4.5%	1
	5%	1
	5.5%	1
6%	4.5%	1
	5%	1
	5.5%	1
9%	4.5%	1
	5%	1
	5.5%	1
12%	4.5%	1
	5%	1
	5.5%	1

Bitumen content	No of specimen
4.5%	1
5%	1
5.5%	1



Fig.1. Marshall stability Test Apparatus



Fig.2. Marshall stability Test Mold

**Apparatus Required:**

1. Marshall Stability testing machine (50 kN capacity)
2. Breaking head (specimen Mold holder)
3. Compaction Mold with collar and base plate
4. Hammer (4.5 kg, 457 mm drop height)
5. Water bath (maintained at 60°C)
6. Dial gauge (0.01 mm accuracy)
7. Oven
8. Balance (accuracy 0.1 gm)
9. Bitumen and aggregates

**Theory:**

The Marshall Stability test evaluates the resistance to plastic deformation of cylindrical bituminous specimens when loaded diametrically. Two key values are obtained:

Stability: Maximum load before failure (in kN or kg)

Flow value: Deformation corresponding to the maximum load (in mm)

**A. MATERIAL SELECTION & PREPARATION****1. Aggregates:**

Use well-graded coarse aggregate, fine aggregate, and mineral filler as per the specified gradation (e.g., DBM, BC).

Ensure aggregates are clean, dry, and free from dust and clay particles. Sieve analysis must be done to conform to desired grading envelope.

**2. Bitumen:**

Use standard paving-grade bitumen, generally VG-30 or as specified.

Check bitumen properties: penetration, softening point, ductility, etc., before mixing.

**B. PREPARATION OF BITUMINOUS MIXTURE****3. Heating Materials:**

Heat coarse and fine aggregates separately to 170–180°C in an oven. Heat bitumen to 150–160°C for fluidity.

Preheat compaction Molds and base plates to 150°C.

**4. Mixing:**

Mix the required quantity of heated aggregates and filler in a large metal pan or mechanical mixer. Add the calculated amount of hot bitumen at the selected bitumen content (e.g., 4.0%, 4.5%, 5.0%, 5.5%, 6.0% by weight of total mix).

Mix thoroughly to ensure uniform coating of aggregates, maintaining mixture temperature at  $\sim 155^{\circ}\text{C} \pm 5^{\circ}\text{C}$ .

**C. SPECIMEN PREPARATION (COMPACTION)****5. Weighing and Melding:**

Weigh approximately 1200–1300 gm of the hot mix (exact weight depends on desired height and specific gravity).

Place a filter paper at the bottom of the Mold.

Transfer the hot mix into the Mold with a collar on, and level it evenly without segregation.

**6. Compaction:**

Compact the specimen using a standard Marshall hammer (4.5 kg) with 75 blows on each face for dense bituminous mixtures (as per MoRTH standards).

The compaction should be done on a solid base (compaction pedestal).

After 75 blows, remove the collar, reverse the Mold, and apply 75 blows on the other face.

**D. SPECIMEN CURING AND CONDITIONING****7. Demoulding:**

Allow the compacted specimen to cool at room temperature (air-cooled for 1–2 hours). Remove the specimen from the Mold using a hydraulic extractor.

**8. Specimen Curing:**

Allow the specimen to rest for 12–24 hours before testing to ensure proper stiffness.

**9. Dimensional Checks:**

Measure the height and diameter of the specimen using a Vernier calliper. Weigh the air-dry specimen ( $W_1$ ).

**E. WATER BATH CONDITIONING****10. Immersion in Water Bath:**

Place the specimen in a water bath maintained at  $60^\circ\text{C} \pm 1^\circ\text{C}$ . Ensure complete immersion for 30–40 minutes (IS:1206 Part I).

**F. TESTING FOR STABILITY AND FLOW****11. Test Setup:**

Remove the specimen from the bath, wipe off surface water with a damp cloth. Place it between the upper and lower segments of the breaking head.

**12. Fixing in Loading Frame:**

Mount the breaking head in the Marshall Stability testing machine. Ensure proper centering so the load is applied diametrically.

**13. Application of Load:**

Start the machine; apply vertical compressive load at a constant rate of 50.8 mm/min. Monitor the proving ring/digital load cell to record the load.

**14. Flow Measurement:**

Attach a flow dial gauge (0.01 mm least count) with zero set before loading. Record the flow value in mm corresponding to the maximum load.

**15. Recording Stability:**

Note the maximum load (kN or kg) the specimen can resist before failure (cracking or bulging).

**G. REPEAT FOR ALL BITUMEN CONTENTS**

Conduct the test on minimum 3 specimens per bitumen content.

**III. RESULTS AND DISCUSSION****➤ Marshall Stability Test Results (With Out Crumb Rubber)**

Bitumen % = 4.5% (0% Crumb Rubber)

Cr %	Specimen	Stability (Kg)	Flow (Mm)	Bulk Density	Air Voids (%)	Vma (%)	Vfb (%)
0	1	850	3.7	2.28	5.3	15.6	65.7
	2	845	3.6	2.29	5.2	15.5	66.1
	3	855	3.8	2.27	5.4	15.7	65.3
	Avg	850	3.7	2.28	5.3	15.6	65.7

Bitumen % = 5.0% (0% Crumb Rubber)

Cr %	Specimen	Stability (Kg)	Flow (Mm)	Bulk Density	Air Voids (%)	Vma (%)	Vfb (%)
0	1	900	3.8	2.31	4.8	15.2	68.4
	2	895	3.9	2.32	4.7	15.1	68.8
	3	905	3.7	2.3	4.9	15.3	68.0
	Avg	900	3.8	2.31	4.8	15.2	68.4

Bitumen % = 5.5% (0% Crumb Rubber)

Cr %	Specimen	Stability (Kg)	Flow (Mm)	Bulk Density	Air Voids (%)	Vma (%)	Vfb (%)
0	1	875	4.0	2.33	4.4	14.9	70.5
	2	870	4.1	2.32	4.5	15.0	70.0
	3	880	3.9	2.34	4.3	14.8	71.0
	Avg	875	4.0	2.33	4.4	14.9	70.5

Marshall Stability Test Results (With Crumb Rubber)

Bitumen % = 4.5

CR %	Specimen	Stability (kg)	Flow (mm)	Bulk Density	Air Voids (%)	VMA (%)	VFB (%)
3	1	880	3.8	2.3	5.0	15.3	67.3
	2	860	3.9	2.31	4.9	15.1	68.2
	3	875	3.7	2.29	5.1	15.4	66.8
	Avg	872	3.8	2.3	5.0	15.3	67.4
6	1	910	4.0	2.28	5.2	15.5	66.4
	2	900	4.1	2.29	5.1	15.3	67.0
	3	905	3.9	2.3	5.0	15.2	67.2
	Avg	905	4.0	2.29	5.1	15.3	66.9
9	1	875	4.2	2.27	5.3	15.6	65.9
	2	860	4.1	2.26	5.4	15.7	65.6
	3	870	4.3	2.28	5.2	15.5	66.0
	Avg	868	4.2	2.27	5.3	15.6	65.8
12	1	830	4.5	2.25	5.5	15.8	65.2
	2	810	4.6	2.26	5.4	15.9	65.0
	3	820	4.4	2.24	5.6	16.0	64.9
	Avg	820	4.5	2.25	5.5	15.9	65.0

Bitumen % = 4.5%

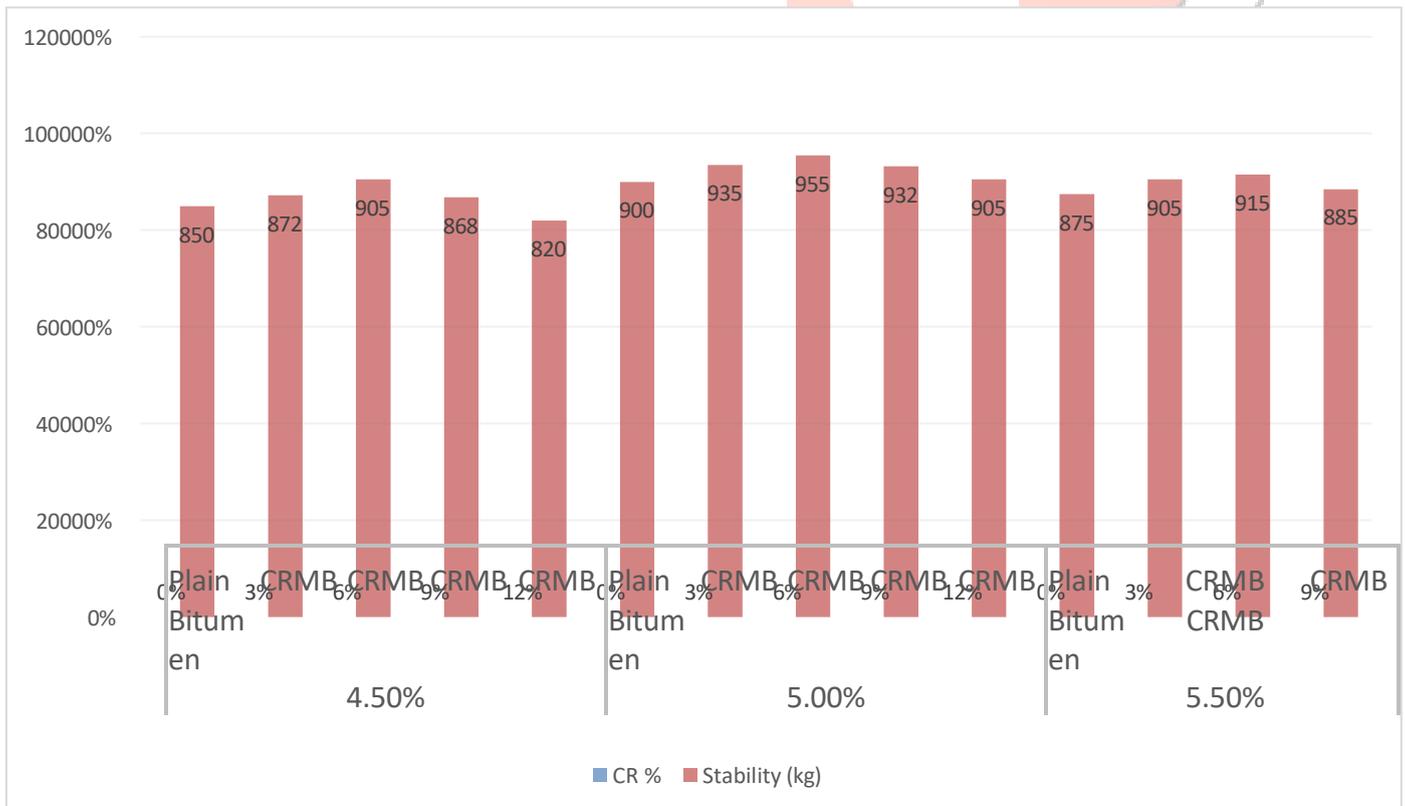
CR %	Specimen	Stability (kg)	Flow (mm)	Bulk Density	Air Voids (%)	VMA (%)	VFB (%)
3	1	940	3.9	2.33	4.6	15.0	69.3
	2	930	4.0	2.34	4.5	14.9	69.8
	3	935	3.8	2.32	4.7	15.1	68.9
	Avg	935	3.9	2.33	4.6	15.0	69.3
6	1	960	4.1	2.34	4.4	14.8	70.3
	2	950	4.0	2.33	4.5	14.9	69.8
	3	955	4.2	2.32	4.6	15.0	69.3
	Avg	955	4.1	2.33	4.5	14.9	69.8
9	1	940	4.3	2.31	4.7	15.1	68.9
	2	925	4.4	2.3	4.8	15.2	68.4

	3	930	4.2	2.32	4.6	15.0	69.3
	Avg	932	4.3	2.31	4.7	15.1	68.9
12	1	910	4.5	2.29	4.9	15.3	67.9
	2	900	4.6	2.28	5.0	15.4	67.5
	3	905	4.7	2.27	5.1	15.5	67.1
	Avg	905	4.6	2.28	5.0	15.4	67.5

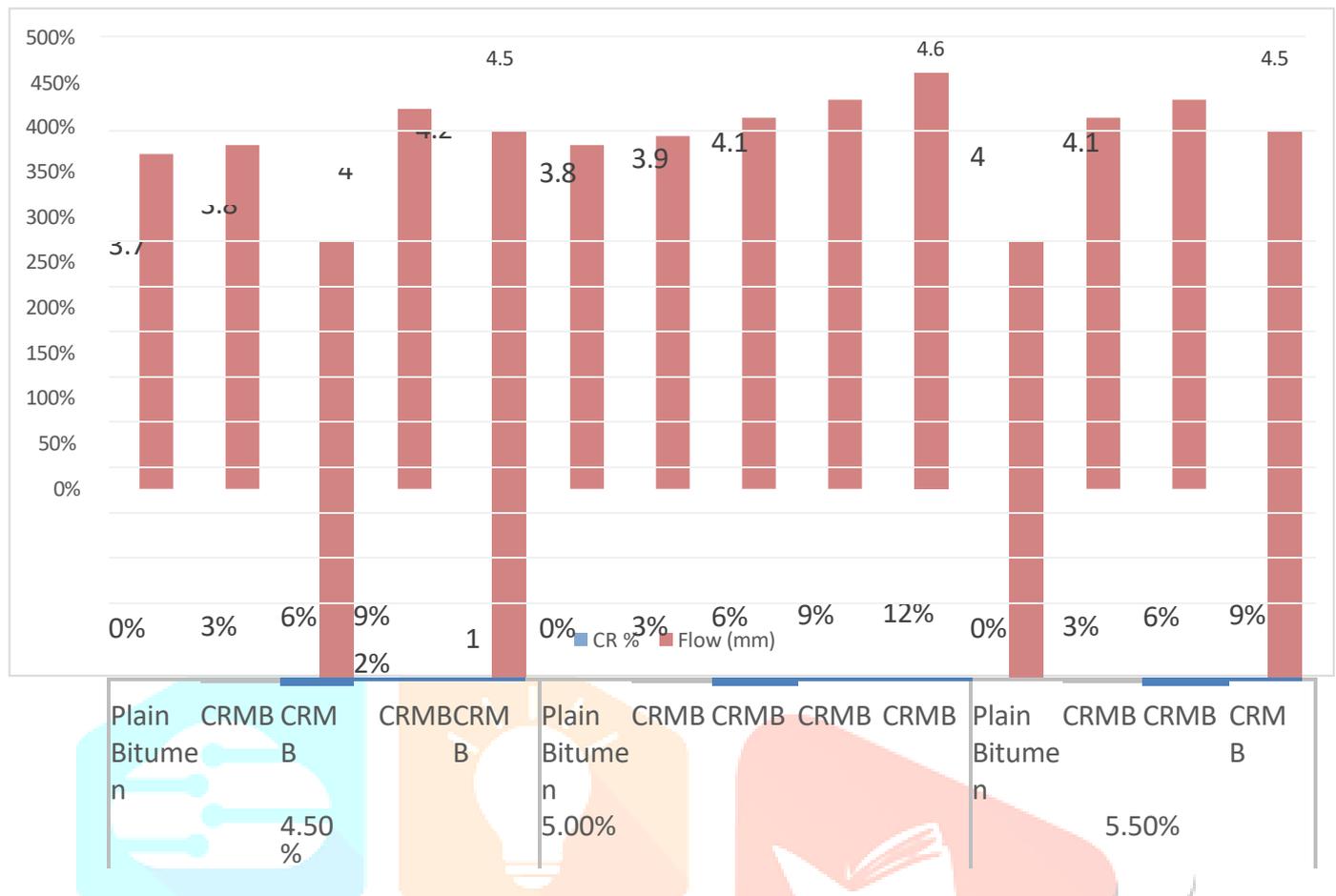
Bitumen % = 5.0%

CR %	Specimen	Stability (kg)	Flow (mm)	Bulk Density	Air Voids (%)	VMA (%)	VFB (%)
3	1	910	4.1	2.35	4.2	14.7	71.4
	2	900	4.2	2.36	4.1	14.6	71.9
	3	905	4.0	2.34	4.3	14.8	70.9
	Avg	905	4.1	2.35	4.2	14.7	71.4
6	1	920	4.3	2.34	4.3	14.8	70.9
	2	910	4.2	2.35	4.2	14.7	71.4
	3	915	4.4	2.33	4.4	14.9	70.4
	Avg	915	4.3	2.34	4.3	14.8	70.9
9	1	890	4.5	2.32	4.5	15.0	69.9
	2	880	4.6	2.3	4.6	15.1	69.5
	3	885	4.4	2.31	4.5	15.0	69.7
	Avg	885	4.5	2.31	4.5	15.0	69.7
12	1	850	4.7	2.29	4.7	15.2	68.9
	2	840	4.8	2.28	4.8	15.3	68.6
	3	845	4.6	2.27	4.9	15.4	68.2
	Avg	845	4.7	2.28	4.8	15.3	68.6

Bitumen % = 5.5%



Comparison Table: Plain Bitumen Mix vs Crumb Rubber Modified Bitumen Mix For Stability (kg)



Comparison Table: Plain Bitumen Mix vs Crumb Rubber Modified Bitumen Mix For Flow (mm)

#### IV. CONCLUSION

1. Crumb Rubber Modified Bitumen (CRMB) outperforms Plain Bitumen up to 6% CR in terms of stability and workability.
2. Beyond 6% CR, stability decreases and flow increases, showing diminishing structural performance.
3. Optimal Mix: 5.0% Bitumen + 6% Crumb Rubber = Maximum Stability (955 kg) and balanced flow (4.1 mm).

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