Experimental Analysis of Direct Carbon Dioxide (CO_2) Emissions from some of the Bitumen Types Normally used in India

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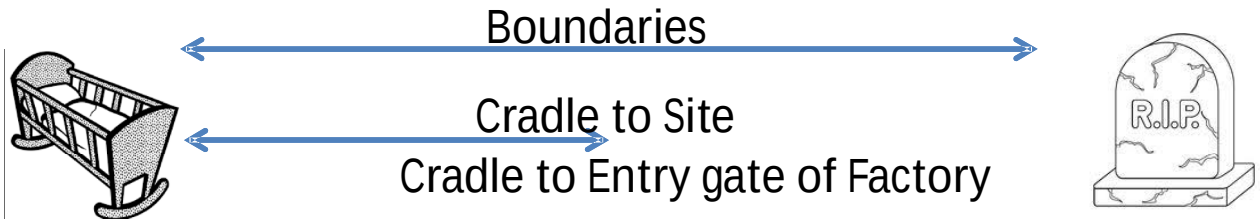
CO_2 Emission from Bitumen

Embodied Emission- Emission involved in Extraction, processing, distribution of an item

Direct Emission- Emission released at a point by that item



Extraction

Processing

Embodied

Heating Bitumen

Direct

Till now- Only straight run bitumen
-Only Embodied Emission

Hypothesis and Objective

Hypothesis:

- Bitumen emits CO_2 when heated for mixing with aggregate at site

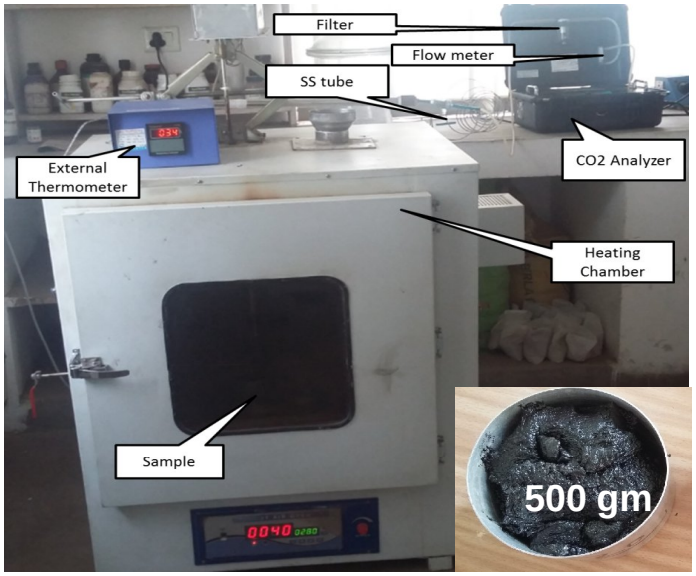
- Emission would differ based on bitumen types

- Warm mix technology is better than hot mix not only in terms of emission from fuel used but also in terms of direct CO_2 emission from bitumen

Objective:

Heat bitumen samples of various types up to their mixing temperature as per codes and record their CO_2 emission at every degree of temperature

The Experiment



Using Heating Chamber and NDIR based CO_2 Analyzer

Using Lime water

- Flow rate through analyzer is 0.47 liters / minute- light air condition at site as per Beaufort scale with the wind velocity of 2.25 km/hour
- NDIR Sensor resolution is 0.001%
- NDIR Sensor range is 0 to 20%
- Gas travel time from chamber to sensor is 47.25 seconds

Bitumen samples for the Experiment

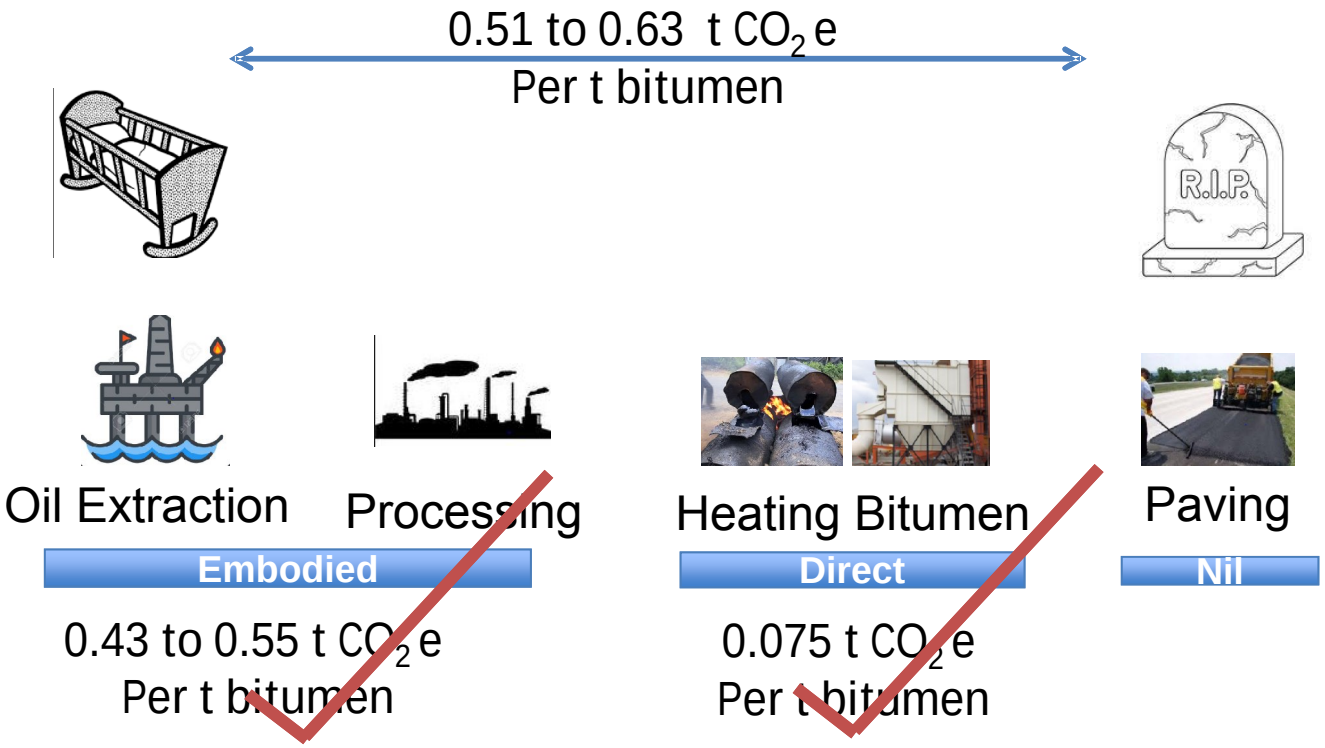
- Samples were collected from various road construction sites i.e. CRMB-60, PMB-40 from Ongole, CRMB-60 from Panipat, VG-30 & VG-40 from Hisar and Suratgarh. Supplied by IOCL Mathura and Mumbai.
- Sample quantity of 500 grams tested for each type
- More than 50 samples of various types were tested
- Physical properties tested to conform to IS 73-2013 on Paving Bitumen and IS I5462:2004 for modified bitumen

Test Procedure

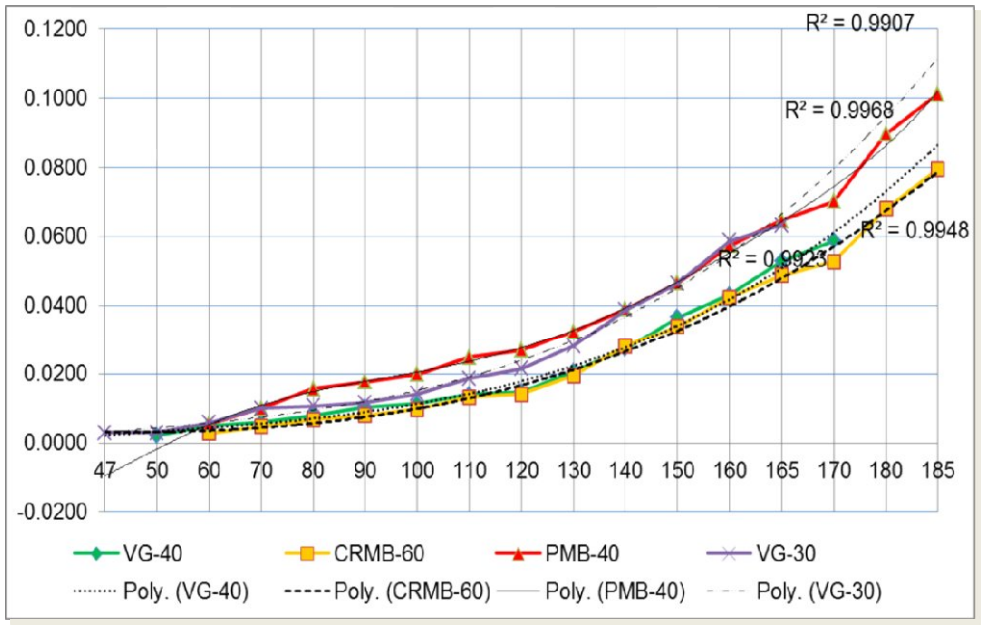
- Ambient CO_2 reading prior to every sampling- later deducted from actual reading of sample
- Temperature noted manually against time displayed in CO_2 analyzer
- Data recorded from softening to mixing point
- Emissions in % were converted to mg/l
- Taking account of sample weight, time and flow rate the emissions were converted to t CO_2 per tonne of bitumen

Findings

- Direct CO_2 emission from Bitumen exists- Heating up to mixing Temperature
- When combined with direct EF total is 14 to 18% more



Findings: Direct tCO_2 Emission per ton of different Types of Bitumen



PMB 40 at 185°C
0.1011 tCO_2 /t

CRMB 60 at 185°C
0.0795 tCO_2 /t

VG 30 at 165°C
0.0632 tCO_2 /t

VG 40 at 170°C
0.0587 tCO_2 /t

- VG 40 at 185°C would show value more than 0.08 t CO_2/t
- VG 30 at 185°C would show value around 0.11 t CO_2/t .

Analysis of Results

- Direct emission from PMB-40 for hot mix is highest at 0.1011 tCO_2/t bitumen.
- Its 1.3 times more than emission from CRMB-60; 1.6 times more than emission from VG-30 ; 1.7 times more than emission from VG-40
- Probably due to lower melting point (<150°C) of Plastomeric Thermoplastic polymers blended with VG-10 to produce PMB
- CRMB is lesser – probably due to high ignition point of rubber (260°C -316°C)
- Direct CO_2 emission at Hot Mix is 2.25 to 2.85 times more than Warm Mix
- CO_2 emission shows positive correlation with temperature (0.91 to 0.94)
- CO_2 emission is inversely related to Viscosity. There is a need for further research

Contribution to the road sector

- Emission factor considered for bitumen has been so far under estimated. Inclusion of direct emission factor for GHG assessment of road construction is a new milestone achieved

- Additional samplings have been conducted and the results have been incorporated in CHANGER 2.0.0. It is the Indianized version of Greenhouse gas calculator developed by IRF

- Intra pavement technology comparison in terms of GHG emission will also be possible viz. Within hot mix – use of VG or PMB or CRMB

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Temperature (°C)	Emission factor (tCo2/t bitumen)			
	VG-40	CRMB-60	PMB-40	VG-30
47	Na	Na	Na	0.0029
50	0.0021	Na	Na	0.0030
60	0.0047	0.0027	0.0055	0.0058
70	0.0060	0.0047	0.0100	0.0100
80	0.0080	0.0067	0.0156	0.0107
90	0.0104	0.0079	0.0177	0.0116
100	0.0113	0.0097	0.0199	0.0141
110	0.0140	0.0133	0.0249	0.0186
120	0.0147	0.0140	0.0268	0.0214
130	0.0207	0.0194	0.0324	0.0281
140	0.0272	0.0281	0.0391	0.0388
150	0.0366	0.0339	0.0467	0.0464
160	0.0432	0.0424	0.0575	0.0587
165	0.0528	0.0487	0.0646	0.0632
170	0.0587	0.0527	0.0702	Na
180	Na	0.0679	0.0896	Na
185	Na	0.0795	0.1011	Na
Note: 1 ton=2204.62 pound; Na=Not Applicable				