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Effect of Zycotherm on Mixing and Compaction Temperature of Hot Mix Asphalt

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Abstract*: *Now day's bitumen industry has been awake of energy saving and environmental benefits, the warm mix bitumen technologies keeping these two motives in vision, has come up with an idea of using warm mix bitumen technology which uses chemical additive. By using this technology we can significantly reduce the temperature of bituminous mix while mixing and compaction, when compared to conventional bituminous mixes. Due to this warm mix bitumen technology is gaining popularity. The warm bituminous mix, which is produced, laid and compacted in a temperature which is much lower than the conventional bitumen mixes. The warm bituminous mix is produced by mixing chemical additives to the conventional bituminous mixes to improve the pavement performance. In this study an attempt is made to compare the Marshall properties of conventional bituminous mix with Warm bituminous mix, which is produced with chemical additive Zycotherm, with an additive dosage rates of 0.1% to 0.3% by the weight of binder, the results of this study showed that the emissions are significantly reduced during mixing and compaction of warm bituminous mix. Laboratory study also concludes that stability and marshal properties were improved for the warm bituminous mix by addition of additive

***Keywords*: *Hot mix asphalt (HMA), warm Bituminous mix, Voids Filled Bitumen, Voids in Mineral Aggregates, Volume of Voids, Polystyrene, Specific Gravity, Bituminous Concrete, Marshal Stability*.**

I. INTRODUCTION

The Bituminous manufacturing unit always looks for a disciplined approach to save energy and decreasing the pollution, increasing energy expense and increased environmental alertness towards bituminous Mix gases, bituminous production unit has diverted attention towards probable benefits of Warm bituminous mixes. Warm bituminous mix is a rapidly developing new technic with prospective of modernizing the production of bituminous mix. Warm bituminous mix technic may authorize the mixing, and compaction of bitumen mixes at 20°C to 30°C lesser temperatures compared to hot bituminous mixes. Warm bituminous mix is manufactured by incorporating additives into bituminous mixtures to authorize the mixing and placement of the mix at temperatures well beneath the temperatures of conventional hot bituminous mixes

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II. SCOPE AND OBJECTIVES

- The To verify suitability of aggregate by conducting various tests
- To verify suitability of Bitumen by conducting various tests
- To evaluate optimal binder percentage using Marshall Method
- To find out Marshall design properties by varying Zycotherm content in optimal binder percentage (obtained using VG 30 grade bitumen by conventional method) at altered mixing and compaction temperatures
- To determine mixing and compaction Temperature for BC mix using Zycotherm and comparing the outcomes with conventional mix.
- To Compare Hot and Warm bituminous mix in the form of marshal stability test results.
- It is aimed to propose the optimum Zycotherm dosage based on laboratory tes

III. MATERIAL AND METHODOLOGY

A. Material

1. Aggregates

Aggregates used in this study consist of clean hard, strong, dense non porous pieces of crushed sand stone sourced from Ulwa village near Bhatkal.20mm, 10mm and stone dust are used for design, all aggregates are sieved to the appropriate size according to different tests as per BIS, IS2386 (part I, III, IV) and selected gradation for mix is as per reference of MORT&H. section 507(for 19mm nominal size). The aggregate properties & aggregate gradation are shown in table 1 &table no.2 respectively

2. Aggregate Gradation

Bituminous concrete mix 0f grading-11 was chosen as per M0RT&H (V Revision) specification Table-500-1. Table 5.2 indicates the specification of bituminous concrete mixes for grade-11. The specification aggregate gradation shows the requirement of minimum coarser material and maximum finer materials which enable the BC layer to bear the load on the pavement which gives smooth riding on the pavement surface

Table No. 1 Basic Properties of Aggregate

SL No	Aggregate propertis	Test results	The Requirement By MORT&H V Revision
1	Impact value, %	17.36%	Max 24%
2	Flakiness and Elongation Index	24.08%	Max 35%
3	Water Absorption,%	0.44	Max 2%
4	Specific Gravity	2.888	
5	Loss Angeles Abrasion value	18.24%	Max 30%
6	Stripping value test	99%	>98 %

Table no.2 Adopted gradation for BC grade 2 mix

Sieve Size (mm)	Adopted Mid Gradation	% Weight Retained
19- 13.2	100	*0*
13.2-9.5	89.5	*10.5*
9.5-4.75	79	*21*
4.75-2.36	62	*38*
2.36-1.18	50	*50*
1.18-0.6	41	*59*
0.6-0.3	32	*68*
0.3-0.15	23	*77*
0.15-0.075	16	*84*
0.075	7	*93*
<0.075	0	*100*

3. Bitumen

Bitumen is defined as viscous liquid mainly consists of hydrocarbons and its derivatives and which is soluble in carbon trichloroethylene and is significantly non-volatile and softens steadily when heated. Bitumen acts as mail binding material in the mix design.

The various properties of bitumen are also checked with respect to its temperature susceptibility, viscosity, elasticity, ductility, flash, and fire. In the present study, VG-30 Grade bitumen is used and All test were performed as per MORT&H 5th revision. The bitumen properties shown in table no.3

Table no.3 Basic Properties Bitumen

s.no	Properties of Bitumen	Test results	Requirements as per IS 73 2013
1	Specific gravity	1.036	> 1.00
2	Penetration, 0.1mm	57	> 45 mm
3	Softening Point, °C	79.2	> 47°C
4	Ductility, Cm	>100	> 40 cm
5	Kinematic Viscosity @135°C, cSt	353.16	> 300
6	Absolute viscosity	3300	2400-3600

4. Properties of Zycotherm additives.

Is a warm bituminous mix chemical developed by Zydex industries Gujarat? It free from odor , this warm bituminous mix additive which has been developed to provide significantly enhanced benefits over current Warm mix additives technologies, by offering lower mixing and compaction temperatures, while concurrently enhancing moisture resistance of pavements by serving as an anti-strip

4.1 Advantages of Zcotherm

- Improves coating and compaction
- Eliminates striping and odor
- Excellent bond strength
- 100% waterproofing
- 100% coating for 100% stress transfer

B. METHODOLOGY

1. Marshal Stability test:

Marshall Test provides the performance extrapolation measures for marshal method of mix design .stability measures indicates the maximum load supported by the test specimen.

2.Preparation of test specimen:

The coarse aggregate, fine aggregate and filler material were proportioned as per desired percentages, so that final mix after blending has the gradation with in specification limit. After that approximately 1200gm of aggregates along with filler are taken and heated to a Tempe of 150°C to 160°C. Bitumen also heated to a Tempe of 140°C to 155°C and the essential quantity of first trail percentage of bitumen (say 4.75 %) is mixed with heated aggregate and thoroughly blended using mechanical mixture or manually. The mixing is continued till 165°C, when temperature reaches 150°C the heated sample is transferred in a mold and compacted by rammer with 75 blows on either side .Three specimens' for each trial bitumen content are prepared by varying the bitumen content at range of 0.25%.

3. Testing of specimen:

Density and Voids analysis:

The theoretical specific gravity (Gt) is calculated separately by knowing percentage by weight of material and specific gravity of each material.

Soon after weight in air and water, average dimensions of specimens are noted, and the bulk density value of the specimen Gb is determined Thereafter marshal parameters are determined.

3.1 Determination of stability, flow, Optimum bitumen content

The specimens to be tested are kept immersed in water bath maintained at 60°C for 30 to 40 minutes. After that specimens are taken out and placed in the marshal testing machine and stability and flow value are noted

3.2 Determination of optimum binder content

Following graphs are plotted with values of bitumen content against the values of :

1. Density Gb ,
2. Marshall stability,
3. Voids in total mix
4. Flow value

5 Voids filled with bitumen

From above graphs the optimum binder content of the mix is determined. The values of flow and VFB are found from the graphs, corresponding to bitumen content. All the design values of Marshall Stability, flow, voids and VFB are checked at the optimum bitumen content, and compared with specified design requirements.

In this study, bituminous concrete has been designed for 19 mm nominal size of aggregate and VG30 (60/70) grade of Bitumen. Marshall Mix design method is adopted and marshal specimens are casted for varying bitumen contents (4.75 to 5.75) for Hot bituminous mix to determine Optimum Bitumen percentage, With obtained optimum bitumen content, marshal molds a casted Warm bituminous mix with different percentage of Zycotherm say (0.1%,0.2%,0.3%)at mix temperatures of 120ºC, 130ºC , 140ºC and 150ºC and compacted at temperatures of 70ºC, 80ºC, 90ºC and 100ºC and tested for volumetric properties, Marshall Stability and Flow value as per MORTH 2013 Clause 505.3.1 Specifications. Performance of Warm bituminous mix for BC-1 grade has been evaluated by conducting various tests on arshall

IV. TEST RESULTS ANALYSIS

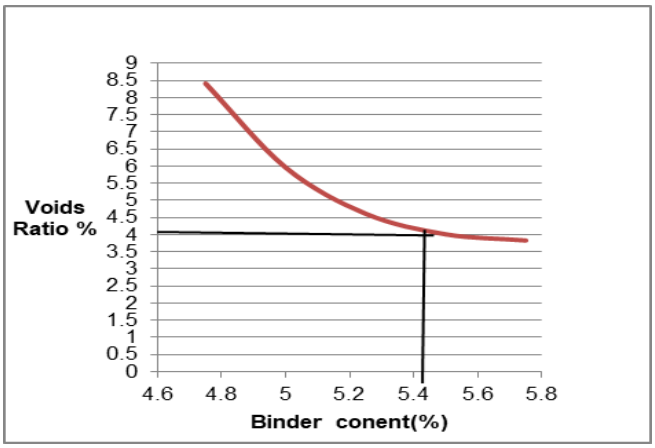
4.1 DETERMINATION OF OBTIMUM BINDER CONTENT BY MARSHAL METHOD (FOR MIX WITHOUT ZYCOTHERM ADDITIVE)

TABLE NO. 4 DENSITY, STABILITY & VOIDS ANALYSIS FOR VG30 GRADE BITUMEN

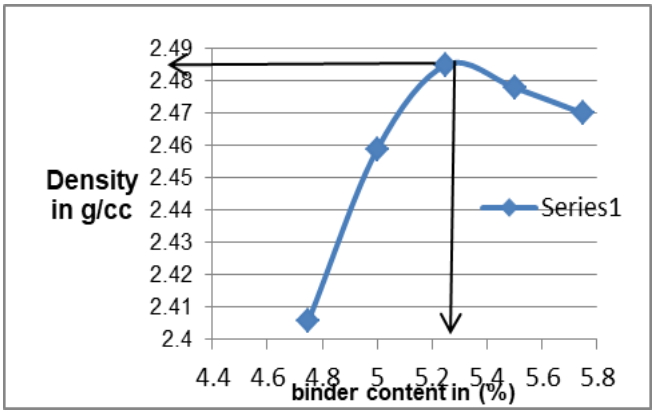
Sl. no..	Bitumen content %	AVG bulk Density (Gb)	Theoretical Density (Gt)	Vv in %	Vb in %	VMA in %	VFB mix in %	AVG Stability in KN	Average Flow in mm
1.	4.75	2.406	2.627	8.41	11.03	19.44	56.74	12.79	2.2
2.	5.00	2.459	2.616	5.96	11.85	17.81	66.52	13.06	2.9
3.	5.25	2.485	2.602	4.61	12.59	17.20	73.22	13.79	3.7
4.	5.50	2.478	2.595	4.51	13.16	17.66	74.49	14.29	4.0
5	5.75	2.470	2.585	3.83	13.80	17.63	78.28	12.89	4.4

4.2 Mix design graphS

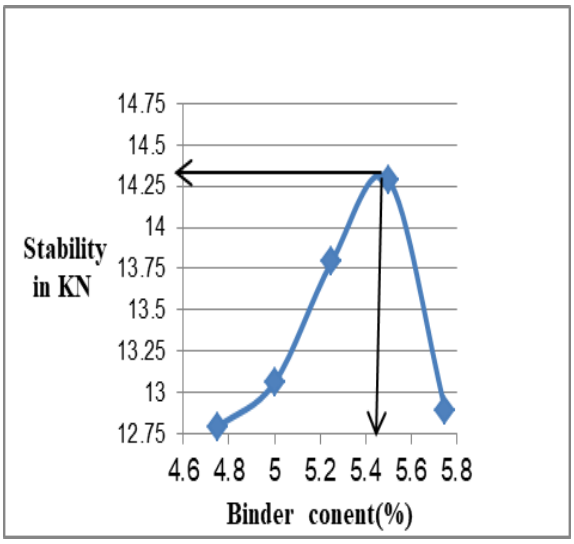
a) Air voids v/s Binder content



b) Density v/s bitumen content



c) Stability v/s bitumen content



From graphs Optimum Bitumen Content is

OBC = (5.23+5.42+5.42)/3 = 5.35 %

From analysis of bituminous concrete (without zycotherm additive) the observed OBC is 5.35 %, same binder content will be considered to analyze effect of zycotherm over the production and compaction temperature of bituminous mix ,for normal mixes usually 150 to 160 0c temperature *will be* adopted while production and mix will be compacted at 90 to 140 0c in site location.

4.3 Conformity test on marshal mix design at obc (5.35%)

Table no.5 Conformity test on marshal mix

Table no.5 Marshal test values L .No.	Design properties	Obtained value	MORT &H Limits Table no.500-11
1	Air voids in %	4.40%	3 to 5 %
2	Voids in Mineral Aggregates (VMA)	13.80%	12 % min
3	Voids filled by Bitumen VFB	69%	65 to 75 %
4	Bulk Density	2.51 gm/cc	
5	Stability	11.60 KN	Min 9.0 KN
6	Flow	3.8 mm	2 to 4 mm

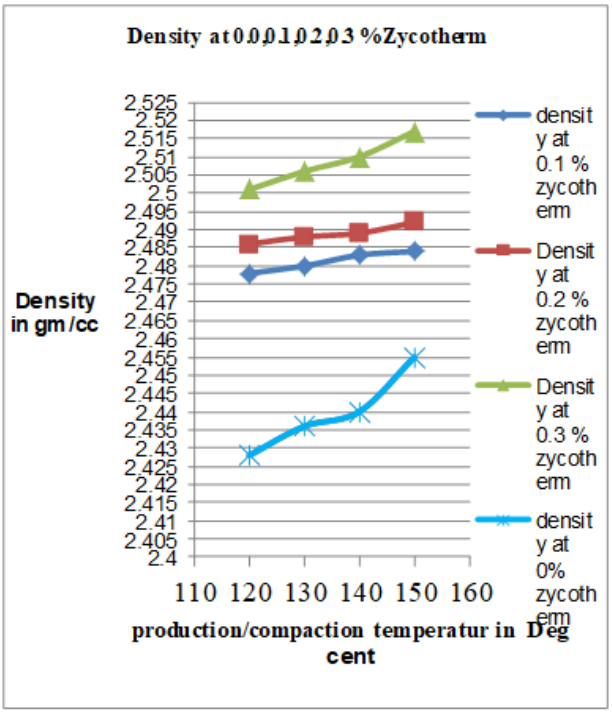
4.4 Analysis of effect of zycotherm on mixing andcompaction temperatures of bituminous concrete

Then by use of zycotherm additive we are analyzing at what reduced temperature we will get the bituminous mix which will fulfill all specification requirements. For this analysis we are taken three different percentages of zycotherm additives by the weight of binder content OBC (say 0.1%, 0.2%, 0.3%) which has obtained during the mix design of bituminous concrete without additive and obtained binder content is 5.35%

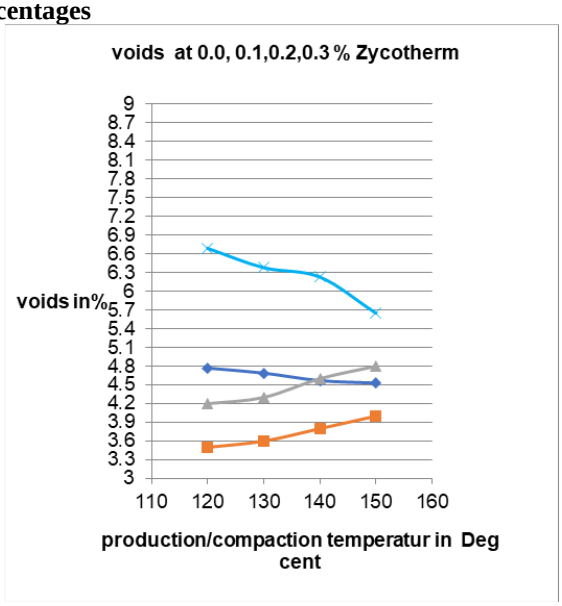
Table no.6 summary of marshal stability test results with zycotherm

% of Zycotherm	Production temp °C	Compaction Temp °C	Bulk density	Voids ratio	VMA	VFB	Stability in KN	Flow in mm
0	120	70	2.428	6.69	19.23	65.22	9.5	2
0	130	80	2.436	6.38	18.96	66.35	10	2.2
0	140	90	2.44	6.23	18.83	66.93	11.24	3
0	150	100	2.455	5.65	18.33	69.17	10.52	3.5
0.1	120	70	2.478	4.77	17.56	72.86	10.61	3
0.1	130	80	2.48	4.69	17.5	73.2	11.61	3.2
0.1	140	90	2.483	4.57	17.4	73.71	13.74	3.3
0.1	150	100	2.484	4.53	17.36	73.88	12.42	3.5
0.2	120	70	2.486	4.46	17.3	74.22	11.32	3.5
0.2	130	80	2.488	4.38	17.23	74.57	12.03	3.6
0.2	140	90	2.489	4.34	17.2	74.75	15.7	3.8
0.2	150	100	2.492	4.23	17.1	75.27	14.26	4
0.3	120	70	2.501	3.88	16.8	76.89	7.57	4.2
0.3	130	80	2.506	3.69	16.63	77.82	9.85	4.3
0.3	140	90	2.51	3.54	16.5	78.57	10.77	4.6
0.3	150	100	2.517	3.27	16.26	79.92	9.98	4.8

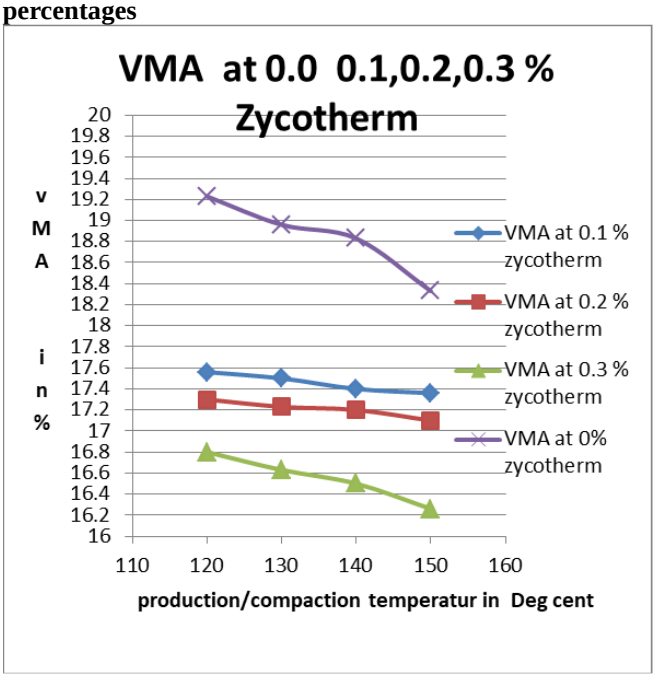
4.5 Comparison graphs of densities at different zycotherm percentages



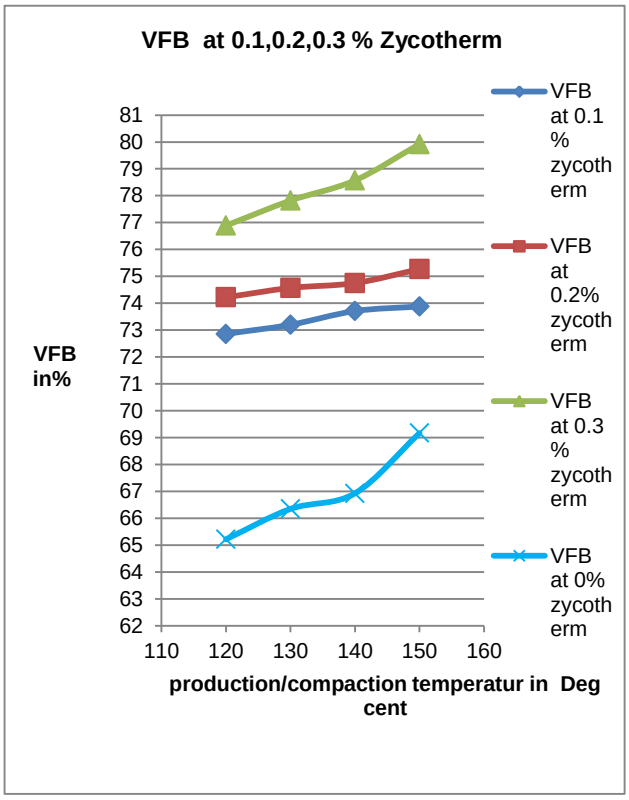
4.6 comparison graphs of voids at different zycotherm percentages



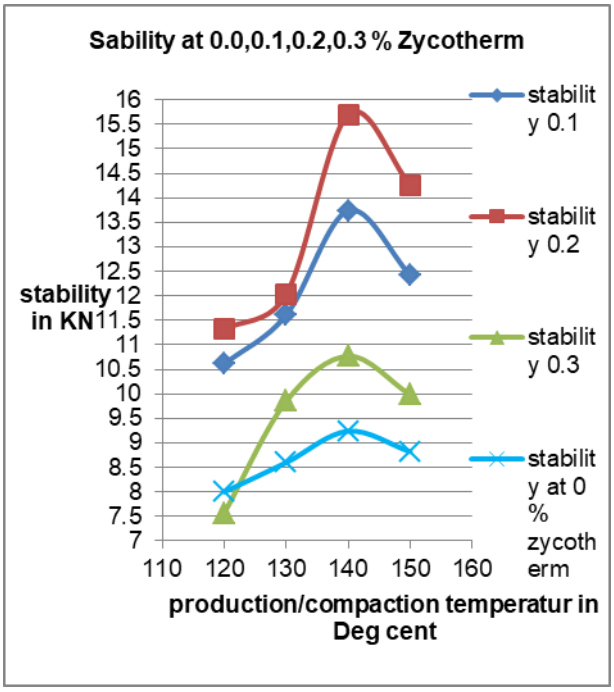
4.7 Comparison graphs of VMA at different zycotherm percentages



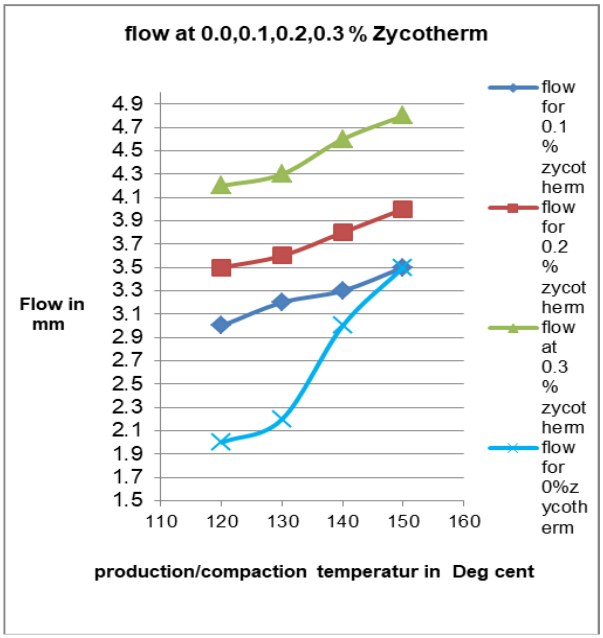
4.8 Comparison graphs of VFB at different zycotherm percentages



4.9 comparison graphs of Stability at different zycotherm percentages



4.10 comparison graphs of flow at different zycotherm percentages



V. CONCLUSION

This experiment was done by the aim to investigate the effect of using Zycotherm on mixing temperature and compaction temperature of bituminous mix

1.By the addition of zycotherm to the mix we can lower the bituminous concrete Mixing Temperature by 20°c and mix can be compacted at lower compaction temperature, at present study stability value and Marshal Properties of warm bituminous mix specimens prepared at 140 °C & compacted at 90°C, were improved by the use of Zycotherm.

2. Due to reduction of bituminous Mix production and compaction temperatures significant amount of production and compaction Cost can be saved.

3. The Density and flow value of mix has been increased as compared to conventional mix with addition Zycotherm. Indicates better compaction.

4..Zycotherm also reduces the odour of bitumen mix which can be decipherable at time of casting of mold.

From present study, bituminous concrete mix produced using Zycotherm at 140°C with Zycotherm dosage of 0.2%, exhibited worthy results, the Warm bituminous mix with 0.2% of Zycotherm is recommended to use in practice

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