Comparing evaluation of compacting capability of foamed bitumen asphalt mixes

Zoltan Puchard[1, a], Agnes Gorgenyi[1, b]

[1] *Technology Department, Colas Hungaria Zrt., Budapest, Hungary*

[a] zoltan.puchard@colas.hu
[b] agnes.vinczenegorgenyi@colas.hu

Digital Object Identifier (DOI): dx.doi.org/10.14311/EE.2016.176

ABSTRACT

COLAS Group in Hungary considers the use of low temperature asphalts as a high priority innovation task.
Since 2008 we have been dealing with LT asphalts. First we made LT asphalts with additives later we changed for foamed bitumen. Between 2012 and 2014, COLAS Group equipped its asphalt mixers with units from different manufacturers, capable of producing foamed bitumen, at four COLAS Group mixing plants in Hungary. In addition, the central laboratory of COLAS Hungária Zrt. also has a foaming device for laboratory use.
Testing the compacting capability properties of foamed bituminous mixtures is deemed to be of prime importance for us.
The compacting of asphalt mixtures containing different sorts (normal and modified) of bitumen manufactured using laboratory-produced foamed and normal bitumen has been tested on test specimens produced using gyrator and Marshall compactor. At the mixing plant, the compacting capability of asphalt mixtures manufactured using the four different foaming kits has been determined for test specimens produced using Marshall compactor, and the results have been compared reference asphalt test specimens.
Each asphalt mixture manufactured using four different foaming kits has been built into a test section. At these sections, the compacting capability of foamed bitumen asphalt mixtures have also be studied, and compared with reference asphalt mixes.
The presentation give a summary of the evaluation of results from laboratory tests and the experiences regarding asphalt productions and test sections produced with four different foaming kits.

Keywords: Asphalt, Compatibility, Energy saving, Foam, Gyratory

1. INTRODUCTION

It is a high priority on the innovation agenda of COLAS Group Hungary to promote the application of low temperature asphalt products in Hungarian road construction. COLAS Group Hungary has dealt with LT asphalt mixes since 2008. Between 2008-2010, we constructed several road sections using the fatty acid amide additive produced by COLAS Ireland. These test sections brought positive results, nevertheless, despite the nearly 30 % energy saving the relatively higher acquisition cost of the additives makes the price of LT asphalt mix in Hungary higher than that of normal asphalt mixes [1].
In 2012, COLAS Group Hungary installed a foaming kit on the Ammann UNIGLOBE 240 mixing plant (batch plant, stationair) located in the vicinity of Budapest (Dunaharaszti). The foaming kit is Swiss production.
In 2013, we installed a foaming kit produced in Germany in our Benninghoven TBA 180 U mixing plant (batch plant, fixed installation) in Felsőzsolca, Northeast Hungary.
In 2014, we installed Colas foaming kits in our Benninghoven TBU 160 mixing plant (batch plant, fixed installation) in Táplánypuszta, West Hungary and Benninghoven TBA 240 U mixing plant (batch plant) that currently is in operation at a motorway project in the Great Plain.
We laid several trial sections after the installation of the first foaming kit in 2012.
During the trial operations, we built in low temperature asphalt in Budapest, near our mixing plant, while we laid the asphalt that was produced at normal temperature after 2-2.5 hours of transport. The asphalt mixes produced were wearing and binder course mixes of different particle sizes designed for various traffic loads. We used normal 50/70 and hard modified 10/40-65 bitumen to produce the mixes. All mixes contained 10-20 % of RA. We dosed 2.5 % water in proportion to the total bitumen amount for foaming in the asphalt mixes. We applied 29 s wet mixing time for all asphalt mixes. We had not problems with foaming bitumen even in the case of hard modified bitumen. The composition of the asphalt mixes produced satisfied the factory production control requirements. The compaction and pavement void values of foamed bitumen asphalt courses satisfied the requirements for WMA courses. When working with foamed bitumen LT asphalt mixes, we obtained a temperature reduction of 50-70 ºC in the case of aggregates and that of 35-40 ºC in the case of the finished asphalt mix compared to the conventional production temperatures. When working with foamed bitumen, asphalt mixtures produced at normal temperature can be transported over distances of about 200 km from the asphalt mixing plant without changes in the quality of the asphalt mixture [2].
We compared the compactability of foamed bitumen mixtures produced with four different foaming kits. We produced Marshall specimens at various compaction temperatures, tested the bulk densities of the specimens, then represented the bulk densities subject to the compaction temperature. We established that the better compactability of foamed bitumen asphalt mixes is independent of the type of the foaming kit. It works for all types of foaming kits [3].

2. PLANNING THE LABORATORY TESTS

The tests of the asphalt mixes produced with the various foaming kits at the mixing plant showed a relatively large variance of Marshall bulk density values, therefore, we conducted a laboratory test series with Marshall and gyratory compaction. We presumed that in laboratory conditions the temperature values applied during asphalt mixing and the production of sample specimen can be kept more exactly than in the case of samples taken at the mixing plant and delivered to the laboratory to make laboratory samples from. We used a laboratory foaming equipment to produce foamed bitumen for the laboratory test series, illustrated in Figure 1. Foamed bitumen was applied directly to the heated aggregate mix, then we mixed it an prepared the samples immediately after mixing.

Figure1: Laboratory foaming kit

We tested four different types of asphalt mixes with a maxium particle sizes of 11 and 22 mm. All four asphalt mixes can be used in heavy traffic roads as wearing or binder courses. We used normal 50/70 as well as modified 25/55-65 and 10/40-65 type bitumen for the asphalt mixes. We used 2.5 % water to foam both normal and modified bitumen. Table 1 presents the types of the asphalt mixes tested.

Table 1: Asphalt mixes included in the test

No	Asphalt type	Used bitumen	Water content in foamed bitumen, %
1.	AC 11 wearing (F)	50/70	2,5
2.	AC 11 wearing (mF)	25/55-65	2,5
3.	AC 22 binder (F)	50/70	2,5
4.	AC 22 binder (mNM)	10/40-65	2,5

We produced the asphalt mixes using a Marshall compaction machine according to EN 12697-30 [4] and a gyratory compactor according to EN 12697-31 [5]. We changed the compaction temperature in 10 ºC steps between 150-100 ºC in the case of 50/70 type bitumen, between 160-110 ºC in the case of 25/55-65 type modified bitumen and between 170-120 ºC in the case of 20/40-65 type modified bitumen. We recorded the compaction curves according to EN 12697-10 [6]. We applied 2x15, 2x35 and 2x100 blows to produce the samples using the Marshall compaction method. We monitored the compaction of samples according to the bulk density change specified in EN 12697-6 B method [7]. We applied 120 cycles to produce the samples using the gyratory method and monitored compaction by checking the voids content.
As a reference, we also produced the mixes listed in Table 1 with normal (non-foamed) bitumen and tested them the same way as the mixes made with foamed bitumen.

3. TEST RESULTS

We represented the test results in two ways. In the first case, we recorded the compaction curves for each temperature in view of the number of blows applied during Marshall compaction and in view of cycles made during gyratory compaction. As an example, in Figure 2 and 3 we present the compaction curves of AC 11 wearing (mF) 25/55-65 mixes made from foamed and normal bitumen using Marshall compaction. In Figure 4 and 5 we present the compaction curves of AC 22 binder (F) 50/70 mixes made from foamed and normal bitumen using gyratory compaction.
The figures show that the mixes with foamed bitumen have wider compaction temperature bands than mixes with normal bitumen for both Marshall and gyratory compaction.

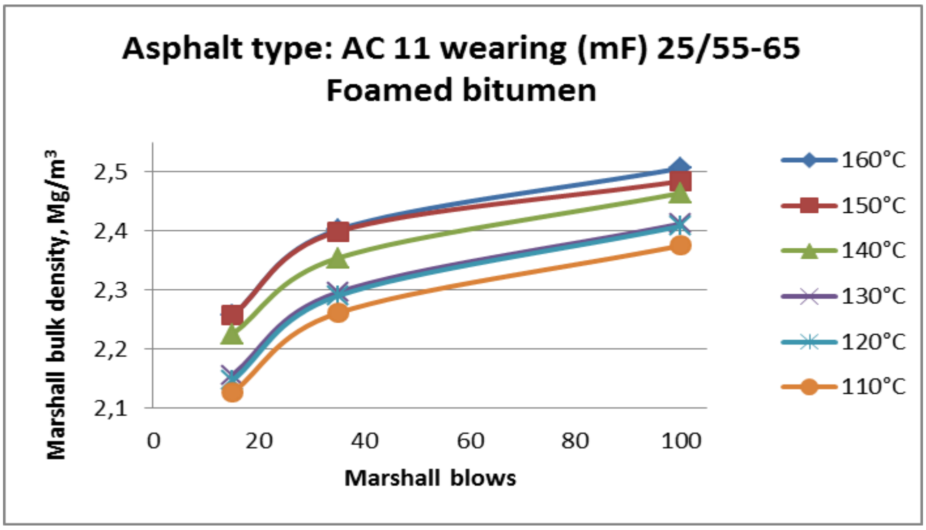

Figure 2: Compaction temperatures at Marshall compaction

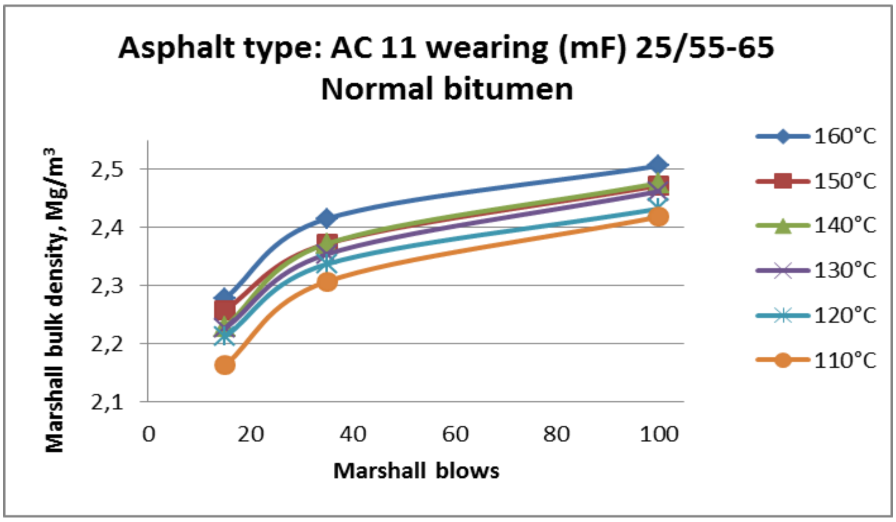

Figure 3: Compaction temperatures at Marshall compaction

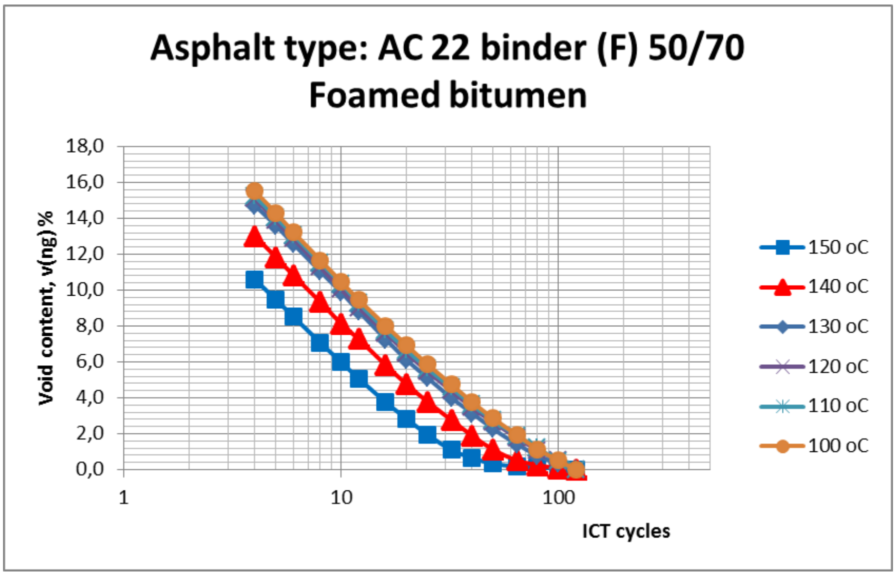

Figure 4: Compaction temperatures at gyratory compaction

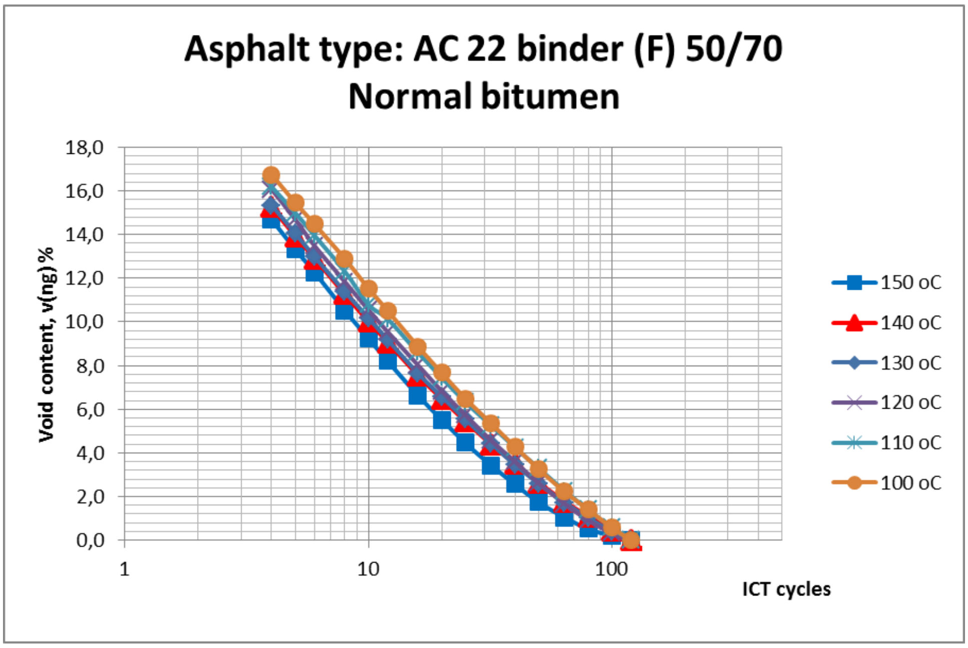

Figure 5: Compaction temperatures at gyratory compaction

The other display method shows that we picked a single number of blows for the Marshall test and a single cycle for the gyratory method, and tested compaction in view of the various temperatures. We picked 2x50 blows for the Marshall method, because this is the number of blows used in Hungary to produce specimen. The number of blows can be read from the compaction temperatures diagram. Figures 6-9 present the compaction curves of the four mixes tested. In the case of gyratory compaction, we selected the test cycle so that the voids content of the samples would fall between the usual voids content of asphalt mixes (3-5 vol %) at the highest compaction temperature. The gyratory compaction curves are presented in Figures 10-13. We indicated the closeness of correlations on both Marshall and gyratory compaction diagrams.

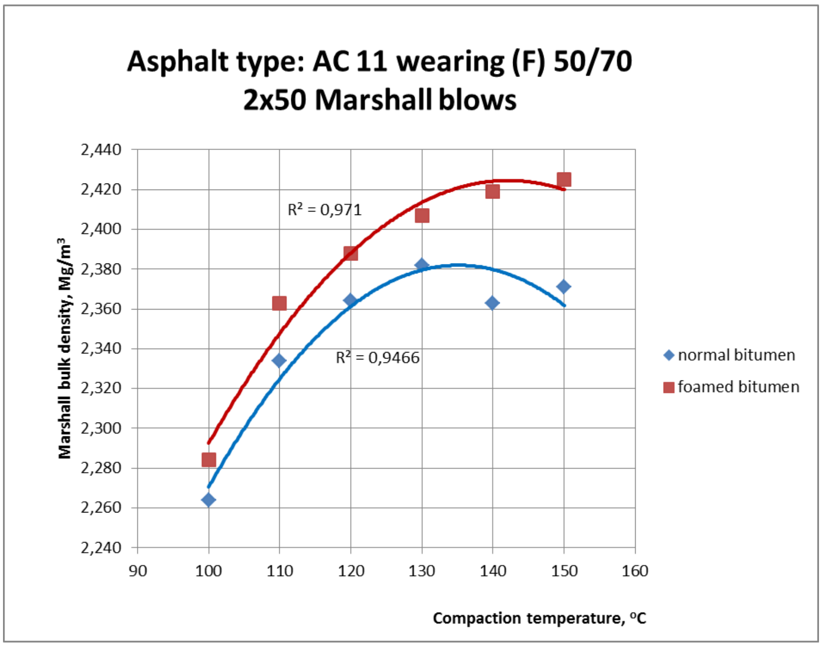

Figure 6: Compaction diagram at Marshall compaction

The Marshall compaction diagrams show that foamed bitumen asphalt mixes have better compactability than the reference mixes. The gyratory compaction diagrams of foamed bitumen asphalt mixes also show better compaction rates at each temperature than the reference mixes.

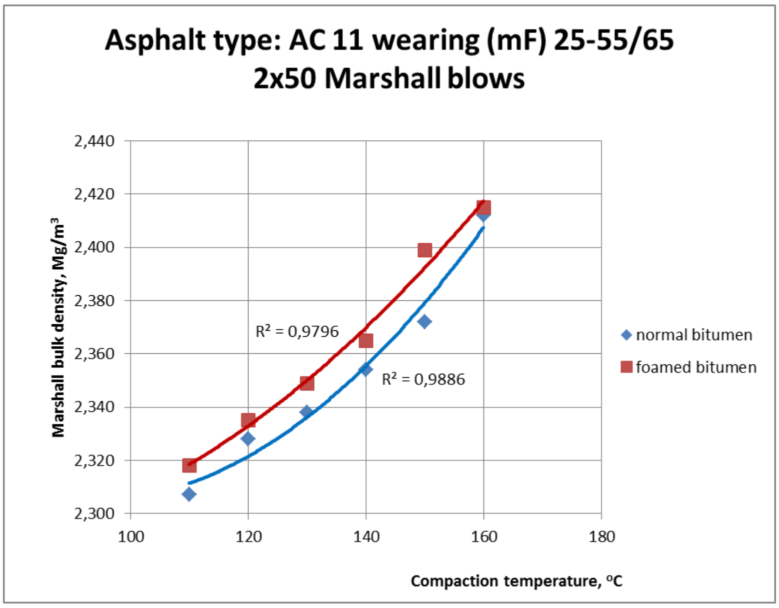

Figure 7: Compaction diagram at Marshall compaction

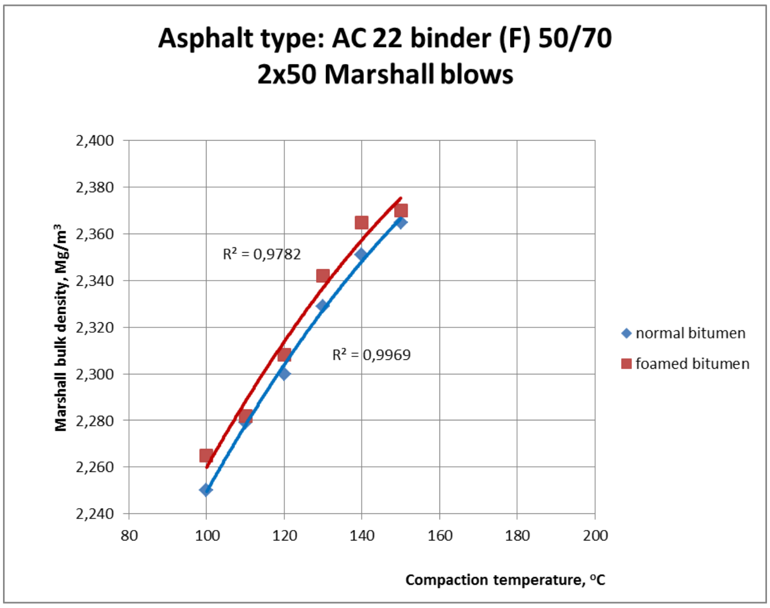

Figure 8: Compaction diagram at Marshall compaction

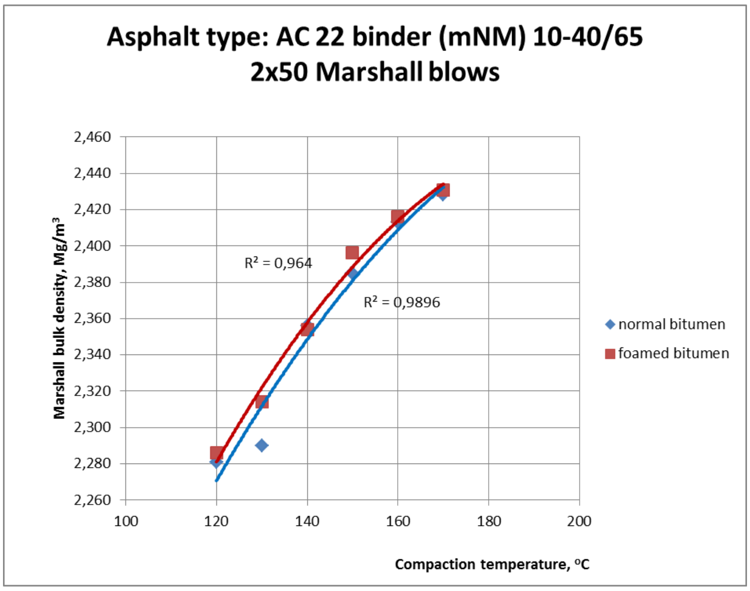

Figure 9: Compaction diagram at Marshall compaction

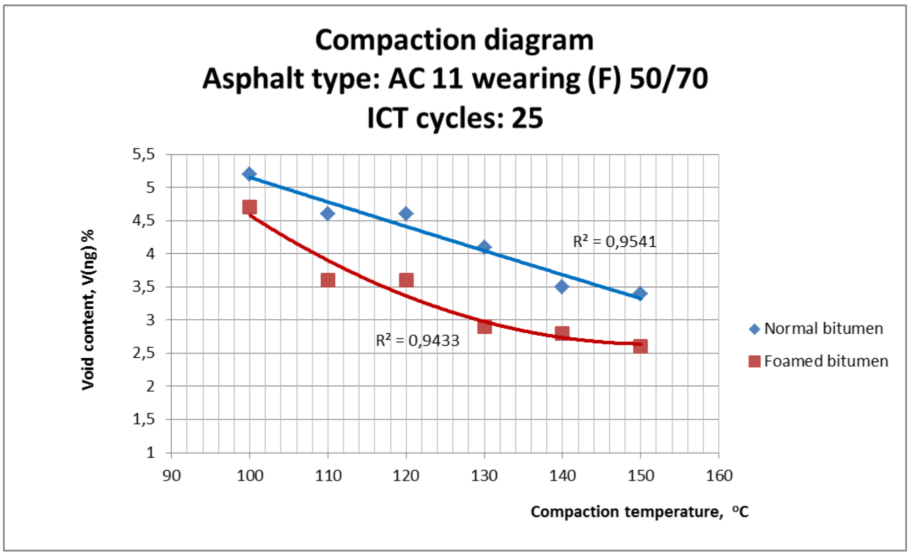

Figure 10: Compaction diagram at gyratory compaction

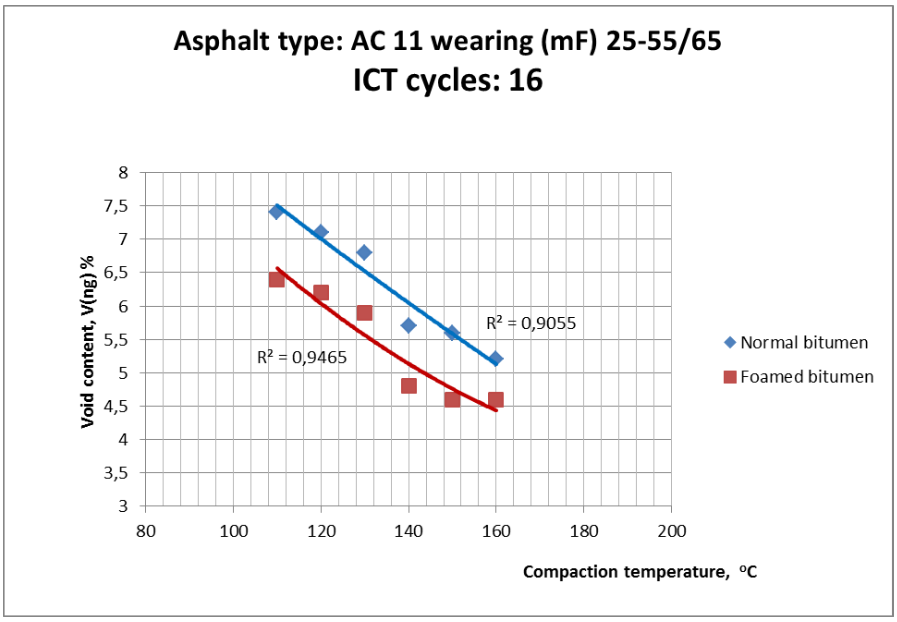

Figure 11: Compaction diagram at gyratory compaction

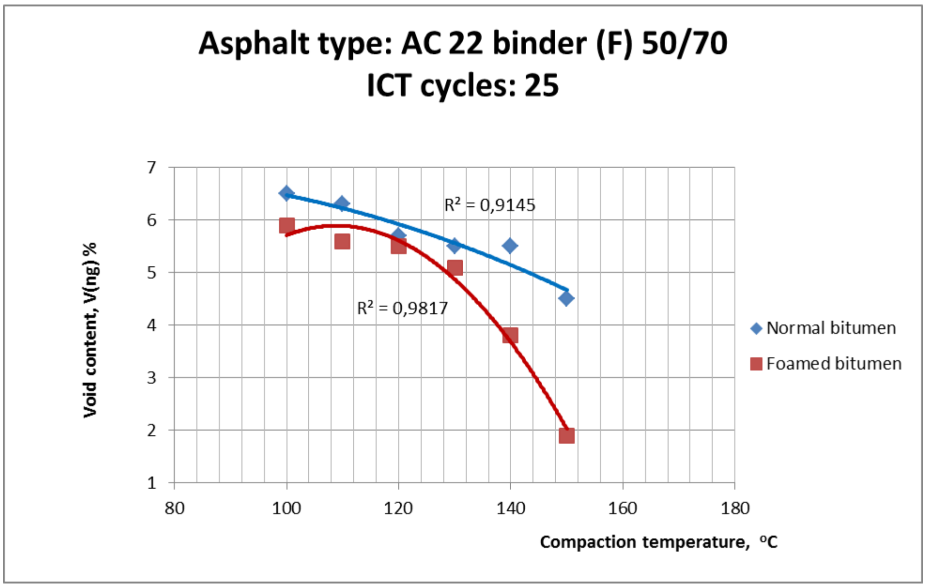

Figure 12: Compaction diagram at gyratory compaction

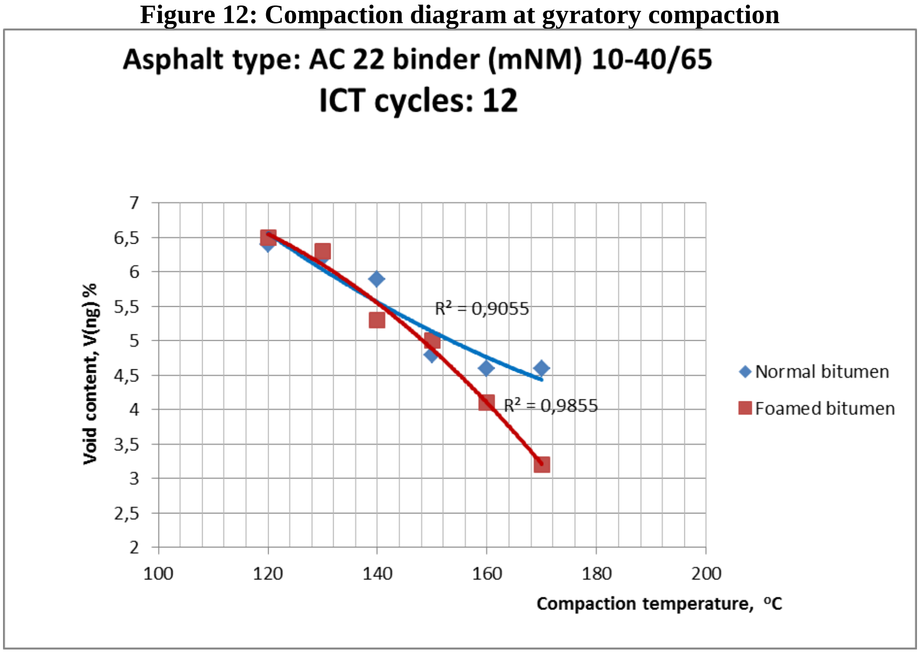

Figure 13: Compaction diagram at Marshall compaction

4. CONCLUSIONS

COLAS Group Hungary has dealt with LT asphalt mixes since 2008. Between 2008-2010, we made several road sections using the fatty acid amide additive produced by COLAS Ireland. These test sections brought positive results, nevertheless, despite the nearly 30 % energy saving the relatively higher acquisition cost of the additives makes the price of LT asphalt mix in Hungary higher than that of normal asphalt mixes (2).

We installed the first foaming kit at a mixing plant in 2012, then based on the positive production and building experience gathered there, we continued to install foaming kits at another mixing plant in 2013, followed by installations at other two mixing plants in 2014. The foaming kits were produced by different companies. The price of the foaming kits was a key factor for the procurement of the equipment.

Foamed bitumen asphalt mix production at two of our mixing plants amounted to some 50% of the total production in 2014. The production of foamed bitumen asphalt mixes at said four mixing plants and the building of mixes have become routine. The better compactability of foam bitumen asphalt mixes is perceptible and can also be monitored by isotopic density measurements during laying. On the other hand, laboratory tests can provide the best exact methods to monitor the compactability of foamed bitumen asphalt mixes.

We subjected the foamed bitumen asphalt mixes of various composition, containing different bitumen types and produced at four mixing plants to Marshall compaction at a variety of compaction temperatures. We performed the same tests on the reference mixes (containing normal bitumen). We represented the Marshall bulk densities in view of the compaction temperatures. We also tested the compactability of mixes produced in laboratory conditions using Marshall and gyratory compaction at various temperatures to prove the better compactability of foamed bitumen asphalt mixes. In the case of foamed bitumen mixes produced at the mixing plant or in the laboratory the Marshall bulk density (better compactability) of foamed bitumen asphalt mixes is higher for all asphalt types both in normal (50/70) and modified bitumen (25/55-65, 10/40-65) mixtures compared to the normal bitumen mixtures. The results were similar for the gyratory compactability of laboratory mixes.

Based on the favourable experience gained with bitumen foaming, COLAS Group Hungary will increase its foamed bitumen asphalt mix production in the future. Low temperature production enables energy saving, reduces greenhouse gas impacts and provides for the health protection of employees. Production at normal temperature, on the other hand, does not produce saving by reducing the mixing temperature, but in this case it doesn't be established mixing plant by working place, so it can be saved e.g.. set up cost of mixing plant.

REFERENCES

[1] Experiences on low temperature (LT) asphalts in Hungarian road building, Puchard, Z., Gorgenyi, A., Transport Research Arena. Proceeding 195. page 2029-2034., 2012

[2] Experiences with foamed bitumen asphalts in Hungarian road building, Puchard, Z., Gorgenyi, A., 17th IRF World Meeting and Exhibition, Riyadh, November 10-14., 2013

[3] New experiences with foamed bitumen asphalts in hungarian road building, Puchard, Z., Gorgenyi, A., CAR 2015. Bucarest,. 2015

[4] Bituminous mixtures. Test methods for hot mix asphalt. Part 30. Specimen preparation by impact compactor , EN 12697-30:2012, 2012

[5] Bituminous mixtures. Test methods for hot mix asphalt. Part 31. Specimen preparation by gyratory compactor , EN 12697-31:2007, 2007

[6] Bituminous mixtures. Test methods for hot mix asphalt. Part 10. Compactability , EN 12697-10:2003, 2003

[7] Bituminous mixtures. Test methods for hot mix asphalt. Part 6. Determination of bulk density of bituminous specimens, EN 12697-6:2003+A1:2008, 2008