Boat transport and quality of hot mix asphalt

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ABSTRACT

The R&D program "Durable Roads" (2011-2014), was a 4-year research program conducted by the Norwegian Public Roads Administration (NPRA). The overall objective was to increase service life and reduce annual costs for the Norwegian road network. One of the activities in the R&D program has been to study the quality of hot mix asphalt (HMA) transported by boat and suggest new recommendations for asphalt transport by boat.

Norway is a long and narrow country, with several fjords and long distance between cities, especially in the northern region. The country has a coast line of 25 000 km, and lies between latitudes 57° and 81° N, and longitudes 4° and 32° E. 7 million tons of HMA was produced in 2014, and about 2 million tons (30 %) was transported by boat. It often takes up to 24 hours to load the asphalt on to the boat, transport it by the boat, unloaded it on to trucks and pave depending on the distance. Because of this the asphalt can in many cases become cold during the transport and segregation can occur, and the quality of the asphalt pavement can be poor. There are several actions which may be taken to prevent this cooling and segregation of the HMA, for instance with use of IR-scanning and specifications for handling. The NPRA has made a study on this and the findings of this study are presented in this paper.

Keywords: Compaction, Low-Temperature, Quality assurance, Segregation (Coarse-Fine Aggregates), Workability

1. INTRODUCTION

The R&D program “Durable Roads” (2011-2014), was a 4-year research program conducted by the Norwegian Public Roads Administration (NPRA). The overall objective is to increase service life and reduce annual costs for the Norwegian road network. For many years there has been a strong need in Norway for improved expertise in the area of road technology and road maintenance. Premature failures /distresses occur too often also on new roads. Focus on cost and completion time often leads to low quality work, improper use of materials is often seen, and there is a growing lack of professionals. “Durable roads” has looked especially upon how to improve asphalt pavement quality and thereby achieve longer service life. Among the activities that were conducted, was development of new recommendations for asphalt transport by boat which is the topic of this paper. IR-camera has been used to promote and document homogenous conditions/temperatures during loading, laying and compaction.
Norway is a long and narrow country, with several fjords and long distance between cities, especially in the northern region. The country has a coast line of 25 000 km, and lies between latitudes 57° and 81° N, and longitudes 4° and 32° E. 7 million tons of hot mix asphalt (HMA) was produced in Norway in 2014, and about 2 million tons (30 %) was transported by boat. The amount of asphalt transported for the NPRA is shown in Table 1, and around 21 % is transported by boat. In Norway, the trend is towards fewer and larger asphalt plants, and fewer mobile plants. This results in larger transport distances. For longer transport distances, boat transport is cheaper compared to transport by truck.
NPRA is divided into 5 regions, as shown in Figure 1 (north, middle, west, east and south), and all regions except east have a relatively long coastline. Many of the stone quarries and asphalt plants are located along the coast, which result in the need for boat transport for about 21% of the materials.
Asphalt is a hot product. For the pavement to have a long service life, the asphalt should be paved and compacted while it is still hot. It is therefore important to avoid loss of temperature under transport from the asphalt plant. It often takes up to 24 hours to load the asphalt on to the boat, transport it by the boat, unloaded it on to trucks and pave depending on the distance. Because of this the asphalt can in many cases become cold during the transport and segregation can occur, and the quality of the asphalt pavement can be poor. There are several actions which may be taken to prevent this cooling and segregation of the HMA, for instance with use of IR-scanning and specifications for handling.

Table 1. Asphalt transported by boat for paving contracts for the NPRA in 2014 [1]

Region	Total transport	Boat transport	
	Tonn	Tonn	%
East	770 000	0	0
South	500 000	53 527	11
West	464 900	227 370	49
Middle	428 000	109 000	25
North	345 760	139 460	40
Total	**2 508 660**	**529 357**	**21**

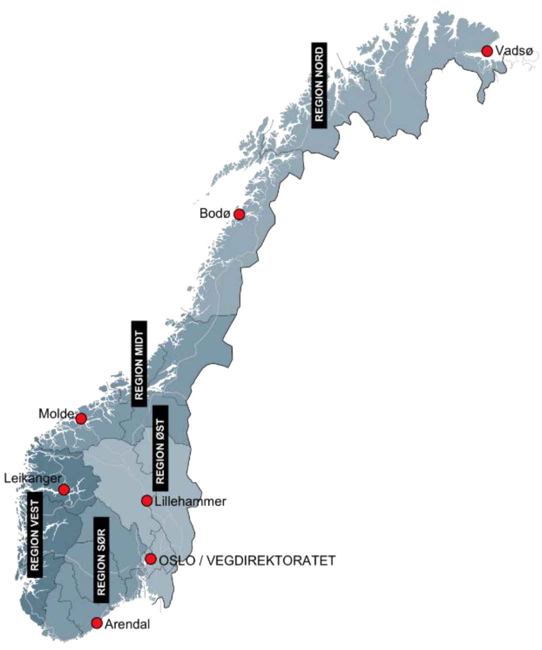

Figure 1: NPRA has divided the country into 5 regions

To achieve a pavement with high durability, high deformation resistance, and ability to resist moisture, it is important to obtain the proper values for void and bitumen-filled void in an asphalt pavement. Compacting the paved asphalt is crucial in order to achieve the right void, and again the temperature of the asphalt mixture is very important to enable proper compaction. At high temperatures, asphalt can easily be compacted. But the asphalt mixture hardens at colder temperatures, and it will be difficult to compact. The compaction must therefore take place while the bitumen is still hot. In other words, compaction must happen within a certain time after the asphalt has been paved. This means that the higher the temperature loss during transport, the shorter is the time interval for effective compaction.

According to the American National Asphalt Pavement Association (NAPA) the most important factors that influence the temperature loss during paving are:

- Asphalt temperature
- Pavement thickness
- Temperature on the ground
- Air temperature
- Wind speed
- Sunlight

In this paper, only the asphalt temperature is considered, and it contains results from field measurements in 2013 and a case study in Region north. Furthermore, the paper gives recommendations on the following parts:

- Production of asphalt
- Loading of asphalt on boat
- Covering of the asphalt cargo
- Transport by boat
- Unloading of asphalt (from boat to truck)
- Use of feeder between truck and asphalt

2. MATERIALS AND METHODS

Temperature of the asphalt was measured in the boat before unloading, during unloading, in the truck and behind the asphalt paver using thermal imaging camera and IR-scanning equipment described below. These equipment have not been used much in Norway before.

2.1 Thermal imaging camera and thermometer

A handheld, mobile thermal imaging camera and thermometer, Fluke Ti55 (Figure 2A) and Fluke 561 (Figure 2B) respectively, were used to measure asphalt temperature during transport.
The thermal imaging camera produces a thermal image showing the temperature of the objects that are photographed, over an area of approximately 3.4 x 3.5 meters. The thermal images are moved from the camera to a PC and analyzed with a program called SmartView. The program displays the maximum, minimum and average temperature of the asphalt surface. In the program, the user can choose a color scale to identify and illustrate the different temperature zones.
An IR-thermometer was also used. It gives the instanteous temperature on the point it is directed.

A

B

Figure 2: A: Thermal imaging camera Fluke Ti55. B: IR-thermometer Fluke 561.

2.2 IR-scanning

IR-scanning was used to monitor the temperature of the asphalt behind the asphalt paver. This equipment is very helpful for the paving team, since they can observe how the temperature is affected by different changes during the paving.

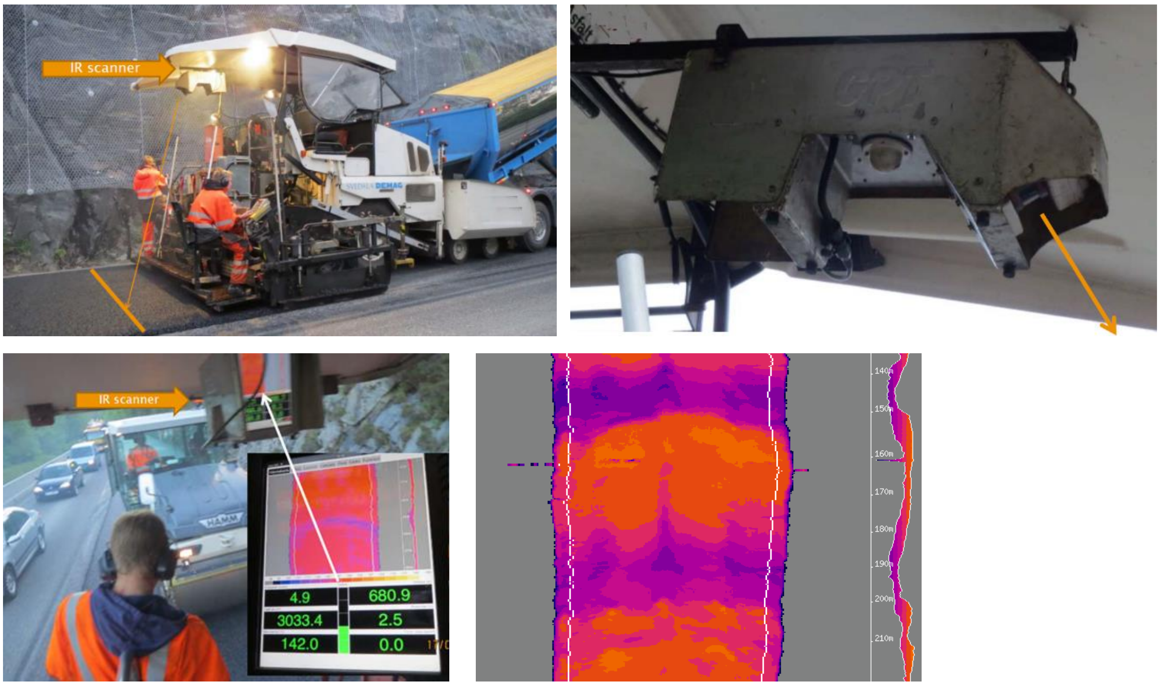

Figure 3: IR-Scanning on an asphalt paver. 142.0 is the asphalt temperature behind the paver, and 2.5 is the percentage of risky area (Photo: Bjørn Hoven)

To achieve good homogeneity in the workmanship of asphalt pavements, the use of the thermal camera / line scanner can be helpful to reveal problem areas. Homogeneity measurement focuses on ensuring that the wearing course has a homogeneous and uniform structure. This can be done by setting the temperature requirements when paving the wearing course. Quality deviation is measured as % of the new wearing course which was laid at a temperature less than the defined temperature limit. Proportion of risky areas is defined as the proportion of surface area which was laid at a temperature less than the defined limit. Measurements were taken with an infrared thermographic measurement equipment, and they scan an area 1 to 2 meters behind the asphalt paver. On the basis of the conducted temperature measurements and calculated data for proportion of risky areas, an incentive/disincentive system is introduced whereby the contractors are given an incentive to avoid a higher proportion of risky areas (low temperature). The NPRA gives a bonus when the proportion of risky area is less than 3% and the contractor has to pay a penalty if the proportion of risky area is over 5%. For a higher proportion of risky areas the guarantee time can be extended beyond the normal warranty period. These requirements are described in an addendum to the tender documents. Such homogeneity or temperature measurements can be a good starting point for control of segregation and void.

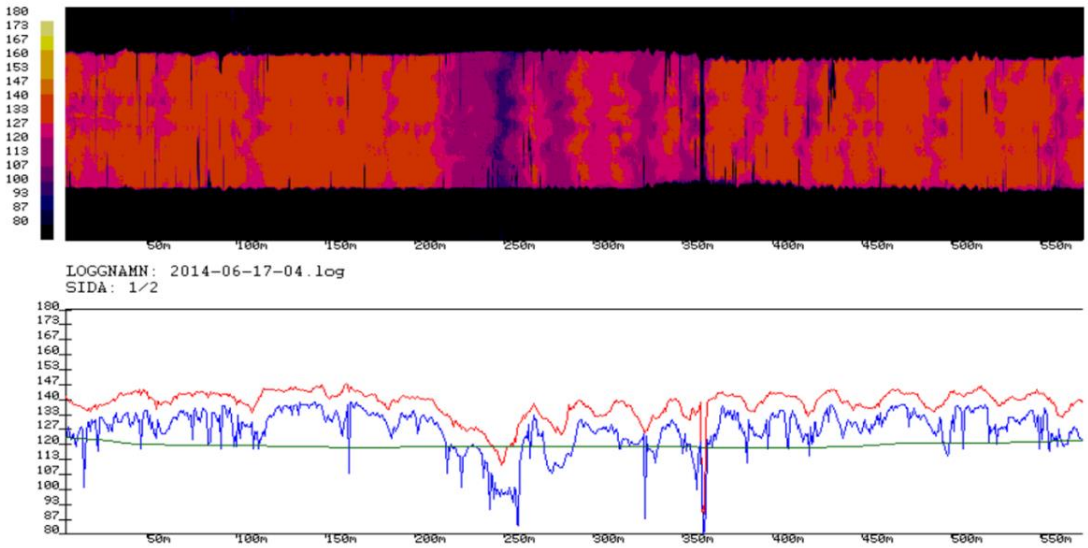

Figure 4: IR-scanning output. Top figure shows temperature scan on a 550 m distance in °C. Bottom figure shows maximum temperature (red line), minimum temperature (blue line) and moving average temperature (green line)

3. RESULTS AND DISCUSSION

3.1 Field measurements in 2013

In 2013 two of the boat transport contracts in the middle Region were followed up with thermal imaging. This included the process of unloading the boat, transport by trucks and paving.
During unloading, the temperature difference between the surface and the middle of the asphalt cargo was around 100 °C. The surface was around 50 °C while the middle was around 150 °C when unloading the boat. When the operator of the excavator was shown how the temperature differ in the cargo by use of a thermal camera and explained the importance of mixing the colder asphalt with the warm asphalt, IR-scanning after paving showed a clear improvement in temperature profile.

A B

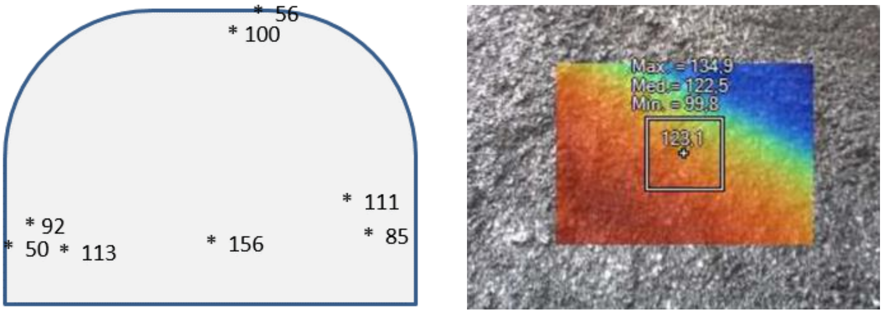

Figure 5: Temperature difference in the asphalt cargo measured with thermal imaging camera. A: Temperature in a cross section of the asphalt cargo. B: Thermal image showing the temperature of the surface and in (Photo: Bjørn Hoven)

Table 2. Examples of registered asphalt temperatures (°C) during unloading of the boat

Time	Truck nr	Temperature (°C) in shovel nr					Average temperature (°C)	Comments
		1	2	3	4	5		
10:35	1	149	154	155	163		155	
10:42	2	98	139	157	122		129	
11:05	3	142	150	158	144		149	
11:10	4	116	158	152	153	151	146	
11:14	5	131	142	147	149		142	
11:20	6	118	111	165	104		125	
12:15	1	131	122	126	139		130	
12:20	2	97	119	153	131		125	
12:28	3	110	140	147	157		139	
12:35	4	113	128	152	161	139	139	
13:05	5	116	157	147	156		144	
13:07	6	130	132	116	155		133	
13:10	1	109	121	153	156		135	
13:12	2	121	151	141	171		146	
13:15	3	139	137	129	164		142	
13:25	4	120	127	142	134	157	136	
13:35	5	140	153	150	100		136	
13:43	6	137	129	142	127		134	
13:50	1	94	154	148	161		139	
14:00	2	125	152	157	154		147	
14:08	3	104	143	103	92		111	
14:15	4	112	129	112	130	84	113	Last load from rear cargo room
14:25	5	137	124	112	94		117	First load from front cargo room
14:30	6	110	150	160	62		121	
14:42	1	116	137	157	136		137	
14:50	2	114	144	122	152		133	
14:55	3	152	160	137	127		144	
15:07	4	91	119	133	130		118	Last load from front cargo room

The temperature was measured in each shovel (4-5 in each truck load) from the excavator when it was loaded on to trucks, and an average value was calculated. This was done by swiping over the pile for each shovel with an IR-thermometer. The IR-thermometer measures continuously when the shutter button is pressed and the average temperature is calculated in the instrument. Measured values were recorded manually together with time and truck number, as shown in Table 2. As can be seen in Table 2 the temperature difference in the shovel can vary up to 60 °C in one truck load.

An IR-scanner was mounted on the paver, and the temperature of the paved asphalt mix from the trucks was registered behind the paver. In this way we were able to follow the temperature of the asphalt mix from the cargo to the paved asphalt. The truck numbers and time were registered when the truck arrived at the paver, and data was recorded as shown in Table 3.

The first column in Table 3 show the distance from start of paving with material from the indicated truck. The corresponding temperature measurements (column 5) are taken during the paving with material from the particular truck and within the indicated range of distance. The gap between the distances in column 1 represent change of truck and are omitted.

The mix temperature is sometimes higher behind the paver than at the boat. There are several reasons for this: 1) there is heat from the screed of the paver, which provides temperature increase at the surface of the pavement, 2) the mixture becomes remixed during handling resulting in changed temperature.

The top line in Table 3 is connected to the top line in Table 2, which means the asphalt mix in Truck 1 has been transported and stored for almost 1.5 hours even though the transport distance is only 0.5 hours. The percentage of risky area is determined based on temperature measurement as illustrated in Figure 4. Areas where the temperature lies below the green line represent the risky areas.

Table 3. Examples of registered range of distance for paving with material from the indicated truck, risky areas and asphalt temperature (°C) during paving

Distance from start of paving (meter)	Risky area (%)	Truck nr	Time for start of unloading on to the paver	Temperature (°C)	Risky area, accumulated (%)
Start	0.0	1	11:55		0.0
35-49	2.8	2	12:02	150-158	2.0
69-88	10.7	3	12:10	148-158	3.8
116-132	6.3	4	12:18	148-157	3.8
159-178	2.1	5	12:28	151-160	3.3
208-219	2.4	6	12:38	148-158	2.7
246-260	8.5	1	12:44	152-158	3.2
286-299	13.5	2	12:51	149-156	3.7
325-338	11.3	3	12:59	151-154	3.7
370-383	8.4	4	13:07	149-154	3.7
424-435	7.3	5	13:18	148-162	3.6
463-478	2.8	6	13:25	154-159	3.6
512-525	7.8	1	13:34	154-158	3.7
559-572	2.0	2	13:42	150-158	3.5
604-617	8.6	3	13:50	149-158	3.6
649-662	3.6	4	13:58	155-161	3.7
697-714	9.3	5	14:07	149-152	3.8
747-755	0.8	6	14:14	148-152	3.5
795-807	0.0	1	14:23	147-157	3.3
847-858	0.0	2	14:32	145-156	3.1
900-909	0.2	3	14:40	138-145	3.2
952-984	64.9	4	14:50	125-134	4.7
992-1021	37.5	5	14:58	138-146	5.0
1041-1068	29,7	6	15:06	132-151	5.0
1098-1108	0,2	1	15:14	142-151	5,2
1147-1159	0,0	2	15:22	146-156	5,3
1194-1217	21,9	4	15:31	133-147	5,7
1222-1233	4,8	3	15:36	133-137	5,5
1267-1272	1,6	stop			

The measurements clearly showed that focus on the unloading process from the boat on the trucks gave much lower temperature variations on the road. The temperature variations in the cargo rooms were large both when starting and when finishing unloading from the cargo rooms. Furthermore, when the asphalt cargo remained uncovered for a long time, the temperature dropped on the surface and a high variation in the temperature and risky area was observed behind the paver.

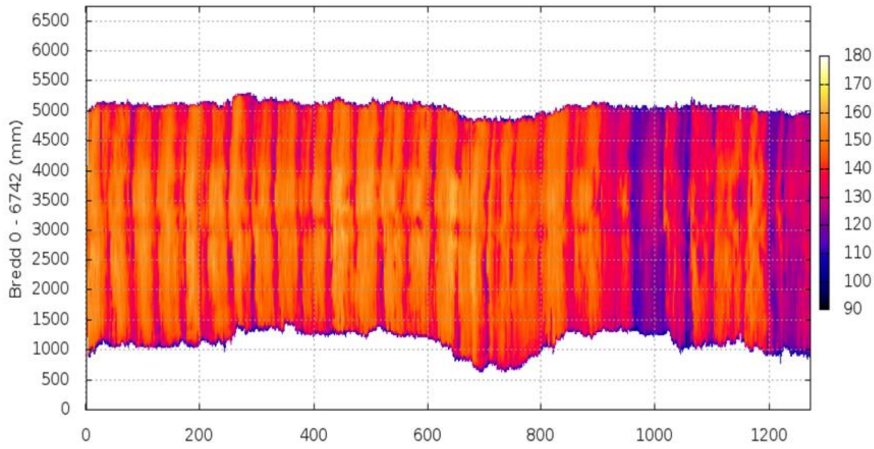

Figure 6: Asphalt temperature behind the paver documented with IR-scanning (x-axis: distance in meter, y-axis: width of the paving course). Temperature scale in °C

The blue areas indicate the switch between the cargo room in the front to the one in the back of the boat.
Figure 7A and Figure 7B shows all truck loads for the whole boat cargo. Each column represents one truck load. A high column in the chart tells us that a large proportion of the paved asphalt for this truck load has low temperature. The area of the cold surface is called the risky area. In Figure 7A the unloading of the boat starts from the front cargo. Proportion of risky areas is high at the start and this means that the surface temperature in the boat cargo has decreased much even though the hatches just opened and the fibre cloth is removed. The risky areas are decreasing gradually as the unloading is going inward the cargo. After 14 trucks are uploaded, the boat crew switch to the rear cargo because the boat was too heavy in the back. Again, it can be observed that starting in unloading a new cargo room causes higher proportion risky area. The risky area improves quickly when the unloading is going inward the cargo. Towards the end of the paving in Figure 7B, the proportions of risky areas (columns) are high. This is because the rear cargo compartment is emptied and the unloading returns to the front cargo room which has now been without covering for 5 hours. This shows that it is not the end of emptying each cargo room which is critical in unloading this boat, but starting unloading a new cargo room.

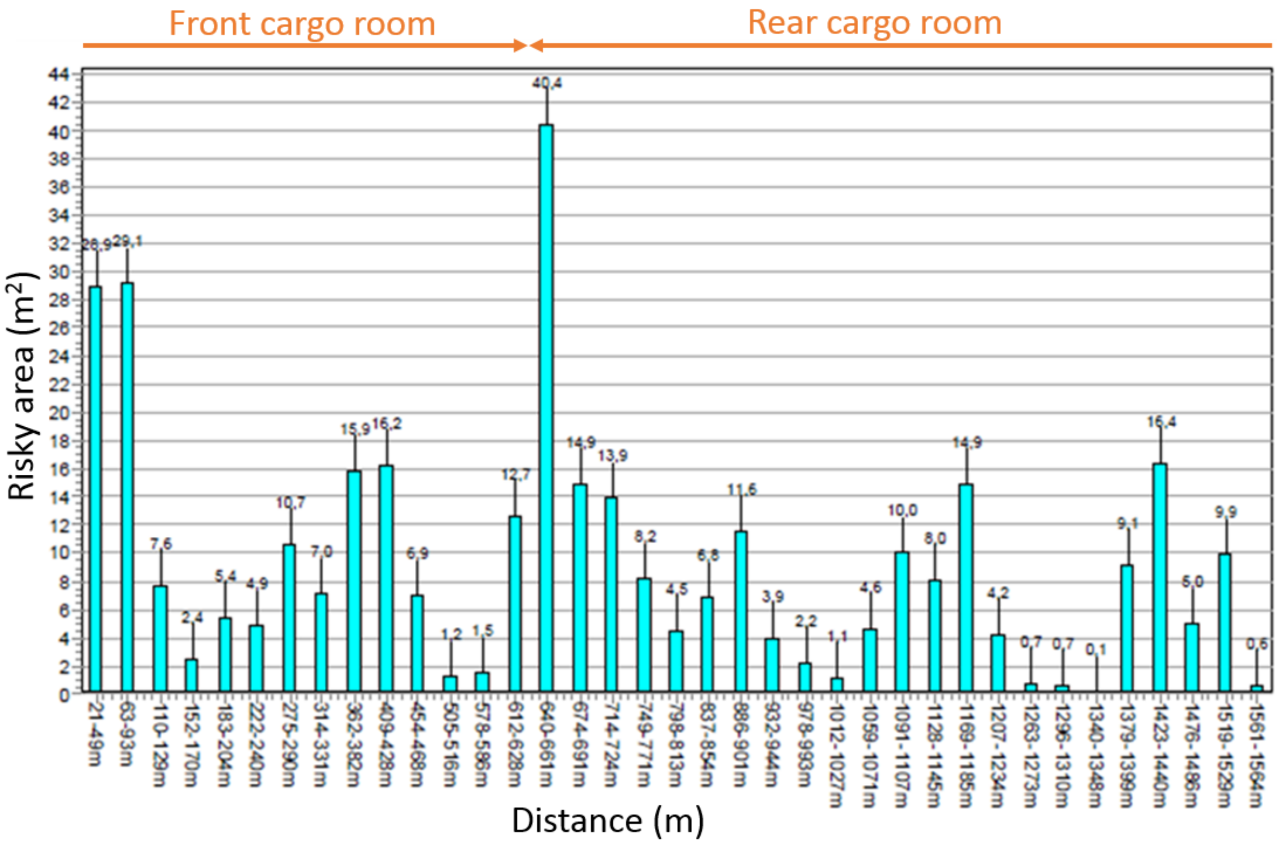

Figure 7A: Risky area (m^2) for each truck, part 1, documented with IR-scanning

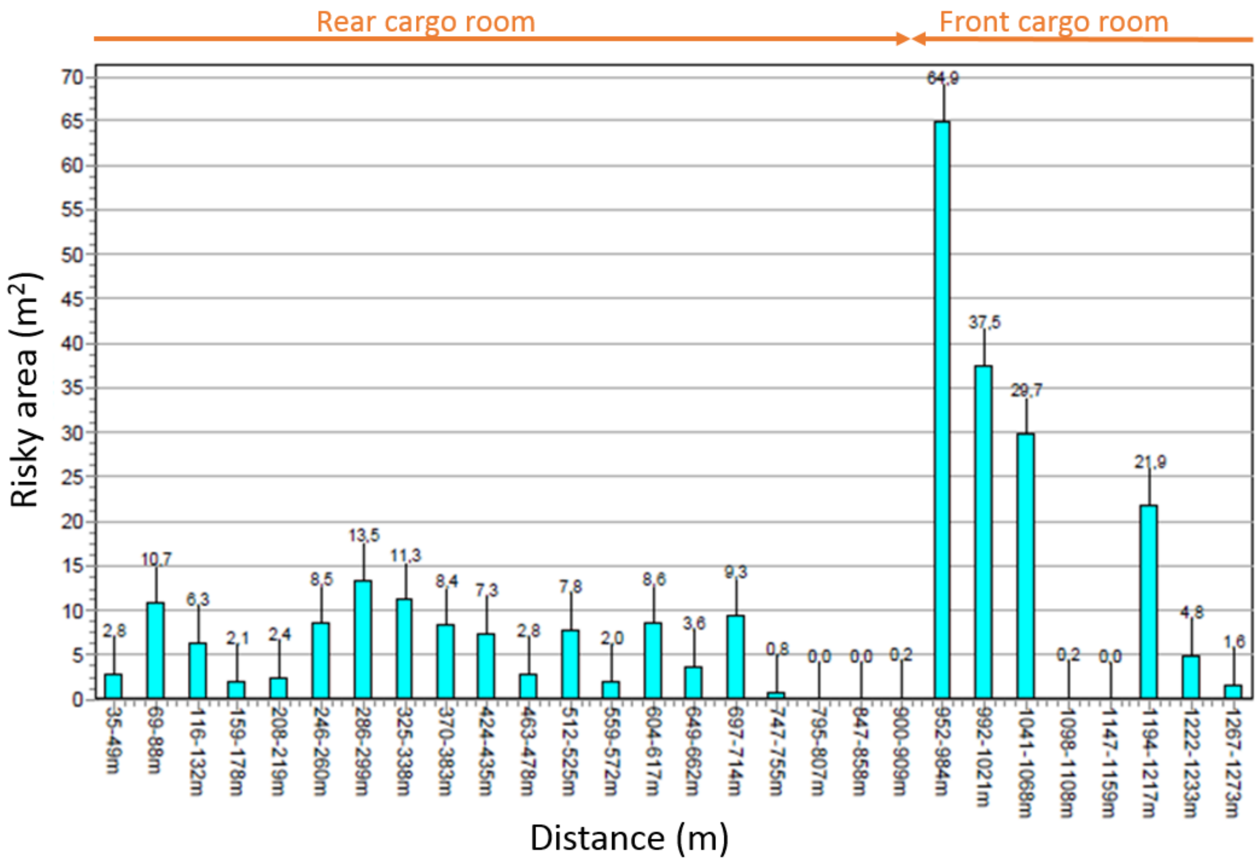

Figure 7B: Risky area (m^2) for each truck, part 2, documented with IR-scanning

This example clearly shows the main problem with boat transport. The asphalt surface has already cooled during the loading of the boat at the plant, and has cooled due to slow loading speed. Covering of the cargo was too poor and the surface temperature has dropped a lot when the unloading starts. This is indicated by high proportion of risky areas at the time of paving and when starting unloading the second cargo room.

3.2 Case study in Region north, NPRA

In this section an example of different transport alternatives for an actual paving contract is presented. The contract was paving 950 tons (1.25 km) of AC 16 at Setermoen in Region north in 2014. Figure 8 illustrates the different transport alternatives given in the offers from the contractors.

Table 4 presents the estimated transport times for each alternative. If the asphalt was transported by trucks, it would take approximately 32 truckloads. One paving shift is around 8 hours, which means a truck driver does not have capacity for more than 2 truckload per shift by alternative 2 and 1 truckload by alternative 3 since the transport time to reach the paving site is 5 and 2.5-3 hours/truck respectively. This means that 16 trucks must be available for alternative 2 and 32 trucks for alternative 3, which is not reasonable or possible.

With regard to quality of the pavement, alternative 3 is a better alternative since this has the lowest transport time. However, by the tender documents and procurement rules, the cheapest offer was accepted. In this case this was alternative 1, which resulted in a very poor quality of the pavement. The reason why alternative 2 and 3 are more expensive compared to alternative 1, is that it is more costly and inefficient with long transport distances by use of trucks. Anyway, alternative 2 with 160 km of transport by truck is undesirable for quality reasons (cooling of the cargo), and is most likely not a better alternative than boat transport.

In 2015 the NPRA submitted a complaint on part of the contract where too cold asphalt mix had been used, and approximately 150 m had to be repaved.

There are several means to prevent cooling of the asphalt cargo and secure sufficient quality on asphalt transported by boat, as described in the next part of this paper.

Figure 8: Illustration of different transport alternatives (adapted from Kåre Nygård, NPRA)

Table 4. Asphalt transport alternatives

Alternative	Boat transport*	Truck transport	Transport time to paving location
1 (Boat+Truck I)	75 nautical mile, 7.5 hours	30 km**	15 hours
2 (Truck II)	-	160 km	5 hours transport time/truck
3 (Truck III)	-	75 km	2.5-3 hours transport time/truck

*Included loading from the asphalt plant
**Included unloading of the boat

4. RECOMENDATIONS

The hot mix asphalt can lose temperature and become segregated during the handling/transport from the asphalt plant to the paving location. It is therefore important to minimize this impact in all the handling steps as described in the next sections [2].

4.1 Asphalt production

Production temperature is often increased for asphalt with long transport distance to avoid reaching critical temperature during paving. However, the asphalt production temperature must not exceed the maximum temperature described in [1] to ensure the binder does not get damaged.
To minimize transportation distance and time, the asphalt mix should be produced at the coast. The plant must have adequate storage capacity to ensure that loading time on to the boat is as short as possible. The silo capacity should equal the amount to be loaded on the boat minus the amount the plant can produce during loading.

Figure 9: Asphalt plant and loading of boat (Photo: Bjørn Hoven)

4.2 Loading boat before transport

Loading of asphalt on the boat can happen directly from the asphalt plant or from trucks driving between the plant and the boat. The shorter the loading time and driving distance and the fewer the number of loadings, gives lower loss of temperature and less segregation of the asphalt mixture. Insulation of the boat and trucks are important to minimize cooling of the mixture. Loading directly on the boat should be done with low falling distance and a shaft around the hot mix. The higher the falling distance, the higher is the segregation and temperature loss of the asphalt mix. The asphalt mixture should not be exposed to rain and wind.

A **B**

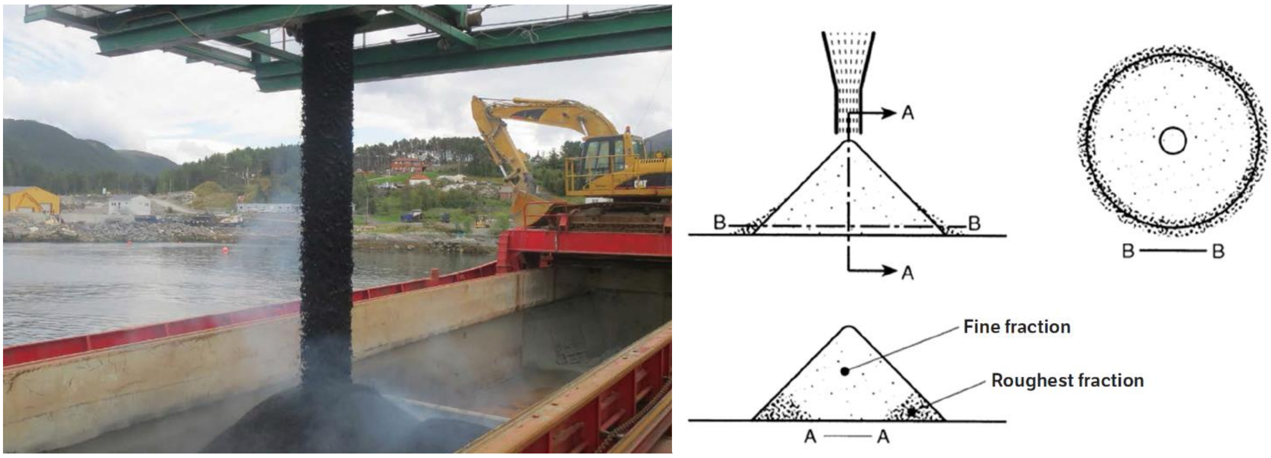

Figure 10: A: High falling distance results in cooling and segregation (Photo: Bjørn Hoven)
B: Coarse particles gather at the outer edges of the pile

When the cargo room is filled up, it is important to cover the cargo well. Before covering the cargo an excavator can be used to smooth the surfaced in order to seal the mix. This will reduce the surface area and reduce heat loss.
The boats often have two cargo areas with a loading bulkhead in the middle. The asphalt is dropped beside this bulkhead and a cone is made. Where this cone meets the floor and walls of the cargo room, the surface area is large relative to the mass and the heat loss is large. Coarse particles will also gather here due to separation.

4.3 Covering of the asphalt cargo

Covering of the asphalt mix should be done both during and after loading the asphalt mix on the boat to minimize loss of heat. It is recommended to use two layers of fibre cloth and loading hatches over the loading room as a minimum coverage. For longer transport distances, the covering should be strengthened, for instance by using insulating mats.

A **B**

Figure 11: Proper covering prevents loss of heat. A: Fibre cloth. B: Loading hatches (Photo: Bjørn Hoven)

4.4 Transport by boat

The transportation distance from the asphalt plant to the unloading location determines together with sailing speed how much time it takes before the mix can be unloaded. If the boat is well insulated and the covering is good, the temperature

remains acceptable under the boat transport, even over longer distances. Sometimes there can be additional delays due to rain and other delays in the paving. This will also affected the results.
There are no requirements for insulation on boats used for asphalt transport in Norway today. However, it is recommended that both the floor and walls are properly insulated, for instance with wood or double hull. The loading hatches should be closed during transport. It is important to prevent rain and seawater from entering the cargo hold.

Figure 12: Boat transport (Photo: Bjørn Hoven)

4.5 Unloading of asphalt (from boat to truck)

The cover should be removed stepwise during unloading, and in case of a break in the unloading, the asphalt should be covered completely to avoid loss of heat. Rain on the asphalt mixture should also be avoided since evaporation of water takes a lot of energy from the asphalt.

Figure 13: The cover should be removed gradually to avoid loss of heat (Photo: Bjørn Hoven)

The shape of the cargo room is important for unloading the asphalt in an effective way. If the excavator unloading the boat manages to remove the mix at the edges continuously, increased cooling of the mix that is left behind is avoided.
The asphalt cargo is colder on the surface and on the edges and warmest in the middle. To ensure uniform temperature it is important that the operator of the excavator/loader mixes cold and warm asphalt well before loading. It is beneficial if the shovel of the excavator/loader stays in the mixture to maintain heat in between loadings on to the trucks. A thermal camera can be a useful tool for the operator to visualize the temperature difference in the asphalt cargo.

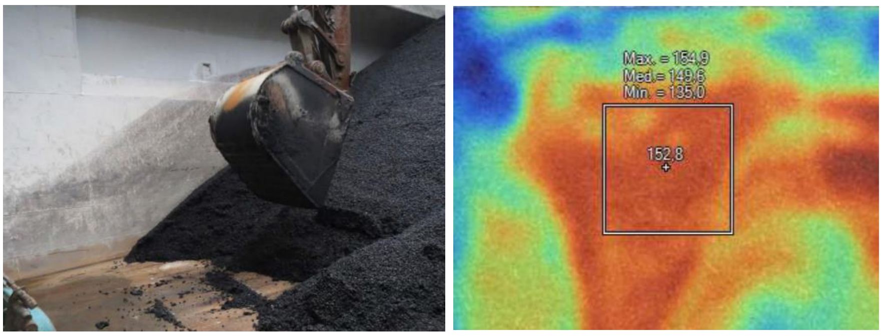

Figure 14: Good mixing with the shovel gives uniform temperature in the truckload (Photo: Bjørn Hoven)

To prevent segregation and ease the unloading, the truck should be perpendicular to the side of the boat during unloading.

Figure 15: The truck should be perpendicular to the side of the boat during unloading (Photo: Marit Fladvad)

Good communication between the boat and the paving crew is important. The paving crew should inform the boat when there is a break in the paving and when they change lane so that the unloading of the boat also stops and the asphalt cargo is covered. In this way, unnecessary cooling caused by waiting time for the loaded trucks can be avoided.
Experience shows that the temperature variation is large when starting unloading from the second cargo room. By mixing the surface asphalt with warmer asphalt inside the cargo, the temperature differences should become smaller. This can be done before the first truck is loaded from the second cargo room.

Figure 16: Cold asphalt gathered from the bottom and edges of the cargo must not be loaded onto the truck (Photo: Bjørn Hoven)

Cooled asphalt at the edges of the cargo, should never be loaded onto one truck, it should be mixed with warm asphalt. However, cold clumps of asphalt and collected left-over asphalt from the cargo should not be paved on the road, and should be returned to the asphalt plant for reuse and certainly not be thrown into the sea. Paving the cold asphalt gives a pavement with very short service life.

Figure 17: Cold asphalt results in defects in the asphalt pavement (Photo: Geir Johnsen, NPRA)

4.6 Use of feeder between truck and asphalt paver

A feeder is a machine that runs between the trucks and the asphalt paver. The trucks empty asphalt in the feeder which supplies the paver with asphalt mix in a steady stream. This has been used to achieve a more even feeding of the paver and a faster unloading of the trucks. Temperature differences in asphalt can be evened out by this method when the asphalt is mixed together in the feeder. Especially for jobs with boat transport, this has been found to reduce the disadvantages the boat transport causes. The paver can run with a much smoother speed and are less affected by change of trucks.

Figure 18: The feeder evens the temperature difference (Photo: Bjørn Hoven)

4.7 Information folder

The NPRA has made an information folder about boat transport of asphalt [3]. The folder gives brief information about special considerations that should be taken when asphalt is transported by boat. The aim of the leaflet is that it should be an easily accessible tool for boat crew and personnel of the contractors who use boat transport. The folder can be downloaded from:
http://www.vegvesen.no/_attachment/801111/binary/1018440?fast_title=Folder+-+Asphalt+transport+-+by+boat%28GB%29.pdf

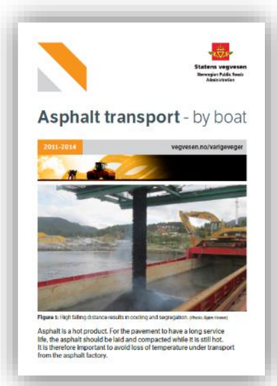

Figure 19: Information folder on boat transport

5. CONCLUSION

Based on the field measurements, case study and recommendations, a conclusion can be drawn. To have high quality asphalt with minimized temperature loss and segregation when transporting asphalt by boat, knowledge about each step of the transportation chain and how it affects both the temperature loss and the segregation is important.
The most important factors during loading of the boat are:

- Minimize the loading time, preferably loading the boat directly from the asphalt plant
- Low air temperature, wind and rain will increase the temperature loss
- Minimize the falling distance when loading the boat, and loading by using a shaft around the hot mix will reduce both the temperature loss and segregation
- Covering of the cargo both during and after loading with fibre cloth and loading hatches to prevent cooling
- The shape and insulation in the cargo room is important for keeping the temperature during transport

The most important factors during unloading the boat are:

- Good communication between the paving team and the boat crew during unloading and paving
- Good mixing with the shovel to secure uniform temperature in the truckload
- Cold asphalt gathered from the bottom and edges of the cargo must not be loaded onto the truck
- The cover should be removed gradually to avoid loss of heat, and if there is a delay in the unloading the cover should be restored
- A thermal camera can be a useful tool for the unloader to visualize temperature differences in the cargo

During paving a feeder can be used to even the temperature difference in the truckloads.

To maintain the temperature of the asphalt and improve the quality of the pavement when boat transport is used, it is suggested that special measures related to this particular form of transport be taken. These measures may include a new requirement for boat transport and detailed guidance.

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