THIN CONCRETE OVERLAYS AND EXPERIENCE AS USED FOR RENOVATION AND UPGRADING FOR TECHNIQUE MILITARY AIRFIELDS

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ABSTRACT

Thin concrete overlays (or inlays) were first used for renovation of a rutted concrete motorway in 1991. Thoroughly investigation by analyse of roughness of casting surface, thin section analyse, bonding strength verified the technique used. After the good experience the technique was further developed and used on several airfields both as a renovation of frost damaged surfaces but also for upgrading of bearing capacity. The technique based on mechanical removing of damaged concrete followed by water milling by high pressure has become a standard procedure for airfields in Sweden. The paper presents results of several airfields where the technique has been used with excellent result. Results of measuring bonding strength, thin section analyse and surface roughness is presented. The technique step by step is also presented.

KEY WORDS :

CONCRETE / OVERLAYS / RENOVATION

RESUME

Les fines couches d’enrobés bitumineux (ou sous couches) ont tout d’abord été utilisés pour la rénovation des autoroutes en béton en 1991. Une enquête poussée avec analyse de la rugosité des surfaces, analyse de lame mince et résistance à l’arrachement a confirmé la validité de la technique utilisée. Après cette expérience positive, celle-ci fut développée et utilisée sur plusieurs terrains d’aviation pour rénover les surfaces endommagées par le gel, mais aussi améliorer et homogénéiser la capacité portante. La technique reposant sur l’enlèvement mécanique du béton endommagé suivi d’un hydrogrésage à haute pression est devenue une procédure standard sur les terrains d’aviation suédois. Cet article présente les résultats obtenus sur plusieurs terrains où la technique en question a été appliquée de façon satisfaisante. Les mesures obtenues en résistance à l’arrachement, analyse de lame mince et rugosité des surfaces seront présentées. La procédure toute entière sera également décrite étape par étape.

MOTS CLES :

BETON / RENOVATION / COUCHES DE ROULEMENT

INTRODUCTION

Today there exist various methods and material for thin concrete overlays or inlays. Unfortunately many materials are not comparable with the existing concrete pavements, especially material with a densely structure. Figure 1 shows one type of material that after three years use come completely loose.

Figure 1. Unsuitable materials for thin concrete layer.

This type of material is not suitable for concrete pavement used for airplane traffic due to the high risk of motor damage. We started the study of thin concrete overlays in 1991. The first use of thin concrete overlays was a concrete motorway with a rutting depth of 13-15 mm due to the use of studded tyres. The result was a success \1\ the bonds between the new top layer and the old concrete was very good.

Principle method for Military airfields

Frost scaling often damages the airfield pavement area in focus, see figure 2. Investigation of the damage area and the depth of damage concrete should always be done by for example thin section analysis. The principle method consists of several steps and can also be divided into two categories of repair equipment methods used. One is for greater areas and one for small areas but the principle is the same only the equipment differs from the two categories.

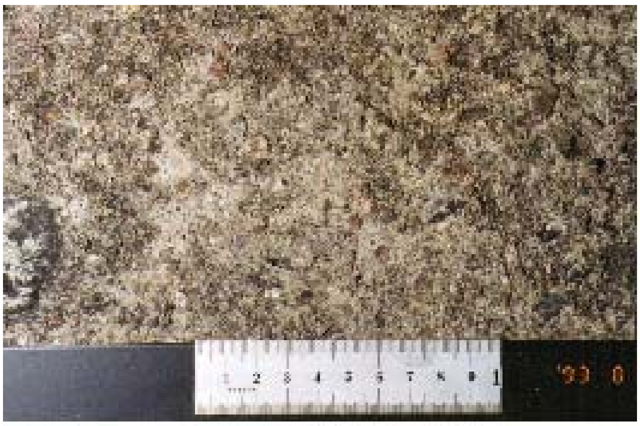

Figure 2. Frost damage area due to scaling.

Below is the principle method described step by step:

1. Milling of damage concrete

   Depending on the area for the repair work different milling machines can be used. It is important that when using an asphalt milling machine with high capacity the following cleanness procedure should use a very high water pressure blasting (800-900 bars), see point 2. For small areas a handhold-milling machine can be used. Good results have been achieved with milling depth from 10-35 mm.

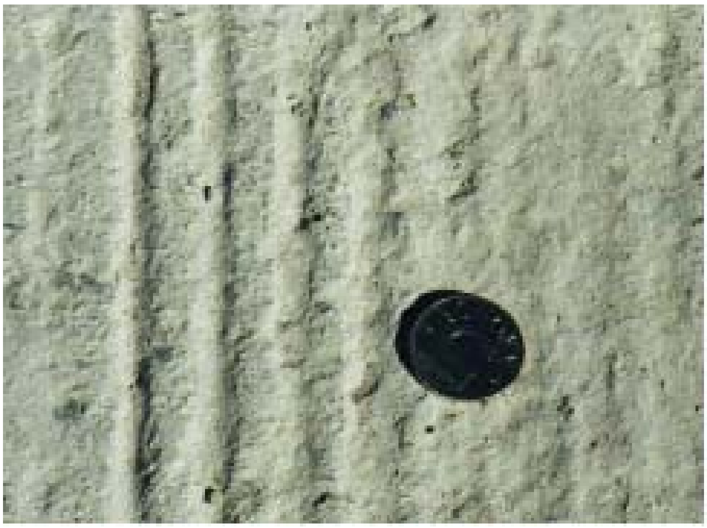

Figure 3. Surface after milling

2. The milled surface should be cleaned by a high pressure water jet blasting (milling) machine (800-900 bars). The machine can have several nozzles acting over a surface area of 500 mm. When using a handhold milling machine lower water cleaning pressure can be used (150-180 bars). The water blasting (milling) is used to remove any micro cracks in the milling surface. A less powerful milling machine will create less micro cracks and thereby less powerful water blasting can be used.

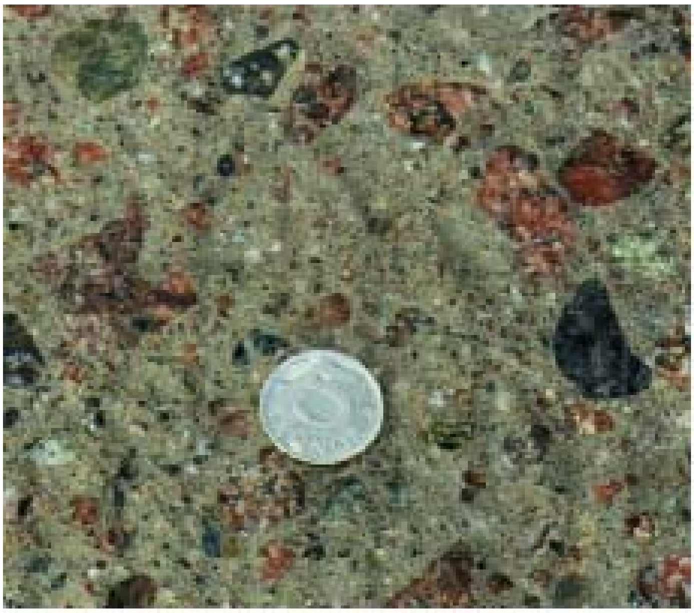

Figure 4. After cleaning with high pressure water.

3. The surface should be prewetted in at least 24 hours. At time of overlay placement the surface should be superficial dry. No bonding agent is necessarily.

4. The overlay should be casted with frost resistant concrete with water cement ratio below 0,45. The maximum aggregate size must be adjusted to the overlay depth. Casting a 35 mm depth the maximum aggregate size should be limited to 12 mm. If the depth is only 10 mm the maximum size should be 4 mm.

5. The final and very important step is the curing of the concrete surface. The best method is water curing for at least 2 days (and covering with a plastic sheet). The pavement should be slowly drying out from the water curing.

Roughness of the contact surface after milling

The roughness of the contact surface has been considered to play an important role to promote good bond between old and new concrete. In the first object the roughness was measured and compared to other methods *Petersson, Silfwerbrand* (1994). The roughness of the contact surface was measured on several slabs with simple equipment. Measurements were made after the milling both before and after water jet blasting (water jet milling). In *Silfwerbrand* (1990) the measured surface profile is proposed to be transferred to a saw-tooth curve with two parameters: double amplitude 2a and wavelength λ. Measurement results are shown in table 1.

Especially the amplitude value reflects difference in surface roughness. After milling the surface was ribbed. The roughness along the ribs was small. After water blasting, the longitudinal roughness was as the roughness in the transverse direction. Comparisons with different treatment methods show that the milling and water blasting had higher roughness than the sandblasted surfaces but lower than hammered and water jetted surfaces.

Table 1. Measured roughness values

Surface treatment	Double amplitude 2a (mm)	Wavelength λ (mm)
Milling (profile//longitudinal direction	0,5	21
Milling (profile//transverse direction	1,4	25
Milling + water jet blasting (profile// longitudinal dir.	1,4	27
Milling + water jet blasting (profile// transverse dir.	1,6	24
Water jet reference *	7,7	44
Jack hammers reference \2\	4,9	41
Sand blasting reference *	0,4	32

*Silfwerbrand** (1990) has shown that less importance ought to be taken to the roughness. Cleanliness and absence of micro cracks are more important. Thin section analysis has been used in order to study the interface between old and new concrete. The analysis shows a very good zone between old and new concrete. No micro cracks have been seen on the old concrete surfaces and elsewhere. The water blasting (water milling) has evidently removed all micro cracks that might have been introduced by the milling machine.

Results on bonding between old and new concrete

The method described above has been used on several military and civil airports with good results. The methods has mostly been used for renovation of frost damaged concrete surface but also for upgrading to higher airplane loadings.

The mean value for bond between two concrete layers shall fulfil the following relation.

$$X_m \geq f_v + 1{,}4\ s_n$$

where :

X_m : is the mean value

f_v : is the required bond strength (N/mm^2)

s_n : is the standard deviation; a value of 0,4 shall be used if $s_n < 0{,}4$

NOTE: Usual required bond strength for normal concrete is $f_v = 1{,}0$ N/mm^2.

Observe that the demands are the same as in the suggested European standard prEN 13877-2 and the testing methods follow prEN 13863-3.

Results from four different military airports using the thin concrete overlays are summarised in table 2.

Table 2. Recommendation and obtained values for bond between old and new concrete.

Swedish recommendation for concrete floors	> 1 MPa			
Silfwerbrand (1990)\	Jack Hammering 0,7 MPa	Sand blasting 1,1 - 1,3 MPa	Water Jetting 1,4 - 1,8 MPa	
Royal Swedish Fortification Administration Experience Four different airports Water blasting *[1]	Helsingborg 2,35 MPa	Hultsfred 2,42 MPa	Ängelholm 1,6 MPa	Kallax 1,7 MPa
Max/Min		*2,7/1,8*	*2,7/0,7*	*2,8/0,7*
Airport ”Malmen” year 2000 ”Simple equipment *[2]”	No primer 1,2 MPa		Primer Densit 1,5 MPa	
Max/Min	*1,8/0,7 MPa*		*1,8/0,9 MPa*	

*[1] Heavy asphalt milling machine followed by water blasting (milling) with 800-900 bars.
*[2] Light handhold milling machine followed by water blasting (150 bars) Note: bond break in old concrete can be the reasons for low values

Conclusion

Recommendation for the construction of thin concrete overlays has been given. Following the recommendations one can presume the following:

- Milling with a planer and subsequent water blasting (milling) with high water pressure gives roughness values above sand blasted surfaces. It seems to be sufficient for promoting a good bond

- The old surface will have no micro cracks (has been studied by thin section analysis)

- A good bond (bond strength values between 1,5-2,4 MPa) between old and new concrete can be obtained. The surface must be clean, but <u>no bonding agents are necessary.</u>

Figure 5. Thin concrete overlay (inlay) Hultsfreds airport done 1994, inspection 1999.

References

Petersson Ö, Silfwerbrand J,(1994)*Swedish experience with and recommendation for thin concrete overlays on old concrete roads*, "7th International Symposium on Concrete Roads" 3-5 October 1994 , Vienna Austria.

\2\ Silfwerbrand J,(1990) *"Improving concrete bond in repaired bridge decks",* Concrete International V 12 No 9 September 1990 pp 61-66

European standard, prEN 13877-2 Concrete pavements-Part 2: Functional requirements for concrete pavements

European standard, prEN 13863-3 Concrete pavements - Test methods – Part 3: Determination of bond between two concrete layers