International Journal of Multidisciplinary Research and Publications
ISSN (Online): 2581-6187

The Semi-rigid Wearing Courses in Austria (HSD)

Kerim Hrapović
EUR ING Civil Eng. PhD Mst. in AUSTRIA
Email address: kerimhrapovic046@gmail.com

Abstract— *Concrete wearing courses with their high deformation stability could be an alternative to asphalt wearing courses here, but these have other disadvantages besides their high production price. The gap between these two different types of wearing course is being bridged by the relatively new construction method of semi-rigid wearing courses. This construction method uses the technological properties and advantages of the flexible asphalt construction method and combines them with those of the rigid concrete construction method.*

Keywords— *Asphalt; beton; pavement; semi-rigid; wearing course.*

I. The Most Important Properties of the Semi-Rigid Wearing Courses

There is another possibility to produce a surface course for roundabouts: the semi-rigid wearing courses (HSD) version. This is a surface course which is produced as a combination construction method of asphalt and concrete in two work steps in a thickness of 4 - 6 cm (Figure 1). It combines the advantages of asphalt (flexibility) and concrete (load-bearing capacity and resistance to deformation) [1].

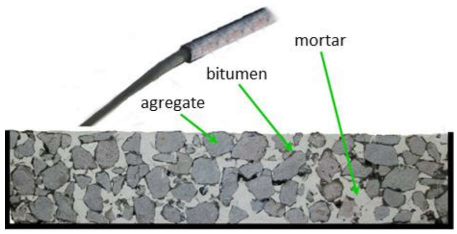


Fig. 1. Cross-section through a semi-rigid wearing course [1]

The advantages/disadvantages of these two different building materials and of the semi-rigid wearing courses are shown in Figure 2.

Product	Advantages	Disadvantages
Concrete	• high compressive strength • high static bearing capacity • high wear resistance	• joint maintenance • thick layer • crack susceptibility • long construction time (due to curing)
Asphalt	• flexible, jointless, crack-free • impermeable on request • short construction times • partial use of the existing structure for renovation of existing buildings	• unsuitable for high point loads • low tensile stress absorption
Semi-rigid wearing courses	• jointless construction • high static bearing capacity • high wear resistance • short construction times • low construction height • partial use of the existing structure for renovation of existing buildings	• no machine application of the mortar possible • trained personnel required for installation • gradient formation only possible up to approx. 5% • initial grip low

Fig. 2. The advantages/disadvantages of these two different building materials and of the semi-rigid wearing course [2]

II. Dimensioning of Semi-Rigid Pavement in Austria

In Austria, semi-rigid wearing courses are subject to the guidelines for planning, construction and maintenance of roads RVS 08.16.03 [3], to be applied to traffic areas with public transport but also to similar, private areas. This RVS specifies the areas of application, tender, building materials, production of the semi-rigid surface course, as well as containment and replacement tests.

The total layer thickness according to the pavement design as per RVS 03.08.63 [4] corresponds to the total layer thickness of the asphalt construction according to the respective load class and is shown in Figure 3.

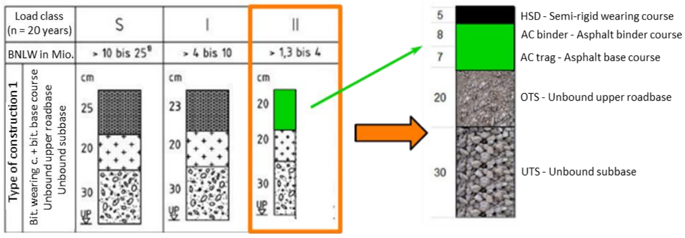


Fig. 3. Total layer thickness according to the pavement structure design - RVS 03.08.63 [1]

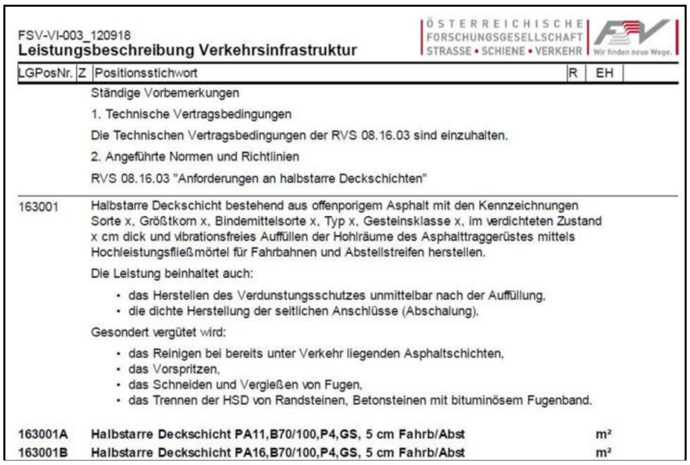
Figure 3 still shows the old designation for load class II - according to the new designation it is load class LK4. This means that BNLW is between 1.3 and 4 million. BNLW = Design normal load change.

III. The Tender Text for the Semi-Rigid Surface Courses in Austria

The tender text for the semi-rigid surface courses according to Standardized catalogue of specifications of services (only in German): FSV-VI 005 [5] can be seen on figure 4.

The Austrian Research Association for Roads, Railways and Transport (germ. *Forschungsgesellschaft Straße-Schiene-Verkehr*, FSV) as standards writing organization is mainly working in creating and editing guidelines and regulations in the fields of transportation and infrastructure.

The standardized catalogue of specifications of services describes standardized services including both legal and technical regulations (contract conditions) as well as the selected terms for a specified specification of services.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Leistungsbeschreibung Verkehrsinfrastruktur
ÖSTERREICHISCHE FORSCHUNGSGESELLSCHAFT STRASSE • SCHIENE • VERKEHR

LGPosNr.	Z	Positionsstichwort	R	EH
		Ständige Vorbemerkungen 1. Technische Vertragsbedingungen Die Technischen Vertragsbedingungen der RVS 08.16.03 sind einzuhalten. 2. Angeführte Normen und Richtlinien RVS 08.16.03 "Anforderungen an halbstarre Deckschichten"		
163001		Halbstarre Deckschicht bestehend aus offenporigem Asphalt mit den Kennzeichnungen Sorte x, Größtkorn x, Bindemittelsorte x, Typ x, Gesteinsklasse x, im verdichteten Zustand x cm dick und vibrationsfreies Auffüllen der Hohlräume des Asphalttraggerüstes mittels Hochleistungsfließmörtel für Fahrbahnen und Abstellstreifen herstellen. Die Leistung beinhaltet auch: • das Herstellen des Verdunstungsschutzes unmittelbar nach der Auffüllung, • die dichte Herstellung der seitlichen Anschlüsse (Abschalung). Gesondert vergütet wird: • das Reinigen bei bereits unter Verkehr liegenden Asphaltschichten, • das Vorspritzen, • das Schneiden und Vergießen von Fugen, • das Trennen der HSD von Randsteinen, Betonsteinen mit bituminösem Fugenband.		
163001A		**Halbstarre Deckschicht PA11,B70/100,P4,GS, 5 cm Fahrb/Abst**		**m²**
163001B		**Halbstarre Deckschicht PA16,B70/100,P4,GS, 5 cm Fahrb/Abst**		**m²**

Fig. 4. Example of a standardized position description for semi-rigid pavement type PA11 and PA16 [5]

Permanent preliminary remarks

1. Technical contract conditions

The technical contract conditions of RVS 08.16.03 must be complied with.

2. Standards and guidelines cited

RVS 08.16.03 "Requirements for semi-rigid surface courses".

163001 - Produce semi-rigid surface course consisting of open-pored asphalt with the designations grade x, coarse grain x, binder grade x, type x, aggregate class x, in compacted condition x cm thick and vibration-free filling of the voids of the asphalt framework using high-performance flow mortar for carriageways and parking lanes.

The service also includes:

- the creation of the evaporation protection immediately after the filling,
- the tight construction of the lateral connections (shuttering).

The following is remunerated separately:

- Cleaning of asphalt layers already under traffic,
- pre-spraying,
- cutting and grouting of joints,
- the separation of HSD from kerbstones, concrete blocks with bituminous joint tape.

163001A - Semi-rigid surface course PA11, B70/100, P4,GS, 5 cm pavement/storage area…..m^2

163001b - Semi-rigid surface course PA16, B70/100, P4,GS, 5 cm pavement/storage area…..m^2

The supporting structure for the semi-rigid wearing course is a porous asphalt PA11 or PA16 with at least 25 % pore volume, which is laid manually or mechanically with the asphalt paver without joints and without vibration. According to Austrian standard OENORM B 3586-1 [6] a void-rich pore asphalt PA 11 PmB 45/80-65, P4, G1 is a representative example (Figure 5).

The asphalt supporting structure of the semi-rigid pavement is made of mono-particle chippings, e.g. 8/11 mm aggregate of rock class G1 (with a Los Angeles value LA 20 and polishing value PSV 50). For the HSD, the good aggregate shape of the aggregate in the asphalt support structure is very important, therefore the SI15 requirement is the minimum requirement to be filled in.


Fig. 5. Support structure for the semi-rigid wearing course a PA11 porous asphalt [7]

Figure 6 shows the grading curve diagram of asphalt PA11 P4 according to (OENORM B 3586-1, 2018) is shown.

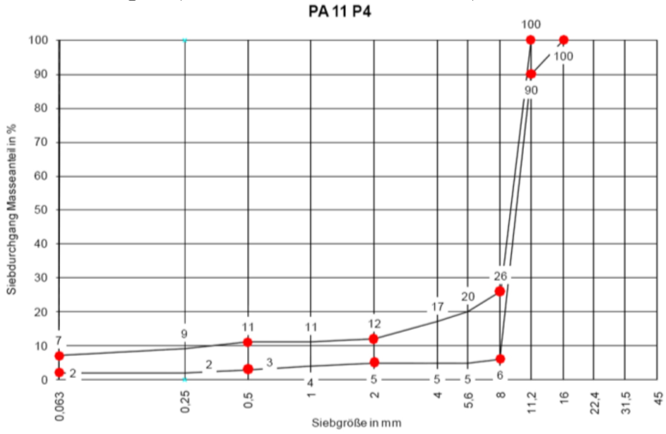

Fig. 6. Recommended and prescribed borderline sieve line ranges [7]

The recommended fillers for semi-rigid wearing courses are limestone powder and the recommended bitumen is conventional 70/100 bitumen or polymer modified bitumen PmB 45/80-65.

The first step in the installation of HSD slabs is the construction of the asphalt supporting structure. This supporting framework is then filled with high-performance flowing mortar in a second work step, whereby all accessible cavities are completely penetrated with the mortar (Figure 7).


Fig. 7. Completely penetrated with the mortar [7]

IV. Requirements for the Mortar

It is extremely important to adhere strictly to the prescribed requirements when producing HSD. The further requirements according to RVS 08.16.03 [3] are shown in the following tables Table I and Table II.

TABLE I. Requirements for fresh mortar (RVS 08.16.03, 2014) [7]

Test parameters	Unit	Requirement	Test method
Marsh time (T_0)	s	< 45	A.2.1
Marsh time after 60 min (T_{60})	s	< 55	
Fresh mortar density (F_0)	kg/m³	> 2.000	
Fresh mortar density after 60 min (F_{60})	kg/m³		
Flow table diameter (A_0)	mm	> 155	A.2.2
Flow table diameter after one hour (A_{60})	mm	> 150	
Water requirement	M.-%	to be specified by the producer	
Water/solids value	-	is to be indicated	ONR 23303 Pkt. 8.4.2 Microwave method 1) 2)
Settling behaviour, density difference	kg/m³	< 50 kg/m³	A.2.3
Settling behaviour, microstructure change	-	to be specified by the producer 3)	
Blood behaviour	ml	< 1 ml	
Solidification time	cm; min	is to be indicated	EN 13279-2, Pkt. 4.4.2

TABLE III. Requirements for fresh mortar (RVS 08.16.03, 2014) [7]

Material parameters	Requirements	
Shrinking at the prism	≤ 3 ‰	
Early shrinking at the prism	≤ 1 ‰	
Strengths	**Class I**	**Class II**
Flexural strength after one day Compressive strength after one day	>5 N/mm² >40 N/mm²	>3 N/mm² >20 N/mm²
Flexural strength after 3 days Compressive strength after 3 days	>7 N/mm² >65 N/mm²	>4 N/mm² >40 N/mm²
Flexural strength after 28 days Compressive strength after 28 days	>10 N/mm² >100 N/mm²	>6 N/mm² >60 N/mm²

It is also important not to clear the traffic area made with HSD ceiling too early for traffic. The traffic release as a function of the average ambient temperature for mortars of strength class I is shown in Table III.

TABLE IIIII. Traffic release as a function of the average ambient temperature for mortars of strength class I (RVS 08.16.03, 2014) [7]

Average ambient temperature	Traffic release
> +20 °C	after 24 h = 1 day
15 – 20 °C	after 2 days
10 – 15 °C	after 3 days

Fig. 8. Damage in the carriageway of a roundabout designed as a semi-rigid wearing course [8]

Fig. 9. Damage in the carriageway of a roundabout, designed as a semi-rigid wearing course [8]

It is very important that the supporting structure cools down to below +30 °C before the mortar is applied. In this sense, after-treatment of the HSD slab is extremely important, such as covering it with white protective foil to protect the semi-rigid wearing course from rain and sunlight, because in summer the surface temperature of the asphalt rises above +60 °C. When filling the asphalt supporting structure, the mortar flows like water for one hour and has a compressive strength of 40 N/mm² after 24 hours.

Therefore, with this type of construction, great care must be taken to do everything correctly, otherwise the road may be damaged, as in the example of the roundabout on Fig.8 and Figure 9.

V. Bitucem – Highly Flowable Mortar for Semi-Rigid Wearing Course

Baumit Bitucem is a highly flowable, low-viscosity, high-performance flowable mortar which is suitable for backfilling drainage asphalt. The mortar is characterized by long working time, low shrinkage and high strength. After mortaring with BAUMIT Bitucem, the semi-rigid slab is usually ready for loading/traffic after 24 hours and has reached approx. 2/3 of its intended final strength [9]. The cement in Bitucem must meet the quality requirements of the standard OENORM EN 197-1 [10].

Baumit Bitucem is suitable for filling all asphalt supporting structures approved according to RVS 08.16.03 - Requirements for semi-rigid wearing courses (HSD). Semi-rigid wearing courses are used in the construction of highly loaded traffic, storage and industrial areas, and industrial areas and areas with increased demands on impermeability and chemical resistance [9].

Technical data of Bitucem:
- Standard classification: RVS 08.16.03
- Nominal maximum grain size D: 0.25 mm
- Bulk density: approx. 1280 kg/m³
- Water requirement: 21.3 - 21.8 %.
- Consumption: approx. 5 - 6 kg/m²/cm with void contents of 24 - 30 % in the asphalt supporting structure

- Marsh time immediately (T0): ≤ 45 s
- Marsh time after 30 min (T30): ≤ 55 s
- Compressive strength (24h): ≥ 20 N/mm²
- Compressive strength (28d): ≥ 60 N/mm²

Semi-rigid wearing courses with Baumit Bitucem are [9]:

- Frost and de-icing salt resistant according to OENORM B 23303:2002 [11] (XF2/XF4)
- Resistant to substances hazardous to water in accordance with DAfStB guideline "Concrete for handling substances hazardous to water (class L2)
- Impermeable to water according to OENORM B 4422-2:2002 [12].

The mortar is delivered in a construction site silo with a flange-mounted silo mixing pump or as bagged goods (25 kg bags).

Higher temperatures and direct sunlight lead to a greatly reduced working time and extreme strength development of the mortar. Both can negatively influence the quality and durability of the semi-rigid wearing courses (e.g.: smooth surface, pinholes, unfilled cavities, etc.). If critical temperature conditions are to be expected, it is recommended to grout in the evening or night hours and to avoid direct sunlight. The protection consists in the application of a special agent to prevent rapid evaporation according to RVS 11.06.42 [9, 13].

The evaporation protection (e.g.: Avenarius Aquastat E, BASF Mastercure 207, SIKA Antisol E, Murexin LF3) must be applied with a high pressure sprayer immediately after mortaring. Application quantity according to TDB approx. 0.2 kg/m² [9].

An increase in the initial grip can be achieved by removing the evaporation protection with a hot high-pressure water jet and wax-dissolving cleaning additive shortly before opening to traffic.

At high temperatures, a building protection mat must be kept damp continuously throughout the entire after-treatment period. Removal must take place in the evening hours [9].

VI. Examples for the use of semi-rigid pavement

So if everything is done correctly, a semi-rigid pavement can be used to asphalt not only roundabouts (Figure 10) but also the most heavily used traffic areas such as roads and highways, without the subsequent formation of cracks in the asphalt pavement or other damage.

Fig. 10. Very good condition of the semi-rigid pavement of a roundabout years after installation [8]

Fig. 11. Industrial bearings with semi-rigid pavement [7]

Fig. 12. Highly stressed traffic areas with semi-rigid pavement [7]

Fig. 13. Highly stressed traffic areas with semi-rigid pavement [7]

Fig. 14. Highly stressed traffic areas with semi-rigid pavement [7]

Fig. 15. Highly stressed traffic areas with semi-rigid pavement [7]

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