
BELGIUM

3.5 Belgium

* Concrete Pavements in Belgium

Belgium has constructed concrete for many years. A 67-year-old jointed concrete pavement constructed in 1925 in south Brussels (Dreve-de-Lorrine) is still in good condition, as shown in Figure 3.14. Approximately 40 percent of freeways are constructed with concrete pavement (645 km (400 miles) out of 1631 km (1023 miles) total) which are mostly CRCP, but a lot of jointed plain concrete pavement exists also. For example, a 35-year-old dowelled jointed plain concrete pavement in good condition was driven over on the freeway between Einhoven and Brussels. The pavement had a 20-cm (7.9-in) concrete slab on 15 cm (5.9 in) of cement-treated sand and 15 cm (5.9 in) of untreated sand. Several sections of even older jointed concrete pavement were also observed during the tour. The Belgian government favors CRCP due to its low maintenance requirements and has built this pavement extensively since 1970 as new pavement and as overlays of old concrete and asphalt pavements.

Belgium is well known for its development and extensive use since the early 1980’s of the exposed aggregate technique that provides reduced rolling noise and vehicle vibration levels but also a high-friction surface.

Figure 3.14 Dreve-de-Lorraine highway, Brussels, a 67-year-old jointed concrete pavement constructed in 1925 with no longitudinal joints.

- **Designs**

Both jointed plain (with dowels) and CRC pavements have been constructed. The original and current CRCP designs are as follows (1):

Item	Original (1970-1978)	Current (1979-1992)
CRC Slab	20 cm (7.9 in) (high strength)	Same
Reinforcement	0.85 percent	0.67 percent
Reinforcement Depth	6 cm (2.4 in)	9 cm (3.6 in)
AC Interlayer	6 cm (2.4 in)	***
Lean Concrete Base	20 cm (7.9 in)	Same
Granular Mat	20 cm (7.9 in) minimum	Same
Longitudinal Joint Depth	< 0.33 Slab	0.33 Slab

*** This layer was eliminated for several years but is now included.

Over 100 km (62 miles) of the original CRCP design was built on freeways which carry heavy trucks. It has shown exceptional performance: no punchouts have occurred over the past 20 years under very heavy traffic. One of these 20-year-old CRCPs is shown in Figure 3.15. This pavement has recently been diamond ground to reduce noise from the original harsh cross tining.

However, in about 1978, the pavements had very tight closely spaced cracks (crack spacing was 0.5 m (1.6 ft)), and the government became concerned that the pavement would break up. On subsequent projects the reinforcement was reduced to 0.67 percent and the AC interlayer was eliminated, which resulted in a larger crack spacing. Some of these newer pavements are starting to show crack spalling and a few punchouts. Typical crack spacings are as follows.

Figure 3.15 20-year-old CRCP in Belgium containing 0.85 percent reinforcement, AC interlayer, lean concrete base and a granular subbase. (Note that a portion was diamond ground to reduce noise emission of the original transverse tining).

Construction Season	Percent Reinforcement	Mean Crack Spacing, m (ft)
Summer	0.85 (original)	0.40 (1.31)
	0.67 (newer w/o AC)	1.00 (3.28)
Winter	0.85 (original)	0.75 (2.46)
	0.67 (newer w/o AC)	1.60 (5.25)

This close crack spacing for the 0.85 percent CRCP is also the result of the 6 cm (2.4 in) of AC interlayer tightly bonded to the CRCP for the original design. The bonding of the CRCP to the AC interlayer is believed by the Belgian engineers to provide a structural equivalent of 2 cm (0.8 in) of concrete.

At about the same time, the depth of steel was changed from 6 cm (2.4 in) to the 9-cm (3.6 in) depth used now because of some problems with construction. On a sunny day one may see the bar pattern due to an effect of vibration near the longitudinal bars: the concrete vibrates more under the bar, causing: unevenness of the surface. However, Belgium still believes that it is best to place steel above middepth to keep the cracks tight.

Several CRCP sections constructed since 1978 with no AC interlayer and 0.67 percent steel at a depth of 9 cm (3.6 in) have had larger crack spacings, wider cracks, erosion of the lean concrete base, and some punchouts.

When the shoulders include an AC surface with a granular base, water can drain laterally. However, when full-depth AC is placed as a shoulder, a bathtub exists and significant erosion occurs, followed by punchouts.

A corrosion study was recently conducted, in which cores at CRCP cracks were examined. Only minimal corrosion was observed, particularly for the original (0.85 percent steel) sections. The loss in cross-sectional area of reinforcing bars, as measured in the most severe cracks in the original and current sections, does not exceed 5 percent for either design. (2)

- **CRCP Overlays**

A number of CRCP overlays have been placed on old concrete pavements and on old asphalt pavements. Performance of these overlays has generally been good.

- **Concrete Material**

The concrete has not contained air entraining agent. However, a high cement content (400 kg/m^3 (674 $pounds/yd^3$)) produces a strong, dense concrete with a compressive strength minimum of 55 MPa (7,860 psi) and a mean of about 70 MPa (10,000 psi) at 90 days. The water/cement ratio is low, at 0.40 originally and 0.45 now. No freeze-thaw or any other durability problems exist and no joint deterioration problems exist. The high cement content helps reduce surface wear also.

Concrete pavements have been recycled back into lean concrete base, but not surface concrete because Belgium has an abundant supply of very good. aggregates.

- **Noise Pollution**

A major concern about traffic noise exists in Belgium. This is largely due to the dense population, especially near highways. Between 1965 and 1975 a large amount of highway construction occurred in Belgium and most of the concrete pavements were textured by transverse coarse tining. This was very good for friction and hydroplaning but caused considerable road noise and vibrations, which precipitated many complaints.

In 1980, Belgium began using an exposed aggregate technique which is described below for the E40 project. In Belgium, however, the slab is placed in one layer only with high-quality hard aggregate throughout, not in two layers as in Austria. This patented exposed aggregate technique has been used extensively and provides a durable surface that has about 4 dB(A) less rolling noise than cross tining. (Rolling noise is the noise produced by the contact of the tire with the pavement.) This is about the same rolling noise level as porous asphalt exhibits after one year (porous asphalt becomes clogged with fines and the noise level increases with time). Porous asphalt overlays of concrete pavements only last 5 to 10 years and then need to be replaced due to deterioration.

- Project Sites Observed

E40 Freeway near Bierbeek. Longitudinal diamond grinding was recently completed on this 20-year-old CRCP as a solution to noise caused by a fairly coarse surface transverse texture (6 mm (0.24 in) depth and 25 mm (1 in) spacing), as shown in Figure 3.15. About 4 to 6 mm (0.16 to 0.24 in) of surface was ground off and the bottom of the transverse tining was still present after grinding. This CRCP carries 63,000 ADT with 20 percent heavy trucks and is in excellent structural condition with no punchouts and close crack spacing. The measured rolling noise levels in dB(A) are shown below. The grinding reduced the noise level by an average of 4 dB(A).

Lane	Before Grinding	After Grinding
1	87.9-90.3	83.4-86.8 dB(A)
2	90.2-91.3	86.287.5 db(A)

The vibration level in the tour bus was significantly lower riding over the ground pavement than over the original cross-tined surface. Measured friction numbers increase significantly after grinding also.

E40 Bertem Widening Construction Site (near the grinding site). The existing 21-year-old, 20-cm (7.9 in) CRCP with 0.85 percent steel was being widened with an additional CRCP traffic lane. An added objective was to provide a low-noise surface texture.

✓ The low-noise surface texture was produced by chemically exposed aggregate. The slab is placed in one layer (the steel was placed on chairs) with the same. aggregate throughout its depth (2 cm (0.8 in) maximum size). After the paver passes, the surface is immediately sprayed with a retarder which penetrates several millimeters into the mortar. A polyethylene sheet is then placed over the surface as shown in Figure 3.16. This serves to protect the retarder from the effects of inclement weather and to provide for curing when the retarded surface mortar is removed through special wire brushing after 24 to 72 hours.

Figure 3.16 Polyethylene sheeting placed over concrete surface after retarder has been sprayed (Robuco process). (4)

The surface aggregate is exposed to achieve the desired texture using a rotating brush shown in Figure 3.17. Either a sugar-based retarder which provides a 2 mm (0.8 in) texture (used on the E40 project), or a chemical retarder which provides a finer 1 mm (0.4 in) texture (as used in Austria) may be used. (4)

✓ The transverse steel reinforcement was skewed to avoid the potential for causing transverse cracks and has been standard for many years.

E40 Freeway CRCP. Traffic on this route is very heavy and similar to the E40 project at Bierbeek This pavement is 20 years old. It has 0.85 percent steel at a depth of 6 cm (2.4 in), a 20-cm (7.9-in) CRC slab, 6-cm (2.4-in) of AC, 20 cm (7.9 in) of lean concrete and about 30 cm (11.8 in) of gravel. Cracks are spaced about 0.5 m (1.6 ft) and are very tight, with no failures. This project is an example of the original Belgian design that has provided excellent service.

A12 Freeway CRCP Overlay. This pavement is 12 years old. It has 0.67 percent steel at a depth of 9 cm (3.6 in), and a 20-cm (7.9 in) CRC slab placed over a badly rutted AC pavement. Cracks are spaced about 1 m (3.3 ft) apart and a few are spalling, with pumping and a few punchouts occurring.

N45 Aalst Whitetopping with Fibrous Concrete. This project has an ADT of 12,000 with 15 percent trucks.

Figure 3.17 Rotary brush removing thin surface layer of mortar to provide the exposed aggregate surface after polyethylene sheeting has been removed.

It consists of a 3-year-old thin steel-fiber-reinforced concrete overlay (30 kg/m^3 (50 pounds/yd^3), 5 cm (2 in) long) placed over a badly rutted AC pavement. The overlay was 12 cm (4.7 in) thick with a 10-m (32.8-ft) undowelled joint spacing. A transverse joint is shown in Figure 3.18. The existing 22-cm (8.7-in) AC pavemeni was milled 12 cm (4.7 in) prior to placement of the 12-cm (4.7-in) fiberized concrete overlay. The pavement was in excellent condition.

Belgium has constructed over 130,000 square meters (155,500 square yards) of this type of overlay. This pavement has performed best when placed over existing AC pavement or when a 4.5- to 6-cm (1.8 to 2.4 in) layer of AC was placed over an existing concrete pavement prior to the fibrous concrete. No cracking or other distress was observed. A 12-cm (4.7 in) thickness is considered a minimum for design and a 5 m (16.4 ft) joint spacing has worked the best. It was stated that there are actually few fibers at the surface (less than 1 percent) so that if they corrode it would not affect performance.

The design assumes that the fibrous overlay bonds to AC. Normal concrete overlays of AC pavement would be 18 cm: Belgium assumes that two thirds of this normal thickness may be used with steel fiber reinforcement. (3)

Figure 3.18 Surface and transverse tining of fiber-reinforced concrete overlay of an AC pavment in Belgium.

- Traffic Loadings

Traffic loadings in Belgium are very heavy. Figure 3.19 shows axle load distribution data for 1965 and 1991, obtained from Belgium. Note the heavy loads and the significant increase over time. The annual number of axles over the current U.S. limit of 8.9 t (20,000 pounds) is 13 percent. There is very little enforcement of load limits in Belgium.

- Summary for Belgium

The performance of concrete pavements in Belgium can only be described as exceptionally good, especially the original CRCP. The primary reasons include the following for the original design:

✓ The previously used 0.85 percent reinforcement placed 6 cm (2.4 in) from the top of the CRCP slab,

✓ High cement content (400 kg/m^3 (674 $pounds/yd^3$)) for good wear,

✓ The 6-cm (2.4-in) AC interlayer providing good bond between the CRC and the lean concrete layer to reduce erosion,

✓ The thick granular layer above the subgrade, and

✓ The high-strength concrete and its complete resistance to freeze-thaw damage.

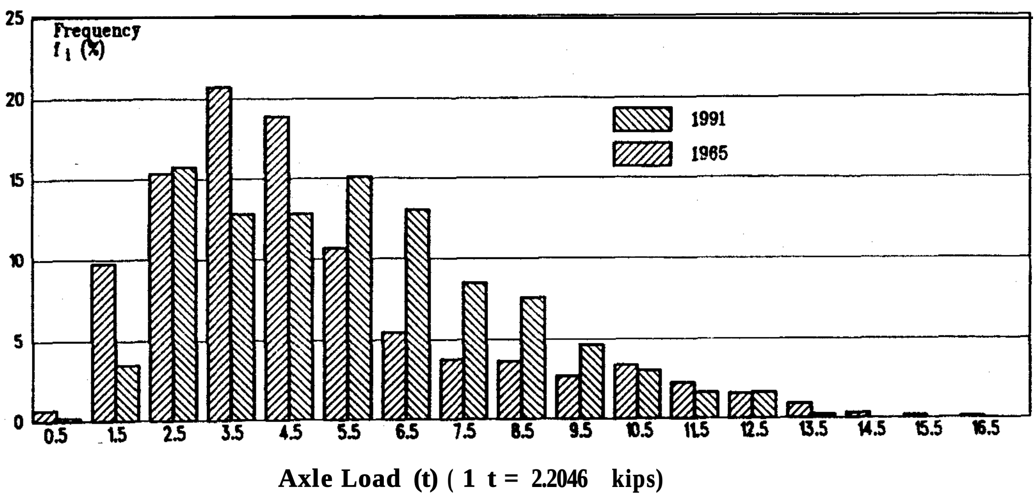

Figure 3.19 Axle-load distribution in Belgium in 1965 and 1991.

A design life of 30 years or more design life with low maintenance is expected due to the tight closely spaced cracks and absence of erosion.

Several recent designs included reduction in steel content to 0.67 percent, placement of the steel 9 cm (3.6 in) deep and elimination of the AC interlayer. This pavement design has not performed as well as the original CRCP design: the cracks are wider and erosion has occurred between the slab and the lean concrete base. It has been reported that the AC layer is now being used again.

CRCP has been built as both new pavement as well as overlays. The CRCP pavement is paved directly over bridge decks. Bridges are designed to carry this increased dead weight.

- **Belgium References**

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