An Update on Kansas' Experience with PCCP Smoothness Specifications and Incentives

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The smoothness or riding comfort of Portland cement concrete pavements (PCCP) is the highest indicator of quality from the user's perspective. Therefore, the smoothness of newly constructed PCCP is of high interest. Since its development in 1990, the Kansas PCCP smoothness specification has undergone several revisions. The 1996 revision changed the incentive/disincentive payment from a percent of bid unit cost for the PCCP paving basis to a dollar-based value. This revision of the PCCP smoothness specification is primarily an attempt to make this smoothness specification more compatible with the asphalt concrete smoothness specification, which has been based on dollar value. This paper primarily outlines the current PCCP smoothness specifications in use in Kansas and also updates this development. Key words: PCCP, smoothness, profilograph, specification, incentives, and disincentives.

INTRODUCTION

Pavement roughness can be described by the magnitude of longitudinal profile irregularities and their distribution over the measurement interval and consists of random multifrequency waves of many wavelengths and amplitudes. Longitudinal roughness has been defined as *(1)*:

> *the longitudinal deviations of a pavement surface from a true planar surface with characteristic dimensions that affect vehicle dynamics,, ride quality and dynamic pave ment load.*"

ASTM *(2)* defines roughness as:

> *The deviations of a pavement surface from a true planar surface with characteristic dimensions that affect vehicle dynamics, ride quality, dynamic loads, and drainage, for example, longitudinal profile, transverse profile and cross slope.*

Pavement smoothness is a *lack* of roughness. This is a more optimistic view of the road condition. Pavement profiles and detailed recordings of surface elevations are frequently used to characterize smoothness. Different wavelengths will have different effects on ride quality depending upon vehicle characteristics and driving speed. Thus, smoothness is an important indicator of pavement riding comfort and safety. From an auto driver's point of view, rough roads mean discomfort, decreased speed, potential vehicle damage, and increased operating cost. A 1995 National Quality Initiative (NQI) national customer survey showed the following priorities for improving highways (*3*):

Pavement Conditions	36%
Safety	22%
Traffic Flow	16%
Visual Appeal	11%
Bridge Condition	6%
Maint. Response Time	6%
Travel Amenities	3%

It is clear that highway users demand a good pavement condition—the ride quality is a function of it. According to Hudson (*4*), the purposes for smoothness measurement are:

1. To maintain construction quality control
2. To locate abnormal changes in the highway, such as drainage, subsurface problems, or extreme construction deficiencies
3. To establish a statewide basis for allocation of road maintenance resources
4. To evaluate pavement serviceability-performance life histories for evaluation of alternate designs.

The road surface smoothness on newly constructed Portland cement concrete pavement (PCCP) is of major concern to the Kansas Department of Transportation (KDOT). The first PCCP with smoothness specification was built by KDOT in 1985, and the first standard specifications were adopted in 1990. The purpose of the specification was to maintain construction quality control.

There is a growing concern in the transportation industry for smoother and smoother pavements. In a 1990 NCHRP study, it was shown that of the 36 states reporting, 80 percent exercised smoothness criteria on new pavement construction (*5*). Just two years later, in another NCHRP study, it was shown that of the 22 states reporting, 91 percent utilized smoothness criteria on construction of new pavements (*5*). A trend toward smoother and smoother pavements will require specifications that are attainable and practical for the contractor.

Since KDOT adopted its first PCCP smoothness specification in 1990, the quality of concrete paving has improved in Kansas. The 1990 specification gives contractors either incentive or penalty payments based on a percentage of the contract bid item price. To make the specification more compatible with the asphalt concrete (AC) smoothness specification, which is based on a dollar amount of incentive or penalty, KDOT revised the 1990 PCCP smoothness specification in 1996 and based it on a dollar amount of incentive or penalty.

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DEVELOPMENT OF PCCP SMOOTHNESS SPECIFICATIONS IN KANSAS

In 1985, KDOT selected a 7.63 m (25 ft) California-type profilograph using the 5.1 mm (0.2 in) blanking band for evaluation of the profilogram used in determining the smoothness of newly constructed concrete pavements. At that time, KDOT developed a provisional set of specifications and tested their attainability on three projects over two construction seasons. The results indicated that the provisional smoothness specifications were attainable and resulted in better quality pavements. In 1990, the specifications shown in Table 1 were adopted as standards for quality control of as-built concrete pavement smoothness in Kansas (*6*).

TABLE 1 Schedule for Adjusted Payment for PCCP(1990 Specification 502.06)

Profile Index mm/km (0.16 km section)	Price Adjustment Percent of Contract Unit Bid Price
48 or less	106
49 to 64	103
65 to 159	100
160 to 191	96
192 to 222	92
223 to 238	90
239 or more	88
	(Corrective Work Required)

In 1990, there was a noticeable, high-frequency vibration on a PCCP reconstruction project on I-70. On a concurrent project on I-470, such a problem did not exist. Viewing the profilograph traces more closely revealed a sine-wave oscillation of about 2.44 m (8 ft) spacing with a 5.1 mm (0.2 in) amplitude. However, most of the surface deviations were covered up by the 5.1 mm (0.2in) blanking band width during the trace reduction. On the I-470 project the oscillation waves were spaced at about 9.14 m (30 ft) with an amplitude of 5.1 mm (0.2 in), which were again covered by the 5.1 mm (0.2 in) blanking band width (*6*).

The I-70 and I-470 projects of 1990 prompted KDOT to study the effects of the blanking band width on trace reductions. It was decided to use a "zero" blanking band width or "null" blanking band. A null blanking band is nothing more than a reference line placed approximately at the center of the trace. Each of the 1990 projects was reanalyzed using the null blanking band. By replacing the 5.1 mm blanking band with the null blanking band achieving bonus sections became more difficult. The change in the blanking band width resulted in a new specification for PCCP smoothness, 90P-111. The new specification was incorporated into the 1992 construction projects (*6*).

Revisions to the original 1990 specification continued to occur. In 1992, another revision was made to the PCCP smoothness specification, 90P-111. With the introduction of 90P-111-R1 in 1993, the maximum amount of bonus was increased from 6% of the unit bid price to 8% of the unit bid price, but the full pay range was narrowed to include slightly more rigid grind-back provisions. In 1994, 90P-111-R2 and 90P-111-R3 were intended to make pavements initially smoother by lowering the PRI values required for the highest, 108%, incentive payment. In 1996, the specification took a major turn and replaced the percent unit bid item price incentive with a dollar value incentive with 90P-111-R4. Revisions continued and are continuing to include such changes as requiring ProScan automated profilogram reduction software, grinding provisions, and a 7.62 mm (0.3 in) bump template (*7*).

ORIGINS OF THE DOLLAR-BASED INCENTIVE/ DISINCENTIVE PAYMENTS, 90P-111-R4

In 1996, it was decided to introduce 90P-111-R4. This revision to the original PCCP smoothness specification changed the incentive from percent of unit bid item price to a dollar value. Table 2 shows the PRI ranges and the incentive or disincentive dollar values associated with each. The specification took on a new form that had only previously been used for in the AC smoothness specification.

TABLE 2 Schedule for Adjusted Payment for PCCP (1996 Specification 90-111-R4)

Profile Index mm/km (0.16 km section)	Contract Price Adjustment per 0.16 km section per lane
160 or less	+$845.00
161 to 240	+$630.00
241 to 285	+$420.00
286 to 475	+$315.00
476 to 710	$0.00
711 or more	-$530.00

This revision to the PCCP smoothness specification was done for two reasons. The first was to make the PCCP smoothness specification more compatible with the AC smoothness specification, which has always been based on dollar value. The second reason was to put an actual value on smoothness. Contractors have a better understanding of what it is worth to KDOT to have newly constructed PCCP as per the smoothness outlined in the specifications. The 1996 revision did have a somewhat positive effect on the number of sections constructed in the bonus range and penalty range as evident by Figure 1.

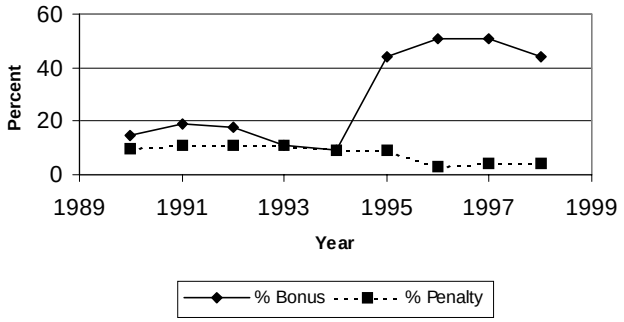

FIGURE 1 Schedule for adjusted payment on PCC Pavements

The AC pavement smoothness specification has always been based on the dollar value incentive or disincentive. KDOT lets asphalt paving construction as unit bid item tonnage. Since asphalt prices are based on the tonnage of material used and not the actual amount of coverage, it was logical to base the AC smoothness specification on a dollar value that was related to the price of one ton of asphalt concrete production, placement, and compaction. This logic was the reason for the dollar value-based incentive and disincentive payments in the AC pavement smoothness specification.

The original PCCP smoothness specification was based on percent of bid item. The PCCP smoothness specification was designed this way because concrete pavement is usually bid as unit item square meter. However, in 1996, KDOT decided to make the PCCP smoothness specification more compatible with the AC pavement smoothness specification. The dollar value-based incentive and disincentive specification, 90P-111-R4, shown previously in Table 2, was adopted.

The derivation of the dollar values was based on the average cost of a square meter of concrete pavement (*8*). The average cost of construction was then increased by the previous PCCP smoothness specification percentages to determine the actual dollar amounts of bonus or penalty.

· The total number square meters in one 3.66 m (12 ft) lane 0.16 km (0.1 mile) long:

3.66 m X 160 m = 585.6 square meters

· The cost of this section of concrete pavement (based on the statewide average cost of doweled, plain jointed concrete pavement for KDOT):

585.6 square meters X $18.03 per square meter = $10,558.36

·The price of this section including incentive payment (maximum 108 percent, based on 90P-111-R3 adjusted schedule):

$10,558.36 X 1.08 = $11,403.04

· The maximum amount of incentive for a 0.16 km (0.1 mile) section:

$11,403.04 - $10, 558.36 = $844.68 » $845.00

The dollar amounts for the other smoothness (profile index) ranges were determined in the same way. Although the penalty amount may appear extreme (-$530.00), it too was based solely on 95 percent of the average cost per section. When put in terms of dollars, contractors are expected to be more discouraged from committing contractor negligence.

CONCLUSIONS

The PCCP smoothness specifications in Kansas, adopted by KDOT in 1990, has been revised several times to take advantage of our growing knowledge in PCCP smoothness. The transition to the dollar-based incentive or disincentive PCCP smoothness specification has given KDOT and contractors a better understanding of the value of smoothness. Also, the PCCP smoothness specification is now more comparable to the AC pavement smoothness specification. This allows contractors and KDOT to better relate and compare the cost of AC pavement versus PCCP in terms of smoothness. By attaching dollar signs to bonus and penalty pavements, the desire to achieve smoother and smoother pavements has only increased. As the measure of pavement smoothness evolves, adjustments to the specifications will continue to be made.

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