

EVALUATION OF TWO LABORATORY-BASED DESIGN METHODS FOR CIR MIXTURES

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INTRODUCTION

In the international technical literature there are many mix design and laboratory testing methods concerning cold in place recycling (CIR) with bitumen emulsion. In Spain, the Circular Order 40/2017 (known as PG-4), replaced the Circular Order 8/2001 (former PG-4). This change in regulation includes new specifications and compaction methods (Table 1).

Standard	Circular Order 8/2001	Circular Order 40/2017
Specimen size	Diameter 100 mm Height 190 mm	Diameter 100 mm Height 66 mm
Optimum Water Content (OWC, %)	MPT (%) – 0.5% – EC (%) (Eq.1)	MPT (%) – 0.5% – BC (%) (Eq.2)
Compaction Method	Static Compaction (NLT-162)	Gyratory compactor 100-150 gyrations (EN 12697-31)
Strength and water sensitivity Tests	Unconfined Compression Strength (UCS) Dry and wet Retained Strength Ratio (RSR) (NLT-162)	Indirect Tensile Strength (ITS) Dry and wet Indirect Tensile Strength Ratio (ITSR) (EN 12697-12)

BC: Bitumen Content; EC: Emulsion Content

Table 1 – Main differences between standards

OBJECTIVE

Compare the two methods specified in the current and the former PG-4 for the design of CIR, showing the difficulties encountered.

MATERIALS

- 100% Reclaimed Asphalt Pavement (RAP)
- Cationic slow setting bitumen emulsion C60 B5 REC
- Portland cement as filler

METHODS

Optimum water content (OWC):

The OWC was estimated on the basis of Modified Proctor Test (MPT) (EN-103-501-94) and the added water is obtained using the equations Eq.1 and Eq.2.

CIR Manufacturing:

The manufacturing process was carried out according to parameters in table 2.

Series Name	Standard	Design Method	Compaction Method	Residual Bitumen	OWC	Portland Cement
Static series	CO 8/2001	Dry and wet Unconfined Compression Strength (UCSd and UCSw) Retained Strength Ratio (RSR) (NLT-162)	Static compaction	1.50% 1.75% 2.00% 2.25% 2.50%	Eq. 1 2.75% 2.33% 1.92% 1.50% 1.08%	0.00%
Gyratory series 1	CO 40/2017	Dry and wet Indirect Tensile Strength (ITSd and ITSw) Indirect Tensile Strength Ratio (ITSR) (EN 12697-12)	Gyratory compactor (100 gyr.)	2.50% 3.00% 3.50% 4.00% 5.25%	Eq. 2 2.75% 2.25% 1.75% 1.25% 0.00%	1.00%
Gyratory series 2	CO 40/2017*			Gyratory compactor (150 gyr.)		
Gyratory series 3			Gyratory compactor (200 gyr.)		1.50% 2.00% 2.50% 3.00%	
Gyratory series 4				Gyratory compactor (100 gyr.)	1.50% 2.00% 2.50% 3.00%	
Gyratory series 5						

*with CO 8/2001 OWC formulation (Eq.1)

Table 2 – Parameters of samples series

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RESULTS AND DISCUSSION

Circular Order 8/2001 (former PG-4)

For static compaction series, the **2.00%** of optimum residual bitumen content comply dry and wet UCS and RSR requirements (Figure 1).

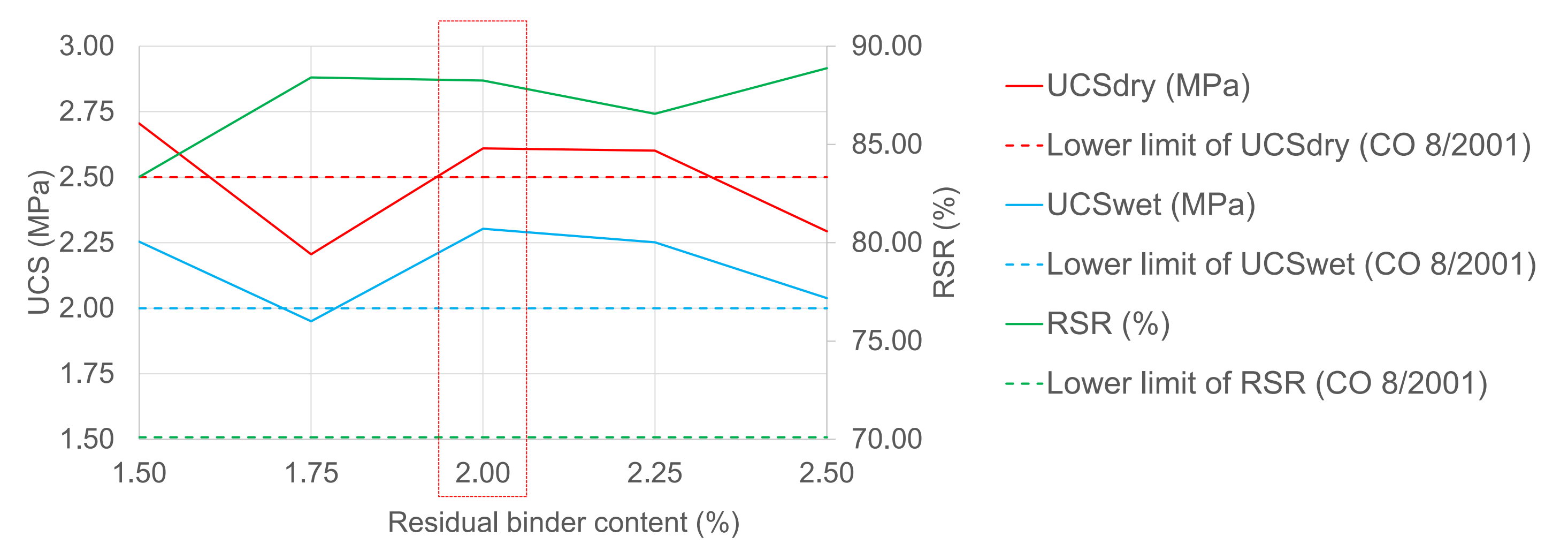


Figure 1 – UCS and RSR results compared with PG-4 requirements

Circular Order 40/2017 (current PG-4)

For gyratory series 1 to 5, dry and wet ITS do not fulfill requirements (figures 2a and 2b). The best ITS values are obtained for the **3.00%** of binder content.

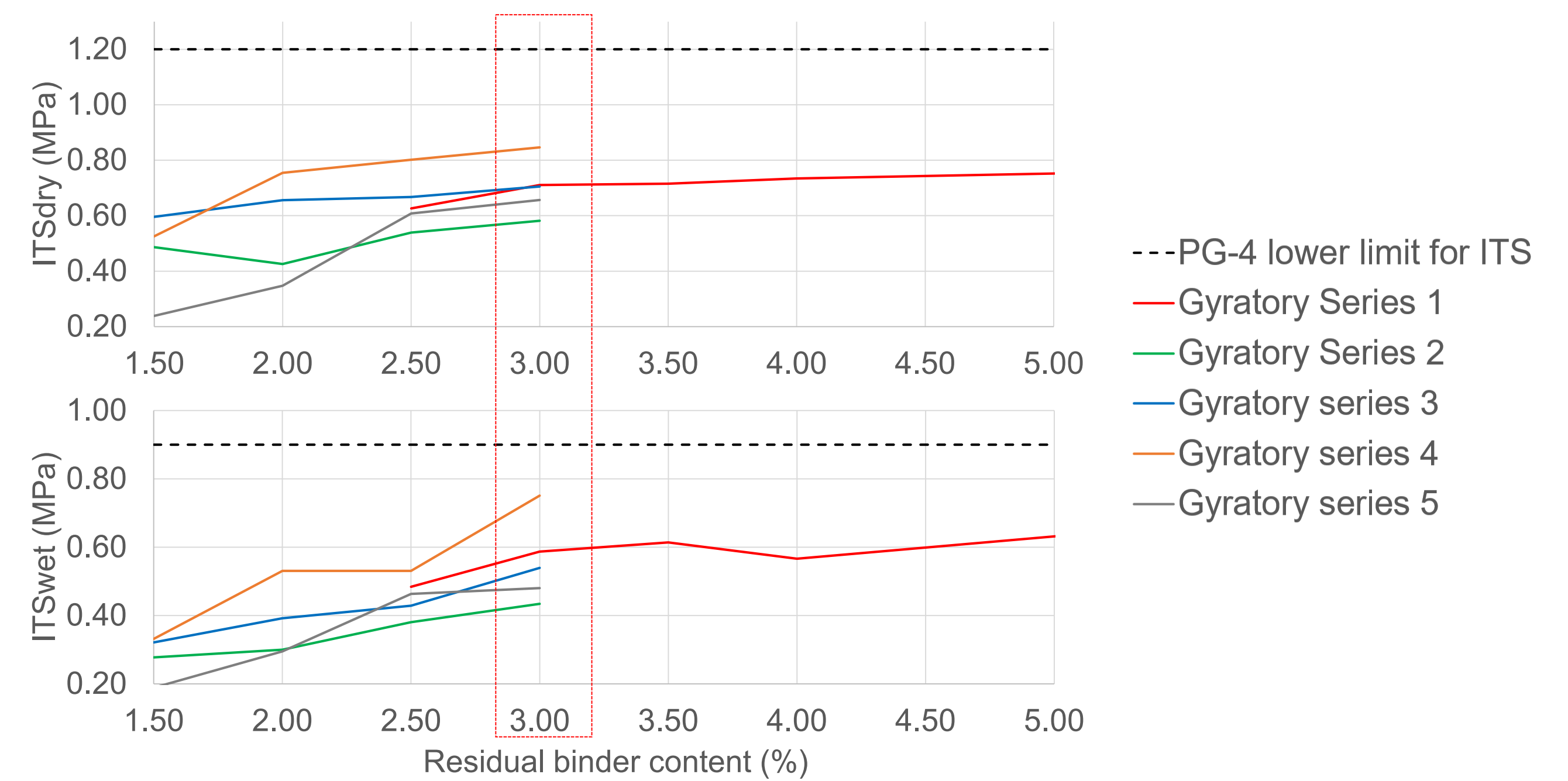


Figure 2 – ITS results of gyratory series compared with PG-4 requirements: a) ITSdry and b) ITSwet

ITSR is correctly satisfied also for the 3.00% (Figure 3).

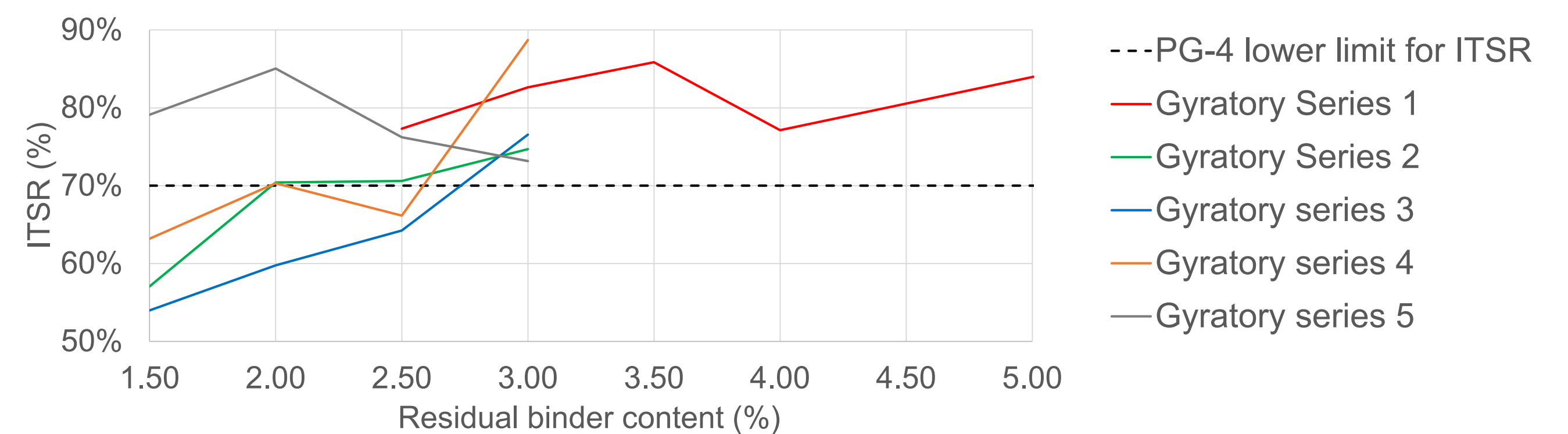


Figure 3 - ITSR of gyratory series compared with PG-4 requirements

CONCLUSIONS

Current PG-4 specifications are very restrictive:

- For the former PG-4 optimum binder content and added water, the specifications of the current PG-4 are not achieved by far.
- Using Portland cement, compacting with a higher number of gyrations, increasing the residual binder content and increasing the water content, the ITS values increase, but the values are still not high enough to meet requirements from current CO 40/2017.

In view of the exigency level from currently in force specifications, it is considered necessary a revision of the requested values of ITSdry and ITSwet and further investigation to that effect.

REFERENCES

- Ministerio de Fomento (2017) "Reciclado de firmes y pavimentos bituminosos". Orden Circular 40/2017
- Ministerio de Fomento (2001) "Reciclado de firmes". Orden Circular 8/2001