

Low noise rumble strips on roads – a pilot study

Jørgen Kragh

Danish Road Institute (DRI)

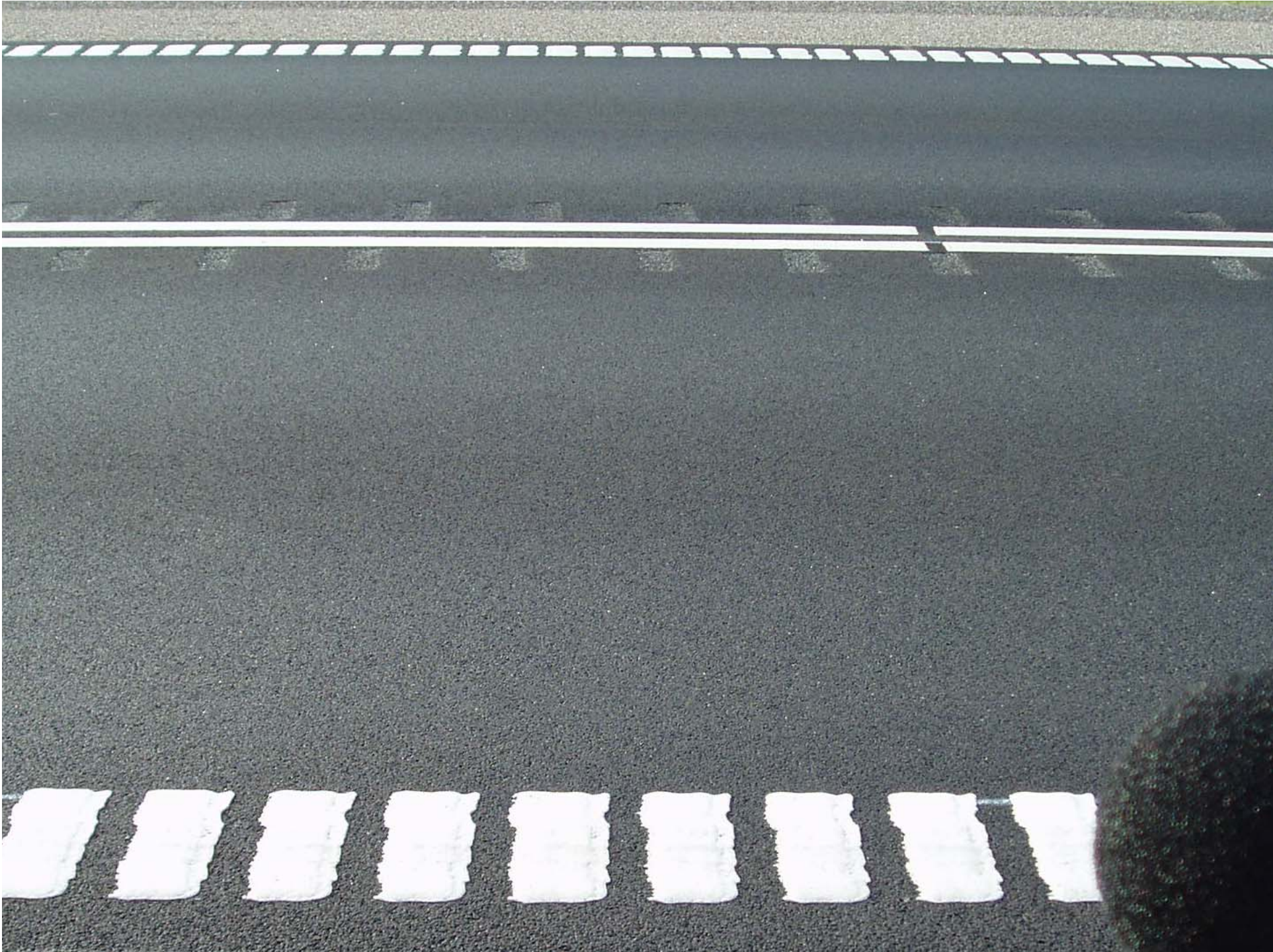
Background and aim

- Rumble strips in the middle of roads to improve traffic safety
- Prevent drivers from crossing road centre line without noticing
- Noise/vibration in vehicle warn drivers
- Noise level outside increases
- Annoyance → neighbors complain
- DRI pilot study of rumble strips → low noise levels in the environment

Conclusions

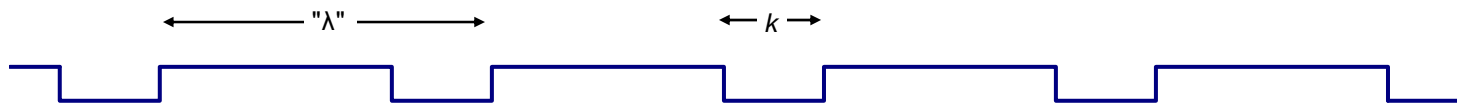
- "Sinus": < 1 dB increase
- "Cylinder 0.6 m": 2 - 3 dB increase
- "Rectangle 0.3 m": 4 – 8 dB increase
relatively to pass-by noise on old SMA
valid > 25 m from road
- Complaints: ← 8 dB increase







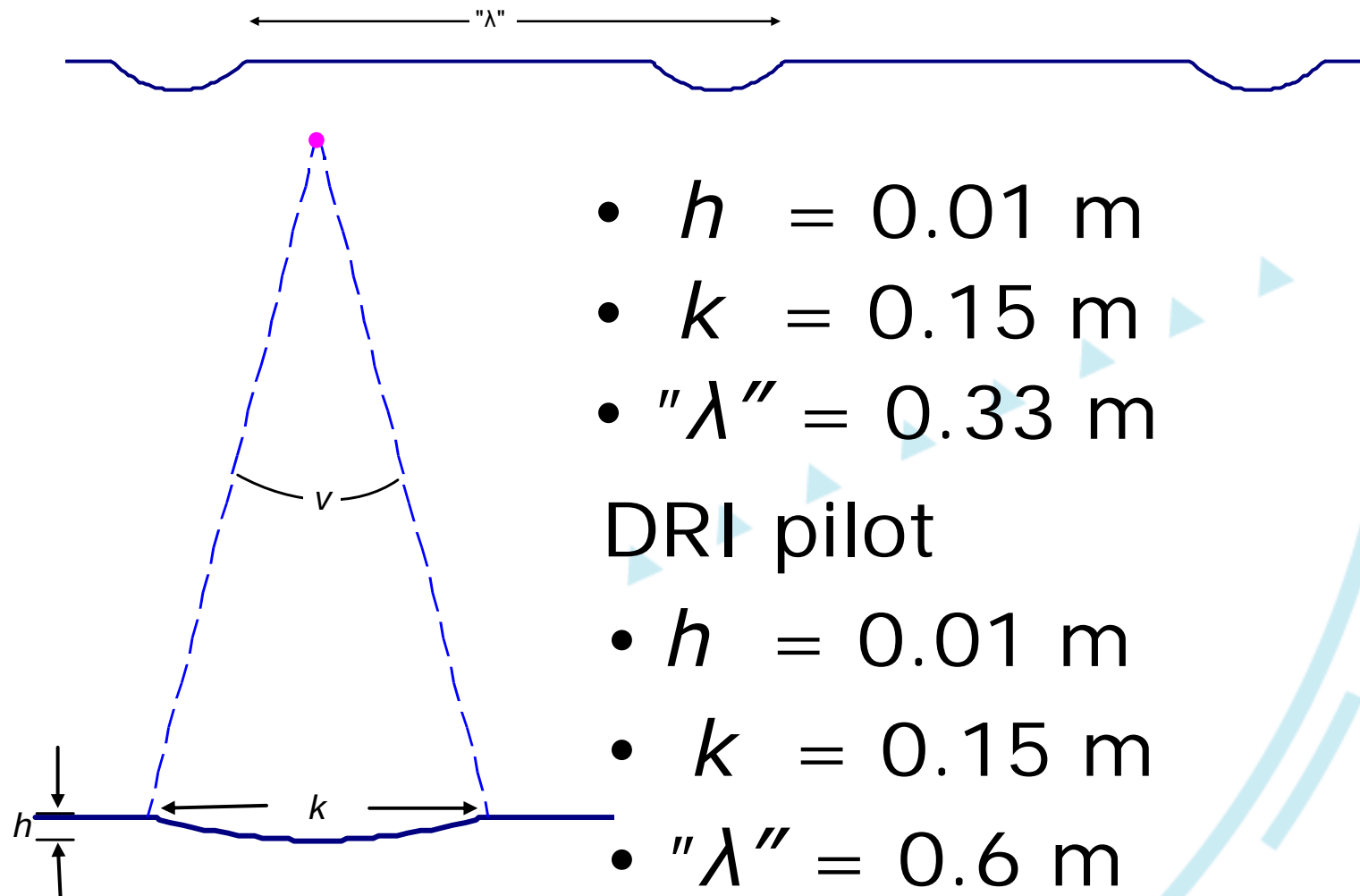
Strips Complaint



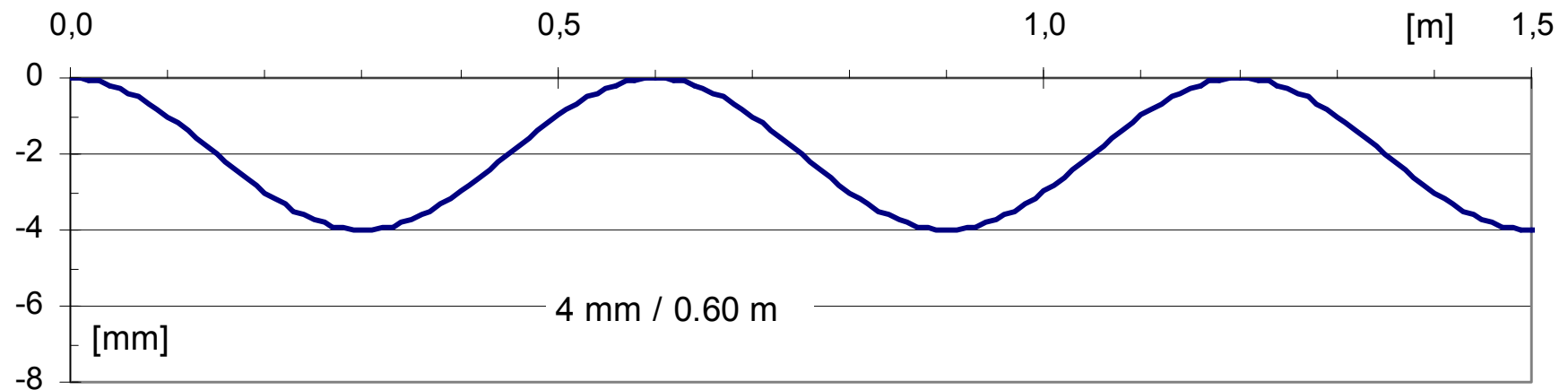
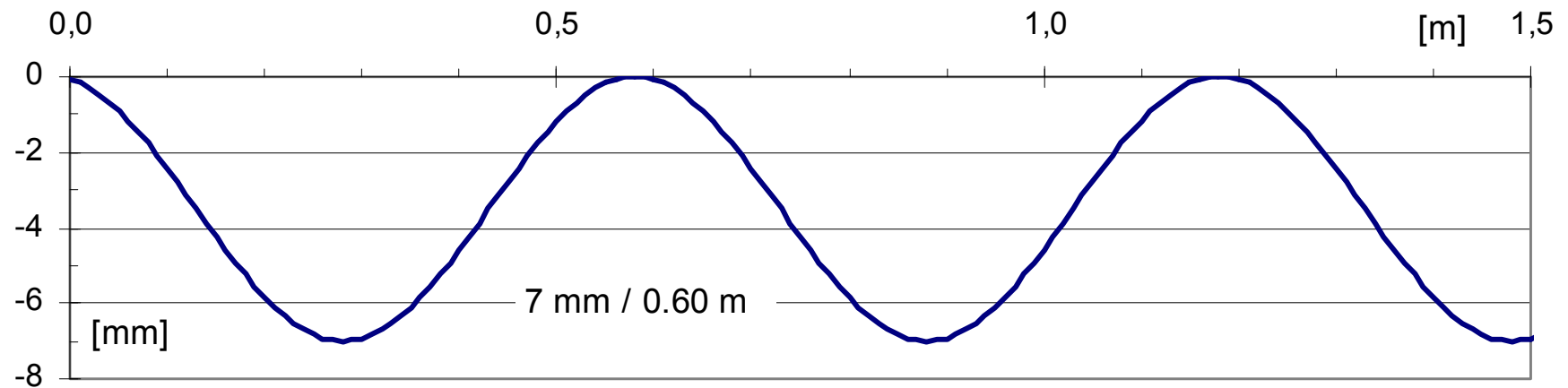
Rectangle:

- " λ " = 0.33 m
- k = 0.1 m

"Swedish": Cylinder



Sinus: $\lambda = 0.6 \text{ m}$



Overview of strips

Rumble strip No. [-]	Indentation
1	Segment of cylinder, max. 10 mm deep
2	Sinus 7 mm top to bottom
3	Sinus 4 mm top to bottom
4	Rectangle 4 mm deep
5	Rectangle 8 mm deep





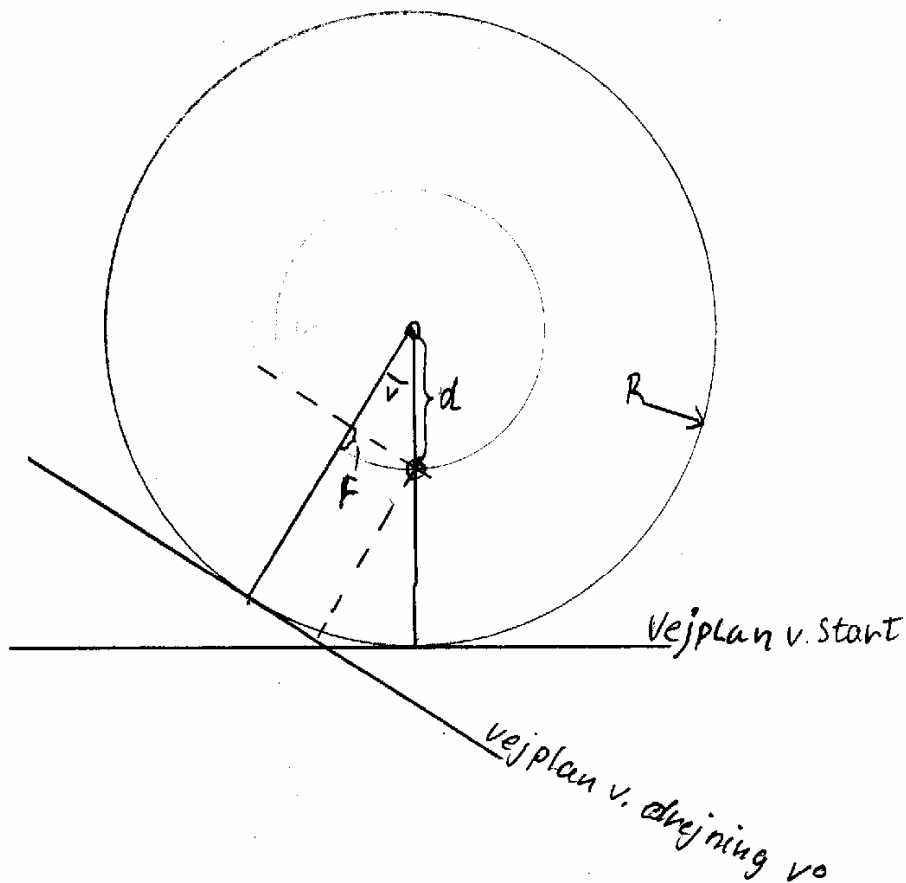


"Swedish"

Sinus 7 mm



v : Rullens drejning
 R : Rullens radius
 d : Lejets forskydning fra rullens centrum
 F : Fræsedybden
 x : Tilbagelagt vejlængde



Den korrekte sinuskurve kan udtrykkes:

$$F = d(1 - \cos(v))$$

$$x = Rv$$

Den fremstillede kurve kan udtrykkes:

$$F = d(1 - \cos(v))$$

$$x = Rv - d \sin(v)$$

I denne situation hvor d er lille (0,35cm) i forhold til R ($60/2\pi = 9,55\text{cm}$) bliver afvigelsen meget lille

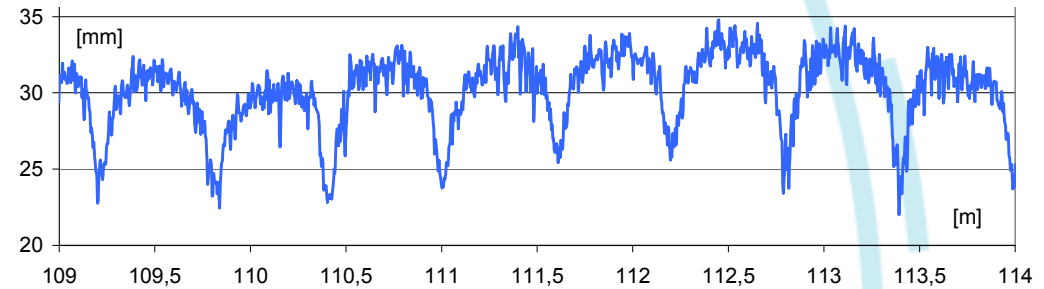
Maksimal afvigelse opnås ved $v = 90^\circ$ og $v = 270^\circ$ hvor den ønskede fræsedybde opnås ved $x = 14,65\text{cm}$ i stedet for ved $x = 15\text{cm}$.

Den maksimale afvigelse i fræsedyben sker ved $x = 15\text{cm}$ ($v = 92,1^\circ$):

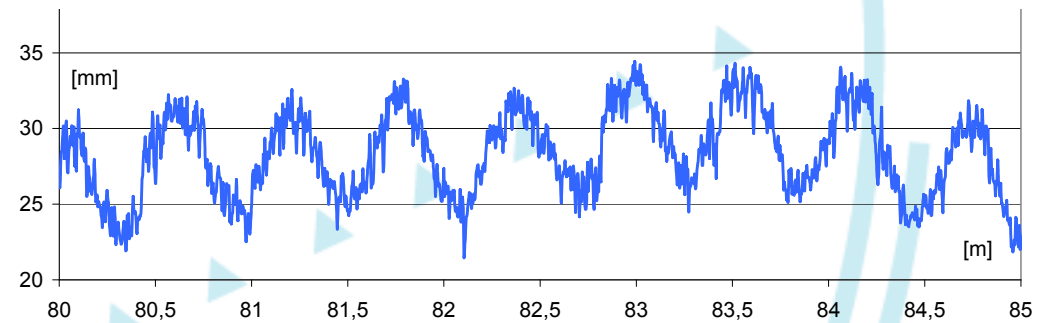
Fræsedybde :	0,363 cm
Korrekt dybde:	0,350 cm
Diff.:	<u>0,013 cm</u>

Measured profiles

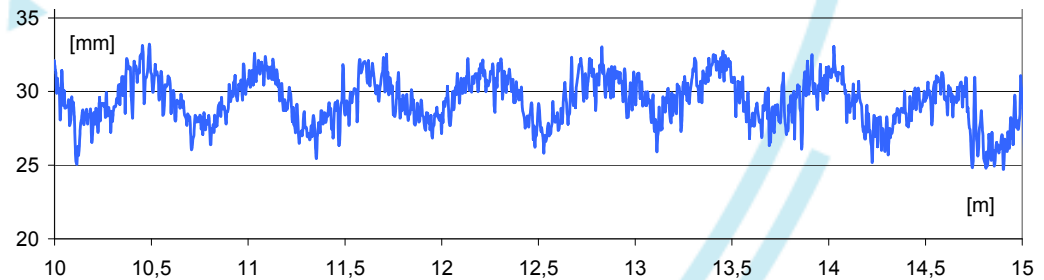
- Swedish



- Sinus 7 mm



- Sinus 4 mm



Cars and tyres

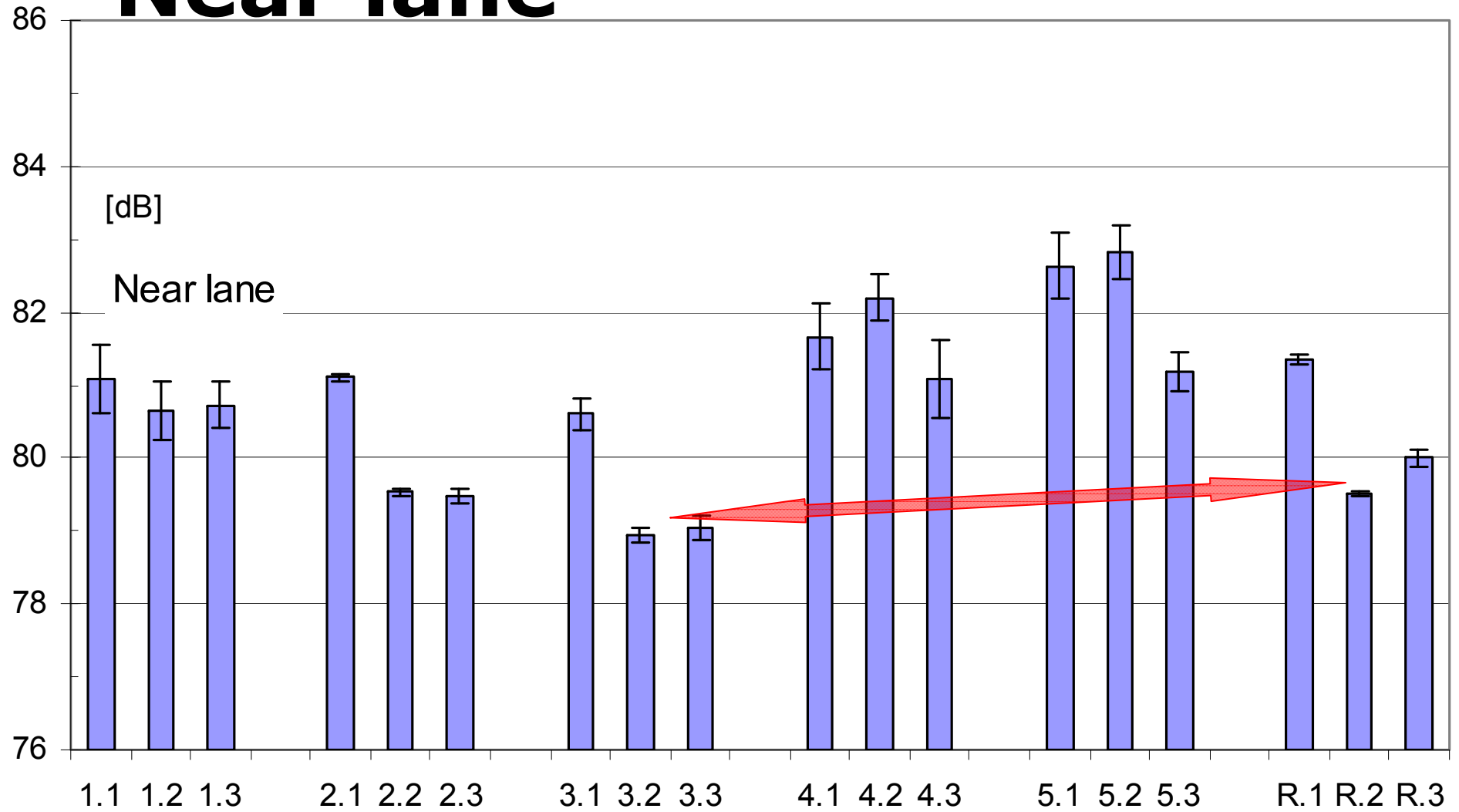
Car No.	1	2	3
Make	Volkswagen	Skoda	Toyota
Model	Golf 1,8	Octavia 1,9 TDI	Combivan (Corolla Verso)
Year	1995	2006	2003
km	200.000	5.000	15.000
Tyres Front	Gislaved Speed 516 185/60 R14 82T	Continental ContiEcontact 3 195/65 R15 91H	Goodyear Ultragrip 6 (M+S) 195/65 R15
Tyres Rear	Michelin Energy 185/60 R14 XT2		

Increments in noise level

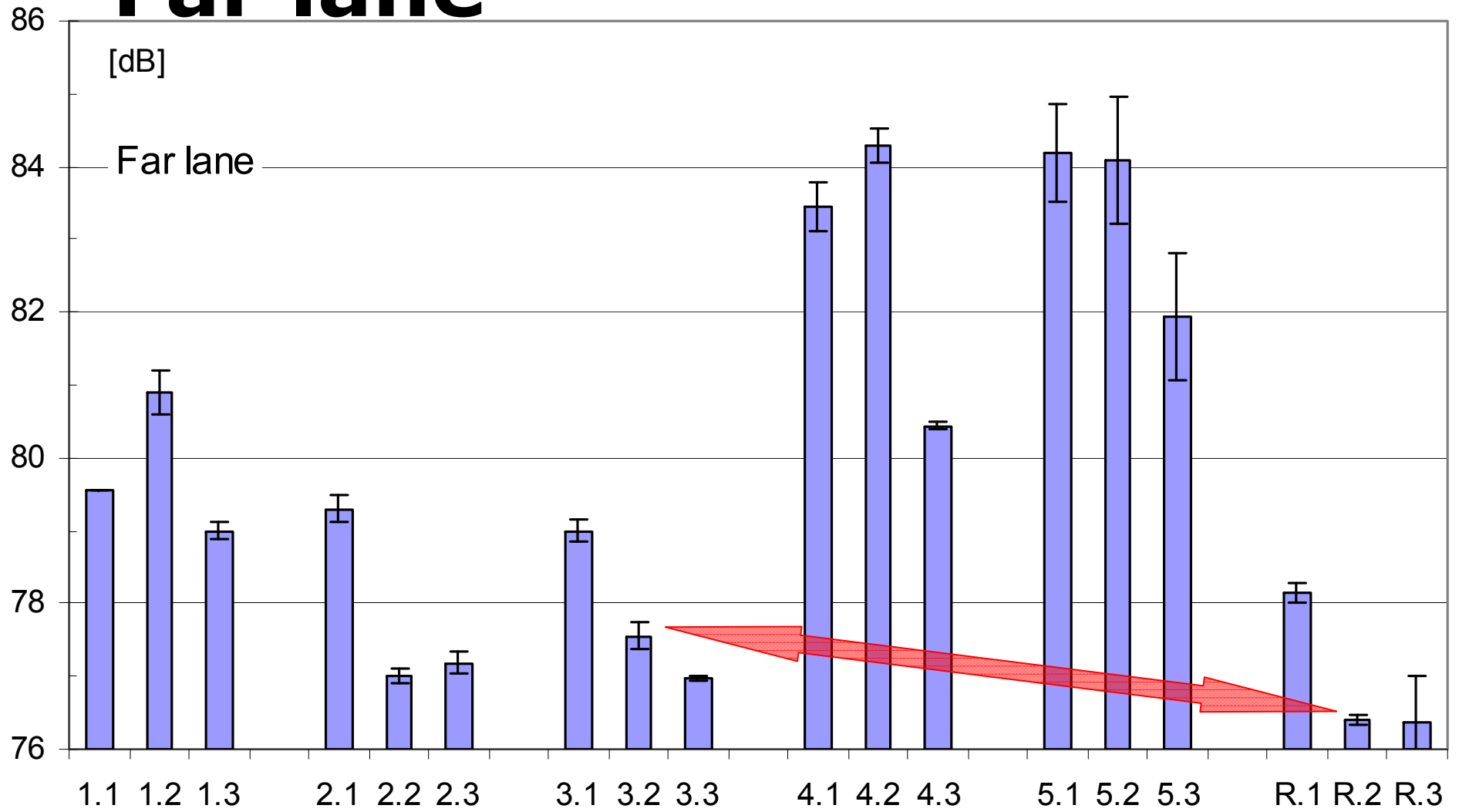
Rumble strip No. [-]	Indentation	Far lane [dB]	Near lane [dB]
1	Segment of cylinder, 10 mm deep	3	2
2	Sinus 7 mm top to bottom	1	0.5
3	Sinus 4 mm top to bottom	1	0.5
4	Rectangle 4 mm deep	6	4
5	Rectangle 8 mm deep	8	5

rel. Old SMA 11

Near lane



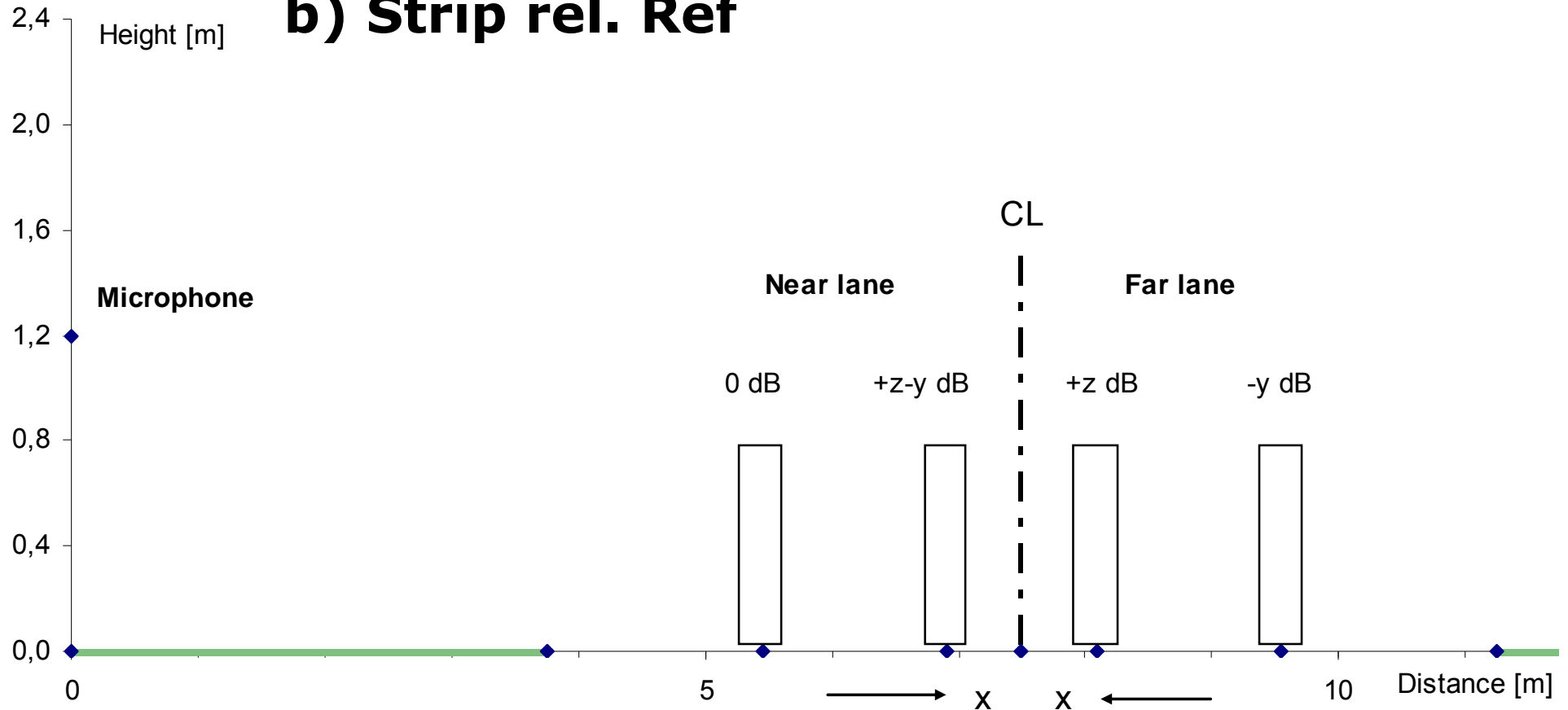
Far lane



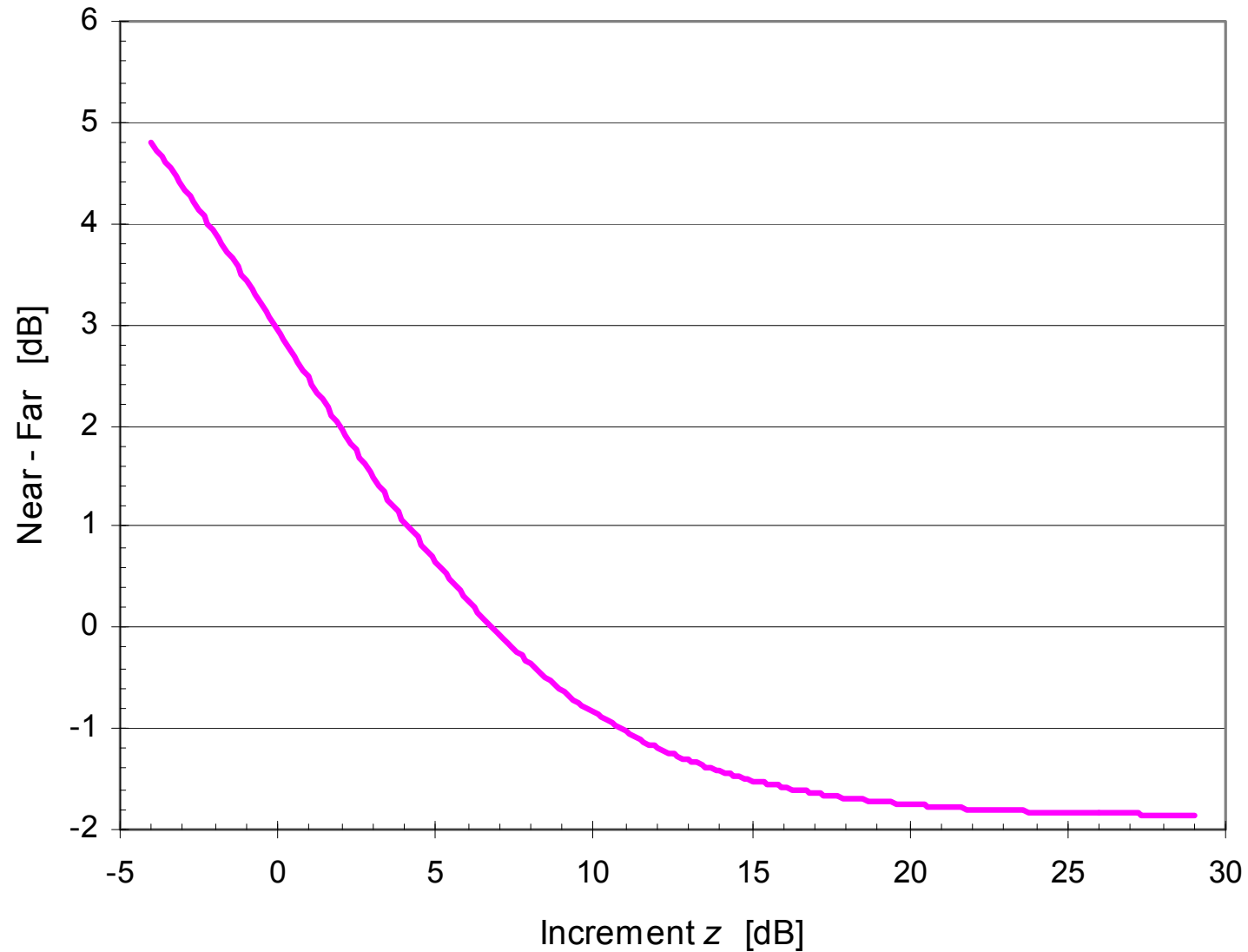
Model → Optimize Measured - Calculated

a) Near - Far level

b) Strip rel. Ref



Near - Far = F(z)



Final result

Rumble strip No. [-]	Far lane [dB]	Near lane [dB]
1	3,0	1,8
2	0,8	0,4
3	0,9	0,5
4	5,6	3,7
5	7,5	5,2

Conclusions

- "Sinus": < 1 dB increase
- "Cylinder 0.6 m": 2 - 3 dB increase
- "Rectangle 0.3 m": 4 – 8 dB increase
relatively to pass-by noise on old SMA
valid > 25 m from road
- Complaints: ← 8 dB increase