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Retroreflection Performance of Urban Road Signs

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Introduction

- Road signs are a determining factor of the road network in terms of safety and traffic flow.
  - prevent accidents by transmitting messages to users (drivers and pedestrians)
  - inform users about the conditions of the road environment, ensuring their safety
  - warnings of dangers in various sections of the road network.
- Signs must either be illuminated by an external light source or to be constructed by materials that have certain reflective properties.
- One of the key parameters that addresses the adequacy of road signs in terms of enhancing users' safety and visibility is their retroreflection level.

About Retroreflection

- Retroreflectivity is the amount of light reflected off a surface from a source to an observer, measured by the units of candelas per lux per square meter (cd/lux/m2).
- EN 12899-1 standard describes 3 types of retroreflective materials that can be used on traffic signs, categorized into three categories:
  - Engineering Grade (Type I),
  - Diamond Grade (Type II)
  - High Intensity (Type III).
- The most commonly used retroreflective sheeting material for traffic sings in urban roads is Diamond Grade (Type II).

Retroreflection Limit Values

- The reflective area of the sign plate should have at least the minimum values of the retroreflection coefficient, with specific lighting angles (βi) and observation angles (αi).

- The minimum required limits of the retroreflection coefficient for each color type have been considered and are stated as follows:
  - White color: R′=180 cd/lux/m2
  - Red color: R′ = 25 cd/lux/m2
  - Blue color: R′ = 14 cd/lux/m2
  - Yellow color: R′ = 120 cd/lux/m2

Geometry of measurements		Colour								
α	β_1 ($\beta_2 = 0$)	White	Yellow	Red	Green	Dark green	Blue	Brown	Orange	Grey
12'	+5°	250	170	45	45	20	20	12	100	125
	+30°	150	100	25	25	15	11	8,5	60	75
	+40°	110	70	15	12	6	8	5,0	29	55
20'	+5°	180	120	25	21	14	14	8	65	90
	+30°	100	70	14	12	11	8	5	40	50
	+40°	95	60	13	11	5	7	3	20	47
2°	+5°	5	3	1	0,5	0,5	0,2	0,2	1,5	2,5
	+30°	2,5	1,5	0,4	0,3	0,3	#	#	1	1,2
	+40°	1,5	1,0	0,3	0,2	0,2	#	#	#	0,7

Data Collection (1/3)

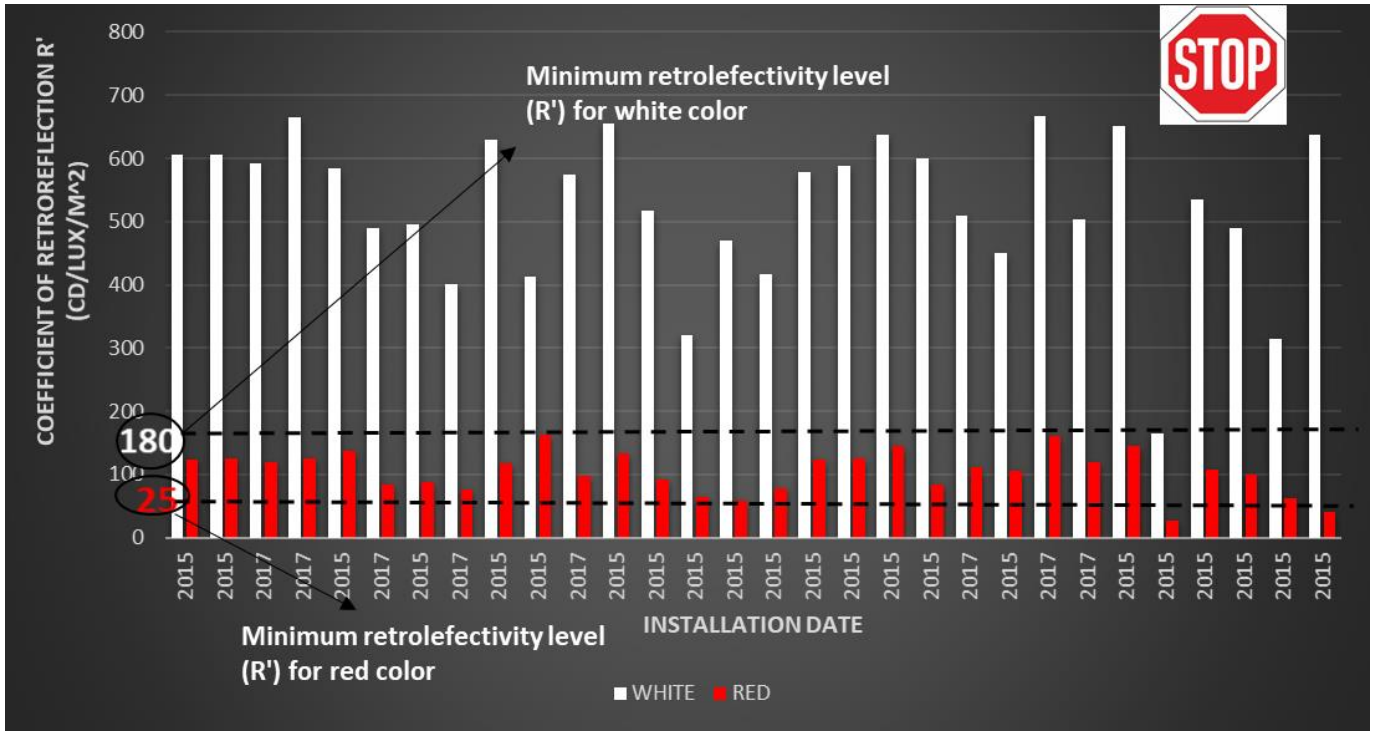
- Examined Road Segments
  - Athens City Centre (Vassilisis Sofias Avenue)
  - Athens Coastal Zone (Poseidonos Avenue)
- Over 200 individual measurements.
- Data Collection was conducted utilizing a portable retro reflectometer device (Retrosign GR3).
  - $+5^0$ entrance angle
  - 0.33^0 observation angle.
- The procedure involves measurements taken from four different areas of the signs for each different color.
- The average of the four recorded measurements was used in order to determine the retroreflection coefficient that was taken into account during the analysis process.

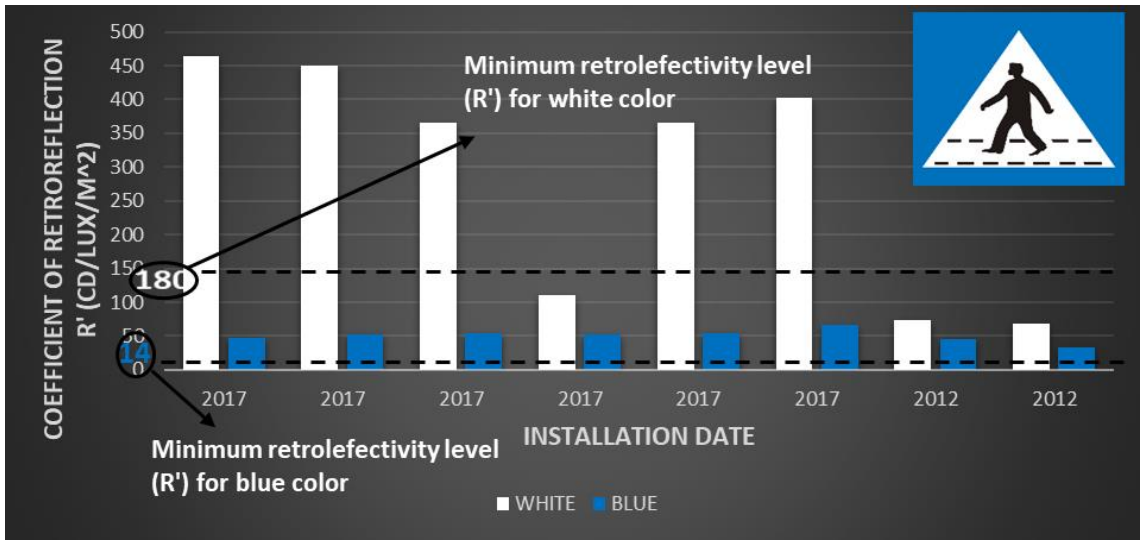
Data Collection (2/3)

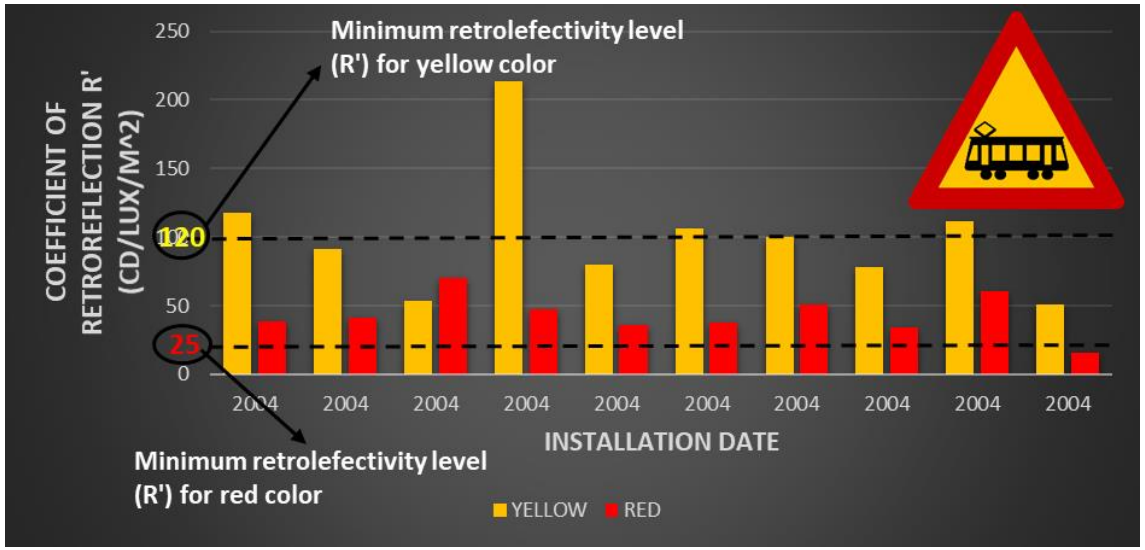
- The reflectivity measurements, as well as some specific characteristics that heavily affect the road signs were recorded simultaneously during the field measurements. These are the followings:
  - Type and code of road sign
    - Warning, Regulatory, Guide Signs
  - Installation date (year)
    - The construction and installation year is indicated at the back side of each road sign.
  - Orientation (north, east, south, west):
    - The orientation of each road sign was determined with the use of a compass (or with the internal compass of Google maps).
  - Material (Type I, II and III).

Data Collection (3/3)

- Coefficient of retroreflection versus Installation Date per color combination.







Methodology and Results (1/3)

- Linear regression modelling approach.
- The parameters that were inserted in the models were:
  - age (current year – installation year)
  - the orientation (expressed in degrees)
  - total reflectivity.
- The total reflectivity was expressed based on the percentage of the occupied color area on each sign.

Methodology and Results (2/3)

Total retroreflection = (percentage of colour 1 area) * (value of retroreflection coefficient for colour 1) + (percentage of colour 2 area) * (value of retroreflection coefficient for colour 2)

where,

- Colour 1 και Colour 2, express the two colours that each road sign contains (white, red , blue)
- Retroreflection coefficient value (cd/lux/m2): the average value taken from field measurements

Area Assumption Example

	Warning Road sign with vehicles no entry permission: The red colour occupies the 80% of the sign area, whereas the white colour occupies the 20% of the sign area

Methodology and Results (3/3)

- Final Linear Regression Model

Retroreflection = 225.981 - 9.805 * **Age** + 0.098 * **Orientation**

Parameter Estimates of the Linear Regression Model

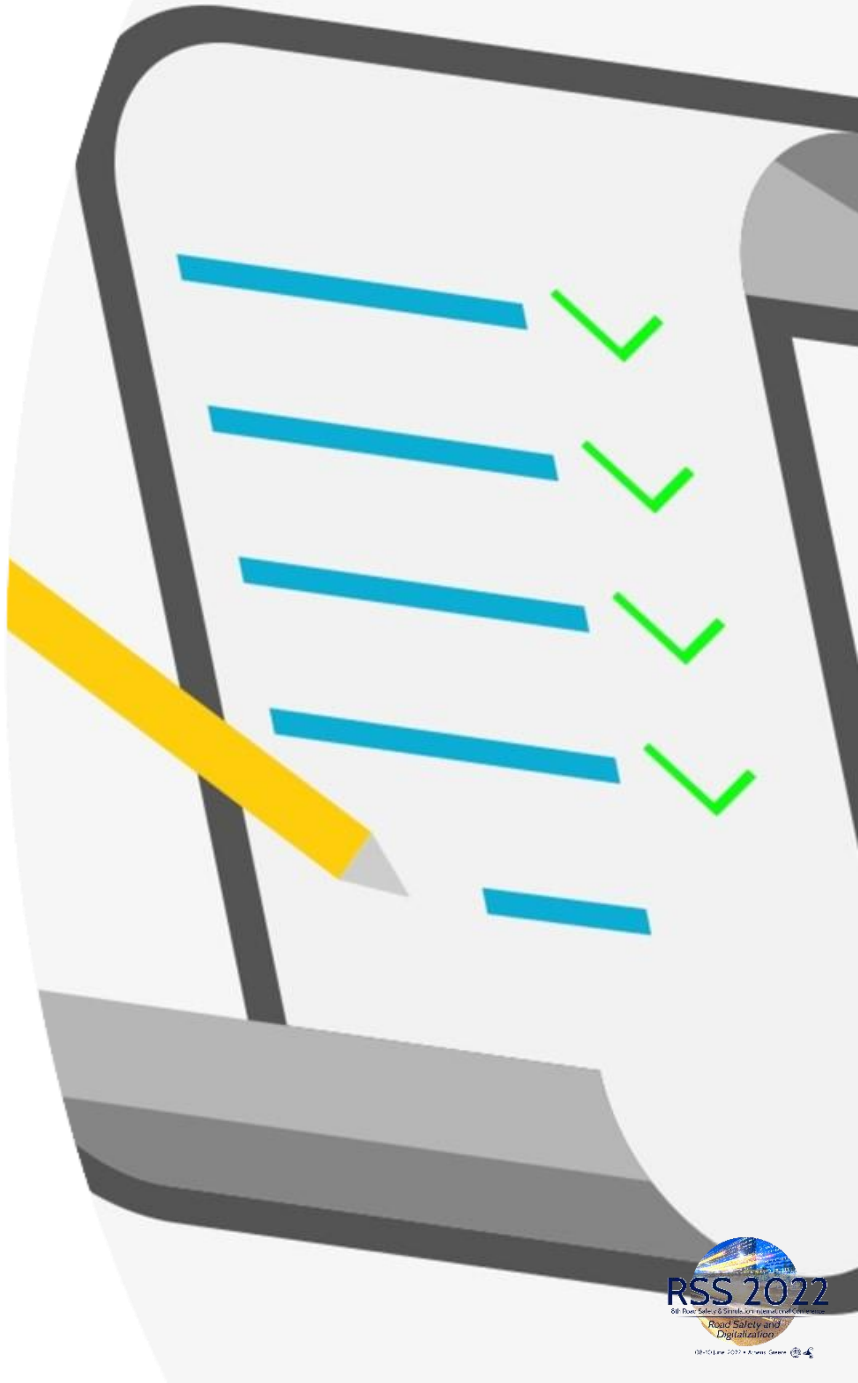
Parameter	B	Std. Error	t-value	p-value
Intercept	225.981	6.808	33.20	<0.001
Age	-9.805	0.477	-20.56	<0.001
Orientation	0.098	0.035	2.67	0.008
df		2		
Adjusted R-squared		0.6154		

Conclusions (1/2)

- Retroreflection is a vital element, in order to assess the safety performance of road signs.
- An attempt was made through field measurements and statistical analysis to find the main causes of low retroreflection performance in traffic signs.
- The signs of Poseidonos avenue appear to have reflectivity issues:
  - due to their exposure to solar radiation and therefore their lifetime is shorter.
- Regulatory STOP Type Signs of Poseidonos Avenue have very low levels of reflectivity.
  - Possibly is a consequence of bad maintenance and old installation date.

Conclusions (2/2)

- The outcome of the modelling approach prove that:
  - the installation year of the signs compared to the sign orientation.
  - The sign orientation as well as their exposure to solar radiation constitute the basic factors that contribute to their reflectivity decrease.
  - However, this statement requires further investigation in order to be adopted, as the quantitative and qualitative data are not adequate
- The general reflectivity prediction model
  - not only takes into consideration the importance of the orientation variable,
  - but also contains the total number of measurements that were collected during the visual/field inspection.
- Expansion of the dataset, investigating more avenues.



Thank you for your attention!!

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