ROAD PAVEMENTS FORUM

2 – 3 July 2019

RECLAIMED MATERIALS COMMITTEE

FEEDBACK

Present reclaimed materials as a viable secondary material for use in road construction and rehabilitation

- To stimulate the industry towards secondary materials
- Provide case studies on projects making use of reclaimed materials
- Develop guidelines with respect to the use of reclaimed materials

RecMat committee

Representatives from:

City of Cape Town

GreenCape

SANRAL

Martin and East

Stellenbosch University

The Concrete Institute

BVi Consulting Engineers

RPF 9 May 2018

Two case studies presented by Kirsten Barnes of GreenCape

Present reclaimed materials as a viable secondary material for use in road construction and rehabilitation

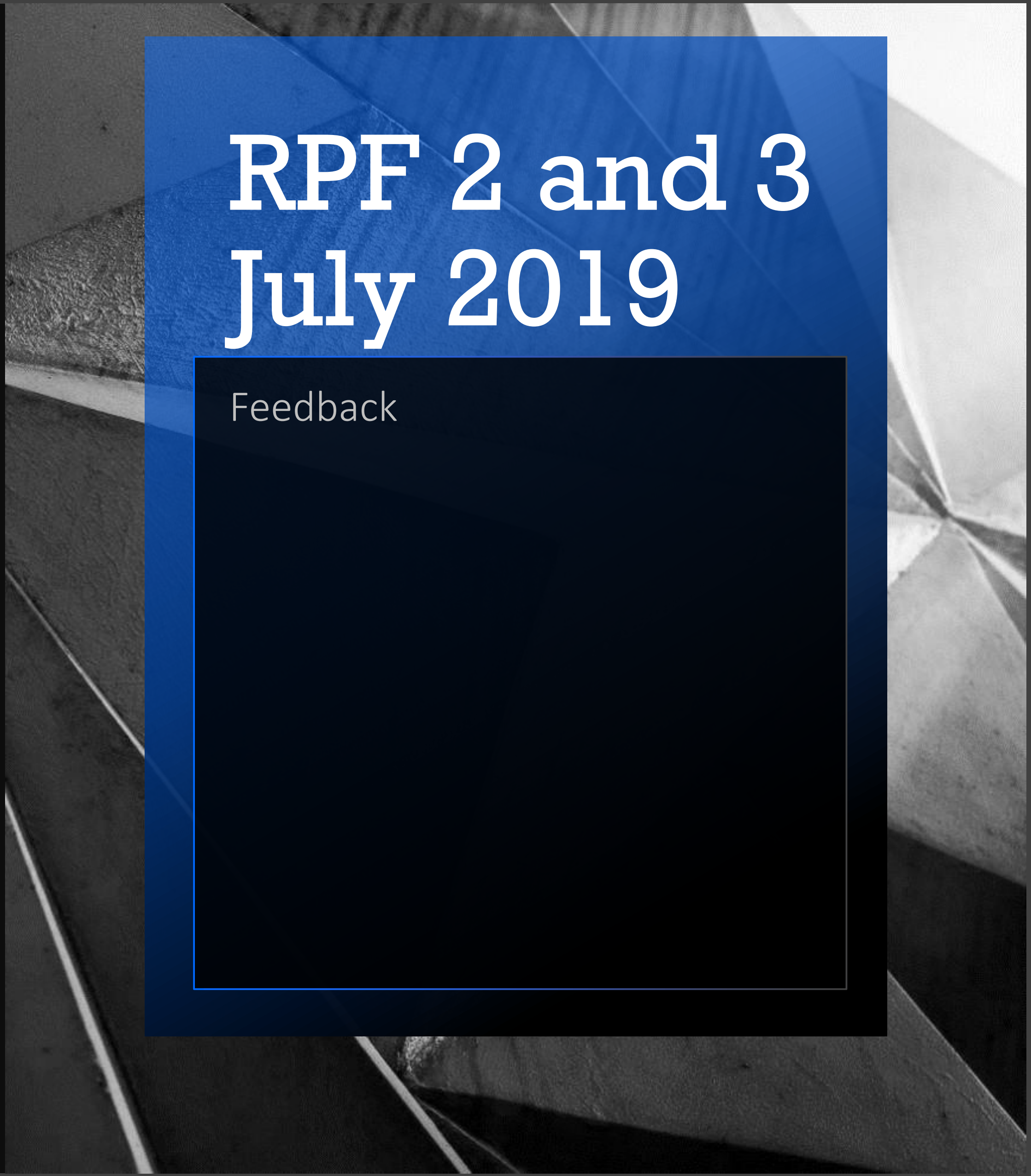
- National Road N2 in Cape Town at Borcherd’s Quarry
- Provincial Main Road P255 in Durban, between Hillcrest and Waterfall

RPF 9 May 2018

RecMat committee feedback presented by Ian Bowker of City of Cape Town

Present reclaimed materials as a viable secondary material for use in road construction and rehabilitation

- Durability testing
- Call for trial sections



RPF 2 and 3 July 2019

Feedback

Present reclaimed materials as a viable secondary material for use in road construction and rehabilitation

- Durability testing
- Guidelines
- Case study

Durability testing

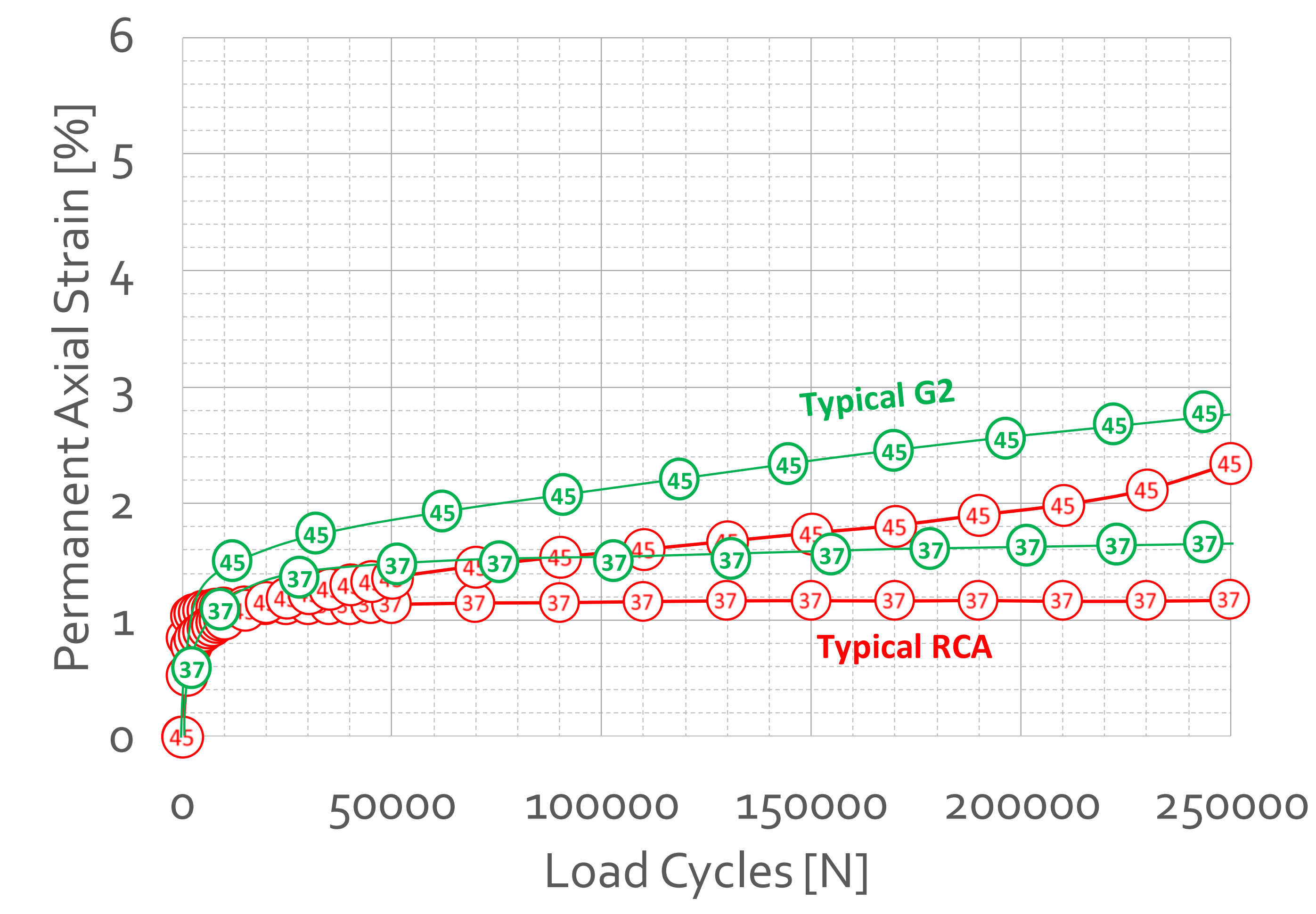
For comparison purposes and to determine if COTO specifications are met

Performed on mixes of RCA and masonry, and compared to G2

- G2 (DMI)
- 100% RCA
- 90% RCA
- 80% RCA
- 70% RCA

Permanent deformation

Triaxial testing – repeated loading (RLT) and resilient Modulus (M_R)



Durability

Ethylene glycol

Durability mill index

ACV

10% Fact

- COTO specification
- Findings
- Discussion

Durability

Ethylene glycol

90% RCA

Durability

Durability mill index

Source	RCA Content	Method	Passing 0.425mm						DMI
			Before	After	%loss	Before	After	%loss	
SU	G2 (PI=3)	Dry ball	21.7	23.9	9.2				74.4
		Water + ball	21.7	24.8	12.5				
		Water mill	21.7	22.9	5.2				
M&E + SU	RCA	Dry ball	18.0	29.2	38.4	6.0	9.0	33.3	30.6
		Water + ball	18.0	30.6	41.2	6.0	7.0	14.3	
		Water mill	18.0	23.1	22.1	6.0	7.0	14.3	
SU	70%RCM	Dry ball	18.5	24.5	24.5				24.5
		Water + ball	18.5	24.4	24.2				
		Water mill	18.5	20.3	8.9				
M&E + SU	30%RCA	Dry ball	17.6	25.6	31.3	7.0	10.0	30.0	26.4
		Water + ball	17.6	26.4	33.3	7.0	8.0	12.5	
		Water mill	17.6	21.5	18.1	7.0	9.0	22.2	
[illegible]	20%RCA	Dry ball				5.0	7.0	28.6	7.0
		Water + ball				5.0	6.0	16.7	
		Water mill				5.0	6.0	16.7	
M&E	10%RCA	Dry ball				7.0	10.0	30.0	10.0
		Water + ball				7.0	8.0	12.5	
		Water mill				7.0	8.0	12.5	
SU	100% RCM	Dry ball	18.3	26.0	29.6				26.8
		Water + ball	18.3	26.8	31.7				
		Water mill	18.3	21.6	15.3				

Source	RCA Content	CBR	ACV (kN)		10% FACT (kN)	
			Dry	Wet	Dry	Wet
SU	100%	198*				
M&E	100%	80	26.5	26.7	151	149
M&E	90%	45	24.1	24.7	166	162
M&E	80%	50	24.2	25.1	165	159
M&E	70%	53	25.1	26.2	159	153

*sample consisted of a lab constituted grading and compaction at 100% Vibratory MOD (=103% MOD AASHTO)

Durability

- ACV
- 10% Fact

Stabilisation

ICC

ITS

- COTO specification
- Findings
- Discussion

Source	RCA Content	% Cement	0	2	4	6	8	10	12
M&E	100% RCA	pH	8.1	10.19	10.88	11	11.04	11.07	11.2
SU 1		pH	12.83	12.83	12.83	12.83			
SU 2		pH	9.45	11.86	12.2	12.4			
M&E	90% RCA	pH	10.9	11.08	12.02	12.02	12.06	12.08	12.08
M&E	80% RCA	pH	10.03	11.06	12.01	12.04	12.04	12.06	12.06
M&E	70% RCA	pH	8.5	11	12.09	12.14	12.14	12.17	12.17

Source: Martin & East and Agnello (Stellenbosch University)

Stabilisation

ICC

Source	RCA Content	Grading	% Cement	Initial pH	ITS (kPa)		
					24 Hours	7 Days	28 days
SU	100%	Continious	2	10.8	303.6	493.6	892.7
SU	100%	Gap	2	11.4	357.9	634.4	1211.08
M&E	90%	Continious	2	10.9	195	215	
M&E	80%	Continious	2	10.03	235	256	
M&E	70%	Continious	2	8.5	269	294	

Source: Martin & East and Beardmore (Stellenbosch University)

Stabilisation

ITS

Summary of results

Variability

Higher absorption

Lower specific gravity

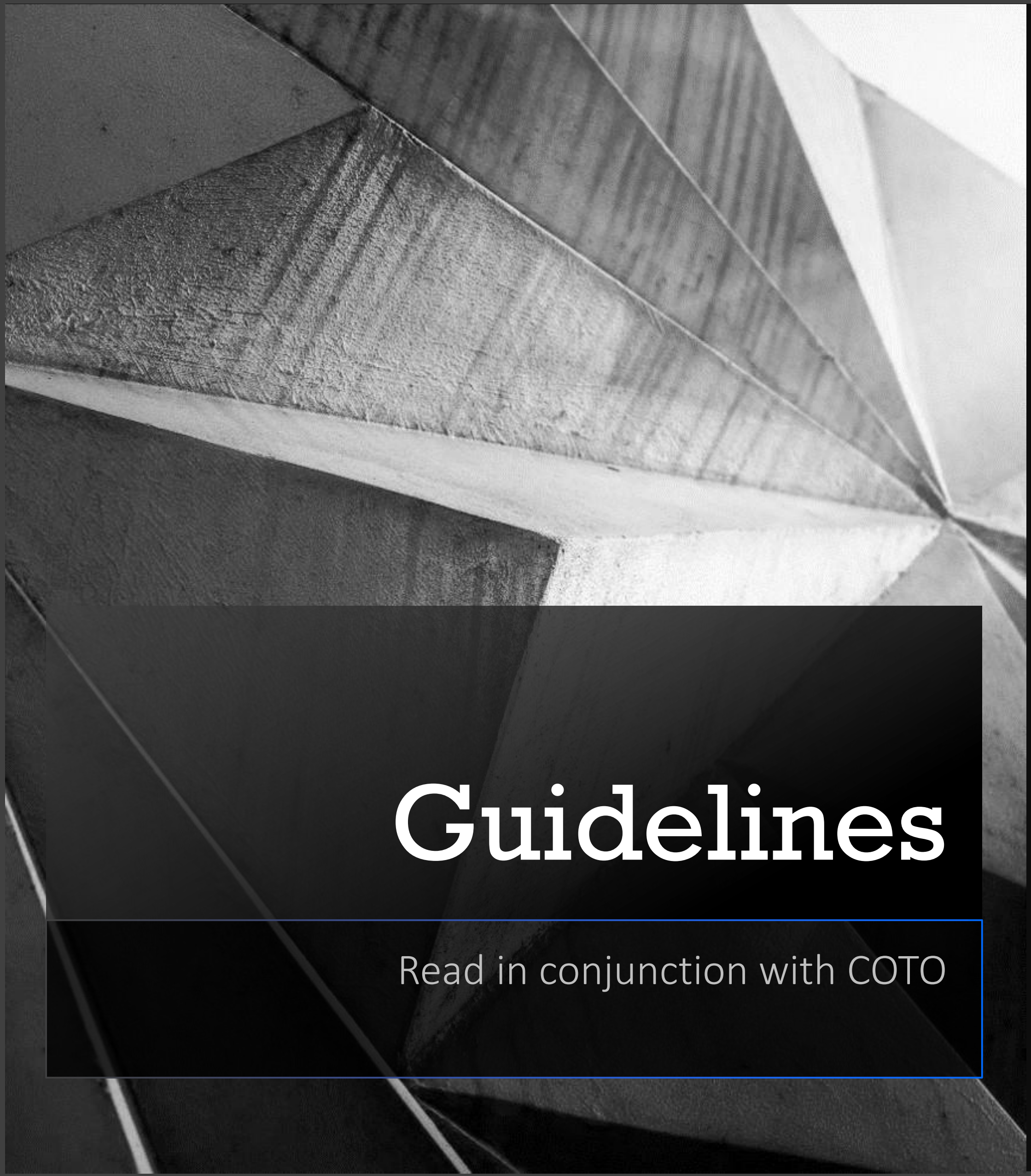
Potential for decreased abrasion resistance

Mortar content influences the mechanical properties of the material

Further testing

Stellenbosch University

- Further structural performance evaluation
- Shrinkage potential (influence of variables such as humidity)
- Water absorption on durability
- Managing variability in self-cementation
- Further durability mill testing on order to correlate to performance
- The main objective is to correlate durability aspects and how this effects performance



Guidelines

Read in conjunction with COTO

Developed in order for authorities, consultants or contractors to propose the use of alternative materials for use in road building projects

- Reduced reliance on virgin materials
- Reduced CO_2 emissions
- Reduced energy costs
- Based on RCA and RMA

Guidelines

Work in progress

Chapter 1 - Introduction

Chapter 2 – Applicable legislation and legal requirements

Chapter 3 – Selection and processing

Chapter 4 – Material specification guidelines - roads

Chapter 5 - Material specification guidelines - concrete

Chapter 6 – Guidelines for construction

Chapter 7 – Case studies

Guidelines – Chapter 4 - **Material specification guidelines - roads**

Material specifications

- Ensure durability
- Ensure applicability

Contents

- Introduction
- Literature study
- Applications for RCA and RMA in South Africa
- Constituent requirements for RCA and RMA
- Utilising RCA and RMA in South Africa
- Additional durability tests

Guidelines – Chapter 4 - **Material specification guidelines - roads**

Introduction

- Provide a suitable platform for construction of overlying layers
- Contribute to the structural capacity of the pavement to ensure acceptable in-service life

Literature study

- Design guidelines based on research from *Delft University of Technology* and USA DOTs.
- Constituents of reclaimed concrete and mix granulates
- Properties of RCA and RMA
- Research on mix granulates

Guidelines – Chapter 4 - **Material specification guidelines - roads**

Applications of RCA and RMA in South Africa

- Unbound layers
- Cement stabilised sub-base layer
- Selected layer

Unbound

Application limited to subbase (and below) layers
Constituent requirements specified in guideline
COTO specifications for a given AG material
Additional durability testing requirements

Bound

Application limited to sub-base layers
Constituent requirements specified in guideline
COTO specifications for a given C class material
Additional durability testing requirements

Guidelines – Chapter 4 - **Material specification guidelines - roads**

Constituent requirements

- RCA
- RCA and RMA

Table 4-1: Reclaimed concrete granulates constituent limits (CROW, 1995).

Reclaimed Concrete Granulates			
Constituents		**Description**	**Limit (% mass/mass)**
Main	A	Crushed gravel concrete and crushed-stone concrete, with a particle density of at least 2100 kg/m^3	A + B ≥ 80 B ≤ 10
	B	Other crushed stone material and stony material, with a particle density of at least 2100 kg/m^3	
Secondary	C	Crushed masonry with a particle density of at least 1600 km/m^3 and other crushed stony material (light weight concrete, glass, slag, etc.)	C + D ≤ 10 D ≤ 5
	D	Crushed asphalt	
Impurities	E	Gypsum and non-stony material ((non)-ferro metal, plastics, rubbers, polystyrene, etc.)	E ≤ 1
	F	Decomposed organic material (wood, rope, paper, plants, remains, etc.)	F ≤ 0.1

Guidelines – Chapter 4 - **Material specification guidelines - roads**

Constituent requirements

- RCA
- RCA and RMA

Table 4-2: Mix granulates constituent limits (CROW, 1995).

RCA and RMA – Reclaimed Concrete and Masonry Aggregate			
Constituents		**Description**	**Limit (% mass/mass)**
Main	A	Crushed gravel concrete or crushed-stone concrete, with a particle density of at least 2100 kg/m^3	A+B ≥ 50 A ≥ 45
	B	Other crushed stone and stony material, with a particle density of at least 2100 kg/m^3	
	C	Crushed masonry, other crushed stone and stony material, with a particle density of at least 1600 kg/m^3	C ≤ 50
Secondary	D	Other crushed stone and stony material (light weight concrete, glass, slag, etc.)	D + E ≤ 10 E ≤ 5
	E	Crushed asphalt	
Impurities	F	Gypsum and non-stony material ((non)-ferro metal, plastics, rubbers, polystyrene, etc.)	F ≤ 1
	G	Decomposed organic material (wood, rope, paper, plants, remains, etc.)	G ≤ 0.1

Guidelines – Chapter 4 - **Material specification guidelines - roads**

Utilising reclaimed concrete and masonry aggregate in South Africa

- Guideline for use developed

Guidelines – Chapter 4 - **Material specification guidelines - roads**

Utilising reclaimed concrete and masonry aggregate in South Africa

- Correlation between G class materials and performance of RCA and RMA combinations sought

Table 4-3: Limitations on the concrete and masonry content for a given G-Class material.

Material Class	Concrete Content (%)	Masonry Content (%)
G4	100	0
G5(a)	80-100	0-20
G5(b)	65-100	0-35
G6	65-100	0-35
G7	65-100	0-35
G8	65-100	0-35
G9	50-100	0-50
G10	50-100	0-50

Guidelines – Chapter 4 - **Material specification guidelines - roads**

Utilising reclaimed concrete and masonry aggregate in South Africa

- Correlation between G class materials and performance of RCA and RMA combinations sought

Table 4-4: Reclaimed concrete and masonry contents applicable to cement stabilised materials.

Material Class	Concrete Content (%)	Masonry Content (%)	Material before treatment
C3 or higher	80-100	0-20	G5(a)
C4	80-100	0-20	G5(b) & G6

Guidelines – Chapter 4 - **Material specification guidelines - roads**

Utilising reclaimed concrete and masonry aggregate in South Africa

- Correlation between G class materials and performance of RCA and RMA combinations sought

Bound and unbound reclaimed materials, defined in the tables above, are applicable to the following:

Material Class	Suitability	Traffic Volume
G4	- Unbound base layer	Low
G5(a)	- Unbound base layer - Bound subbase layer (C3 or higher)	Low High
G5(b)	- Unbound base layer - Bound subbase layer (C4)	Low Low
G6	- Unbound base layer - Bound subbase layer (C4)	Low Low
G7	- Selected material	-
G8	- Selected material	-
G9	- Selected material	-
G10	- Fill material	-

Re-use existing concrete road in sub-base

- Break up and stockpile unreinforced concrete pavement
- Cut and fill to correct alignment
- Rebuild foundation and fill
- Crush and screen concrete to G4 specification
- Blend with imported G5
- Construct new C4 sub-base
- Construct new G4 crushed stone base
- Cape seal

Further case study

CONTRACT C1008.01: THE REHABILITATION OF DIVISIONAL ROAD 1688 FROM CALITZDORP (km 1.00) TO THE CALITZDORP SPA TURNOFF (km 15.64)

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Stimulating the industry towards the use of secondary materials

Thank you

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