Título: "Short report of first experiences in stabilization of fine road soils with shredded face masks in Argentina". Revista: Academia Letters. e-ISSN: 2771-9359. Article AL5869, june 2022. DOI: doi.org/ 10.20935/AL5869. Autores: J. Rivera, I. Zapata, N. Battista.

SHORT REPORT OF FIRST EXPERIENCES IN STABILIZATION OF FINE ROAD SOILS WITH SHREDDED FACE MASKS IN ARGENTINA

Julián Rivera, Ignacio Zapata Ferrero, Nicolás Battista
LEMaC Centro de Investigaciones Viales UTN FRLP – CIC PBA
Universidad Tecnológica Nacional (Argentina)

ABSTRACT

The COVID-19 pandemic caused a disproportionate increase in the use of face masks. This generates an environmental threat because these face masks have become more in a household waste than a pathogenic one. From the LEMaC, a pre-feasibility analysis is generated at the laboratory level to use these residues, once shredded, in the stabilization of fine soils, for the constitution of improved subgrades and subbase layers in pavements. The mechanical results obtained are showed, to simplify the path of future related experiences. It is concluded that the optimal percentage of incorporation can be around 2% by weight, on 100% of the weight of dry soils. This can be extrapolated to other waste that is made with the same textile.

INTRODUCTION

After 2 years of pandemic, according to National Geographic magazine, 129,000 million disposable masks have been used worldwide per month (three million per minute) (CONICET, 2021; Oanh Ha, 2021). However, the increase in single-use plastic waste (gowns, gloves, masks, etc.) is a problem little addressed in the framework of the COVID-19 pandemic, which is observed in the low percentage that the theme has in the publications around this pandemic (Olmedo et al., 2020).

Road engineering should not be left out of the initiatives that seek a solution to the problem of this waste. At the RMIT University in Australia, the incorporation of the particles of these masks, identified as SFM (Shredded Face Mask), in granulometrically stabilized layers, with crushed concrete as aggregate, in optimal percentages of between 1% and 3% has been analyzed (Saberian et al., 2021). However, there are no studies on the use of these residues in the stabilization of fine soils. Therefore, from the LEMaC, a study is carried out with this objective.

MATERIALS AND METHODS

The SFM used

They are made up of layers of a synthetic fabric known as SMS (Spunbond-Meltblown-Spunbond). This material has polypropylene filaments welded by the thermobonded spunland method, which make up the two layers that cover the meltblown. It is used in its different versions in disposable medical applications (i.e.: gowns, caps, shoe covers, sheets, etc.) (Nuñez Montoya & Uema, 2020).

There are various methodologies that can be used on a production scale to achieve particles of useful sizes for the application of these SFM on site in the roads. Among them, there are those of equipment with grinding shafts, with different sizes depending on the level of production sought, with costs starting at 2,500 dollars. Other equipment's are of rotary mills, which have a rotor with blades (flat or V-shaped) and fixed blades, plus a sieve system. There are equipment's of this type and with a production capacity of 150 kg/hour with values from 10,000 dollars. The other system that could be used is that of guillotines, with blades that cut the material transported by a belt. One of these equipment, valued at approximately 100,000 dollars, was made available for trial shredding. Particles with a maximum dimension of 20 mm (Figure 1) were obtained, at a shredding rate of 400 kg/h. Based on this background, it was decided to carry out the laboratory tests with the hand-cutting of the face masks in segments of approximately 20 mm x 5 mm.

Figure 1. The product resulting from the trial shredding

The fine road soils

It is decided to analyze three categories of typical fine soils, to obtain generalized conclusions.

The mixture

On site it is likely that the SFM will be blown away by the wind, so mixing is expected to take place in the plant, transporting the mixture of soil and SFM at their Optimum Humidity, so that it can then be distributed by paver, and immediately compacted. For this, a mixer for bases can be used.
To establish the achievable structural responses, it is decided to use a methodology at the pre-feasibility level, which can be applied to low-traffic rural or urban roads (Rivera et al., 2018). The optimum content of SFM, is established for the Maximum Dry Density (DSMAX) and Optimal Moisture (HOPT), obtained with the corresponding Proctor Test, by the California Bearing Ratio (CBR) without embedding and on specimens molded at predetermined density (Figure 2).

Figure 2. CBR test specimen surface with SFM content close to optimal

RESULTS

The main results obtained in the experiences with the three representative soil typologies selected are presented in Table 1. In the said table, the percentage of pass sieve number X is expressed as “PTN°X” and with “np” it does not have.

Table 1. Characterization of the soils used in the experiences

	Frictional soil	Medium plast. soil	High plast. Soil
	A-2-4	A-4	A-6
LIQUID LIMIT (%)	np	35	32
PLASTIC LIMIT (%)	np	29	21
PLASTIC INDEX	0	6	11
PTN°10 (%)	99,7	86,3	99,4
PTN°40 (%)	89,7	78,0	88,4
PTN°200 (%)	23,5	63,5	72,7
HRB CLASSIFICATION	A-2-4(0)	A-4(3)	A-6(7)

Due to the classification obtained, it then proceeds to analyze samples with different SFM contents, using the Proctor Test according to the corresponding Type for the HRB Classification of each natural soil, obtaining the results shown in Table 2. As can be seen, at least in the analyzed range, there are no noticeable trends in the modification of the DSMAX or the HOPT. For this reason, structural response analyzes are carried out from the mean values of the records for each soil, as a valid decision for a pre-feasibility analysis with results such as those obtained.

Table 2. Proctor Test results according to the corresponding Type

			Face Masks Percentage			
Soil	Proctor	Parameter	0.0%	1.5%	3.0%	Mean
A-2-4	Type V	DSMAX (g/cm^3)	1.807	1.812	1.798	1.806
		HOPT (%)	11.0	10.9	10.7	10.9
A-4	Type II	DSMAX (g/cm^3)	1.606	1.610	1.569	1.595
		HOPT (%)	22.4	19.0	20.3	20.6
A-6	Type II	DSMAX (g/cm^3)	1.656	1.649	1.658	1.654
		HOPT (%)	17.0	17.2	16.5	16.9

The results of non-embedded CBR achieved in specimens molded at a predetermined density are those observed in Table 3, graphed in Figure 3.

Table 3. Results of non-embedded CBR with the analyzed soils

	Non-embedded CBR		
Face Masks Percentage	A-2-4	A-4	A-6
0.00	20.2	19.9	9.8
0.50	24.0	20.2	9.9
1.00	24.9	20.8	10.0
1.50	34.2	29.5	10.5
2.00	48.3	25.4	15.7
2.50	34.4	20.1	13.0
3.00	34.4	17.7	11.1

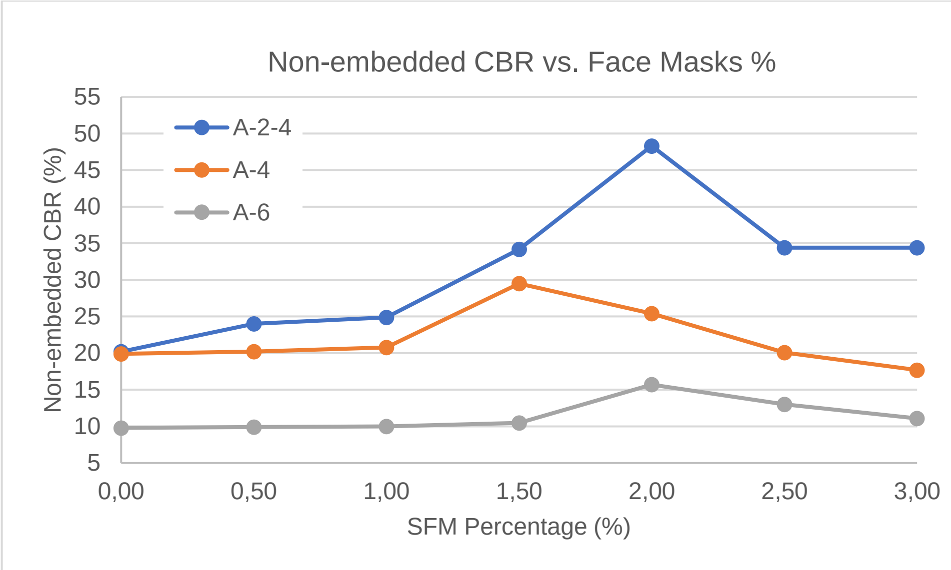

Figure 3. Graphs of non-embedded CBR versus % of SFM in the analyzed soils

Finally, the relation of increase of structural contribution in terms of non-embedded CBR is analyzed in the soils, for the 100% obtained for the natural soil, in each of the optimal contents of established SFM (Table 4).

Table 4. Increase in CBR not embedded in optimal SFM content vs. in natural soil

		Non-embedded CBR (%)		
Soil	Opt. % of SFM	Natural soil	Soil + face masks	Increase %
A-2-4	2.0	20.2	48.3	139
A-4	1.5	19.9	29.5	48
A-6	2.0	9.8	15.7	60

The optimal structural contribution seems to be around 1.5% and 2.0% of SFM. It is worth noting, for example, if the results achieved with the frictional soil are analyzed, it could think about the use of the optimal mixture in a subbase. Since it would be a mixture with a Dry Density close to 1.800 g/cm^3, usually applicable in a layer thickness of 20 cm, it would have a SFM weight of approximately 7.2 kg/m^2. This, applied to a typical block that can be adopted in a suburban area of 100 m in length by 6 m in width, would translate into 1,600,000 face masks per block based on its useful weight.

CONCLUSIONS

The preliminary study undertaken allows it to conclude that:

- There is worldwide an environmental threat generated from the exponential growth in the use of single-use face masks because of the COVID-19 pandemic, of which Argentina would not be a stranger.
- This environmental threat is related to specific household waste, but it can be amplified if the results obtained are extrapolated to other similar waste.
- Depending on the area in which the application is carried out and the volumes involved, there is various equipment that would allow the planned face masks grinding to be carried out.
- The optimum face masks inclusion percentage setting (expressed in face masks weight above 100% of the weight of dry natural soil) would be between 1.5% and 2.0%.
- This content should be established, however, for each soil, deepening the analysis regarding implications in its saturation and compaction methodology on-site; in addition to how much would the implied increase in structural contribution be located.

REFERENCES

CONICET (2021). Los barbijos son indispensables pero muy contaminantes. Consejo Nacional de Investigaciones Científicas y Técnicas, Argentina [https://ier.conicet.gov.ar/los-barbijos-son-indispensables-pero-muy-contaminantes/]

Nuñez Montoya, S. & Uema, S. (2020). Uso de barbijos (mascarillas) en la pandemia por COVID-19. Repositorio Digital, Universidad Nacional de Córdoba, Argentina.

Oanh Ha, K. (2021). The Quest for a Disposable Mask That Won't Pollute, Bloomberg Green.

Olmedo, C., & Ceberio de León, I. (2020). Basura y COVID-19 ¿el nexo que no estamos queriendo ver? Proyección 28, vol XIV, pp 142-167.

Rivera, J. J., Bianchetto, H. D., & Queizán, A. F. (2018). Modelo para corrección de dosaje de riegos de liga sobre superficies fresadas en refuerzos asfálticos. Carreteras: Revista técnica de la Asociación Española de la Carretera, (218), 46-54.

Saberian, M., Li, J., Kilmartin-Lynch, S., & Boroujeni, M. (2021). Repurposing of COVID-19 single-use face masks for pavements base/subbase. Science of the Total Environment, 769, 145527.