Electric public transport vehicle with composite material body diagnostic - user safety

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Abstract. The project contemplated the elaboration of modules of composite material, with which a bus body of less weight was built, compared with the traditional kind, and adapted for the chassis that are currently being used in the city. The structure was prepared for the evaluation of the security space of the future users. The panels were instrumented with different sensors and configured to the conditions of the test by means of a data acquisition system. The test was carried out following the procedure of regulation 66 of the UNECE. The results obtained demonstrated the feasibility of using this type of bodywork in public transport.

1 Description

Latin American countries are traditionally consumers of European and American transport technology. Due to its topographic conditions, public bus transport leads the mobility of big cities. In the last two decades, the city of Medellín has become a benchmark for social, economic and environmental transformation, this is possible in large part because of the integration of its inhabitants through its environmentally friendly public transport network; metro, tram, transport by cable, bicycles and buses with low emissions.

The feeder vehicles of this public transport network are an automobile fleet mainly made of metal body and uses fossil fuels; Diesel and gasoline. In order to generate alternatives for environmental improvements, the EAFIT university and the ICOLFIBRA company established an alliance to develop a body and a motor module in feeder microbuses. This article presents part of the results of the research project with code 67597475630 of the Administrative Department of Science and Technology - COLCIENCIAS, focused on the development of a vehicle with a body made of composite materials that meets the conditions of safety, accessibility and comfort.

1.1 CONTEXT

The Ministry of Transport of Colombia has published different standards, resolutions and technical regulations in order to ensure the safety, accessibility and comfort of users. In 1995 Resolution 7126 was issued, where some parameters are required for the manufacture and / or assembly of vehicles for public transport of passengers. Under this resolution, the chassis and bodies that meet the established requirements are approved by the Ministry. In 2009, the standards NTC 5206: 2009 and NTC 5701: 2009 are published, which cite global standards, and some sections of these become technical regulations in 2016 through resolution 3753. Comfort is evaluated from requirements of the NTC5206: 2009 [1] and is validated through the metrology of position of chairs, location of handholds, distances of corridors, height of the vehicle, width of doors, height of the steps, and the verification of the measures and quantities of emergency protocols, certificates of glasses and materials. Accessibility refers to sections of NTC 5701: 2009 that are addressed to the access of people with reduced mobility or PRM to the vehicle, the PRM space, travel distances,

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access ramps, PRM zones, entry platform are measured. Vehicle safety is verified through the structural strength of the body under the requirements of two different standards: the standard NTC5206: 2009 with the load test on roof and lateral load, applies 50% of the gross vehicle weight on the vehicle for 5 minutes and the roof should not suffer a deflection of more than 70 mm, and the ECE R66 [2] standard by means of the rollover test, which consists of dumping a complete vehicle under established conditions and the survival space should not be affected.

Numerous investigations have been carried out in which the properties of composite materials are evaluated in comparison with conventional materials in real applications, in order to create composites as an alternative that may have additional benefits in specific functions. [3, 4]

The norm states that the superstructure of the bus must support the potential energy transformed into kinetic energy in the following way:

$$E_T = 0.75 \cdot M \cdot g \cdot \Delta h \quad (1)$$

(M) represents the mass of the loaded vehicle, (g) states the standard earth gravity and (Δh) refers to the distance of the center of mass from the floor.

This article will show all the necessary conditions to perform a rollover test on a vehicle with a body made of composite materials.

2 Vehicle description

The vehicle to which the rollover test will be performed, is a minibus that transports 19 passengers plus driver. It is made up of a metallic chassis and a body made with 100% composite materials. The object of study is characterized by the complexity of its geometry and its body made of composite materials. A Class II vehicle (Vehicles to provide the collective public service within the national scope of action) will be used, which will be used to verify the requirements of annex 5 of Regulation 66 of the United Nations. The complete vehicle dimensions are shown in table 1.

Fig. 1. Bus used on test.

Table 1. Bus dimensions.

Vehicle	
No. Of passengers	19
Type of chairs	Plastic fixed chairs
Chassis serial number	304
Front overhang	1330 mm
Rear overhang	2177 mm
Total lenght	6857 mm
Total width	2296 mm
Total height from the floor	2888 mm
First step height	400 mm
Internal free space height	1800 mm
Bodywork weight	1780 kg
Chassis weight	2470 kg
Total weight	4250 kg
Number of operative doors	1 de 650 mm free space
Driver door	No
Hatch	1

The chassis brand is MITSUBISHI FUSO; its characteristics are shown in the following table.

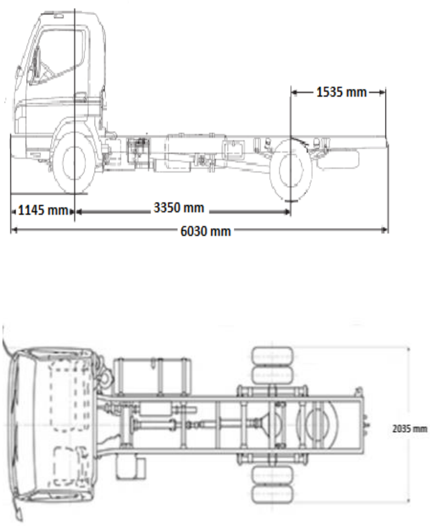

Fig. 2. Bus schematic.

Table 2. Bus technic description

Chasis	
Brand	MITSUBISHI FUSO
Reference	FE85DE6SLGP
Homologation	FTH-TPP 16165
Motor placement	Forward
Motor type	Diesel turbo charged 4 cilinders in line 4899 cm^3
Max power	177 HP@ 2700 rpm
Torque	54 kg.m @ 1600 rpm
Emission standard	Euro IV
Distance between axis	3350 mm
Gauge width	2035 mm
Front overhang	1145 mm
Rear overhang	1535 mm
Front axle weight	1485 kg
Back axle weight	885 kg
Total unoccupan weight	2370 kg
Permissible weight front axle	2800 kg
Permissible weight back axle	5100 kg
Gross Vehicle Weight	7500 kg
Tire	215/75 R17,5,

3 Rollover test description

The test is to tilt the vehicle, which is suspended on a tilting platform with the fixed suspension, it is slowly raised until the vehicle loses its equilibrium position, according to ECE R66 [2] the tipping conditions must meet the conditions shown in fig 3. The rollover test begins at the unstable position of the vehicle with zero angular velocity and ends at the moment of impact of the vehicle with the concrete. The test is satisfactory if the survival space is not affected. The survival space is defined as the space that must remain in the compartment or compartments of the driver, travelers and staff so that the driver, travelers and staff are more likely to survive in the event of rollover [5].

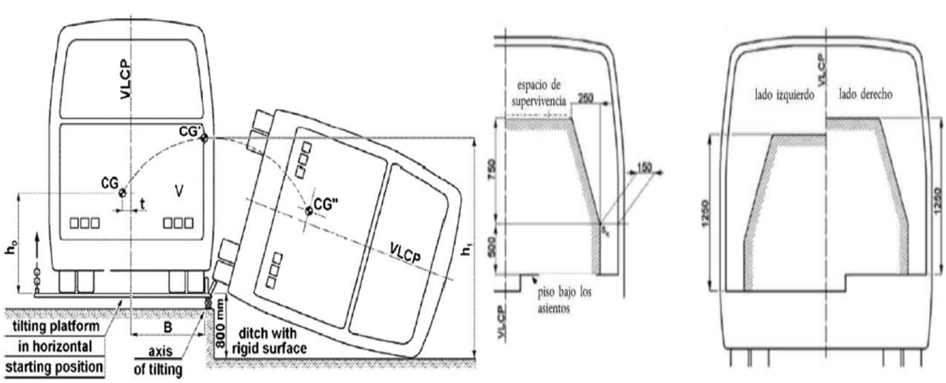

Fig. 3. Test conditions.

Table 2. Measurement elements used

MEASUREMENT ELEMENT	NOMENCLATURE	QUANTITY
Strain gauges	G	10
Displacement sensors	L, E	4
Accelerometers	A.D, A.T, A.C	3
Gyroscope	N/A	1

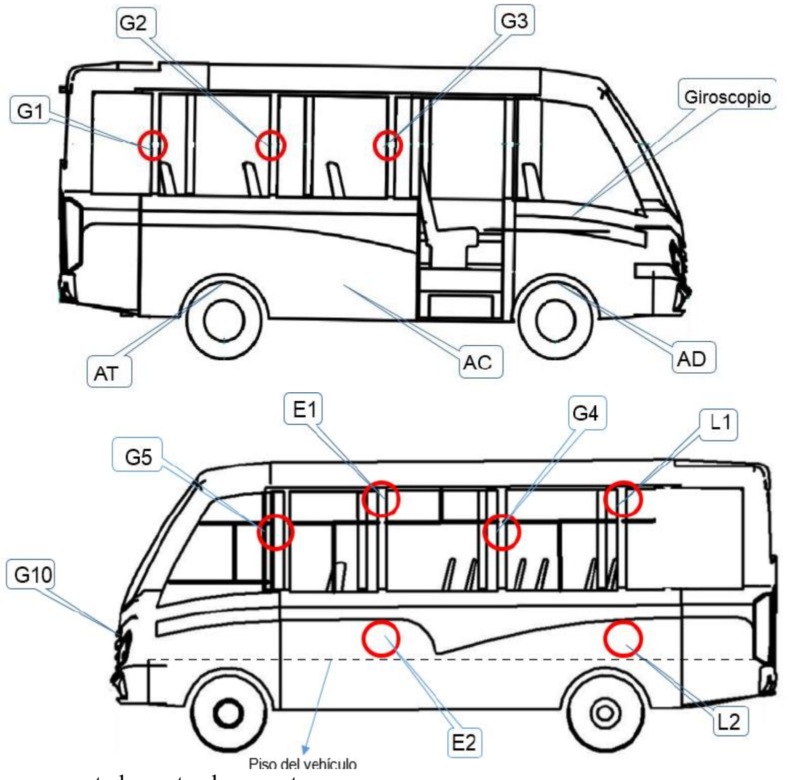

Fig. 4. Measurement elements placement.

4 Results and discussions

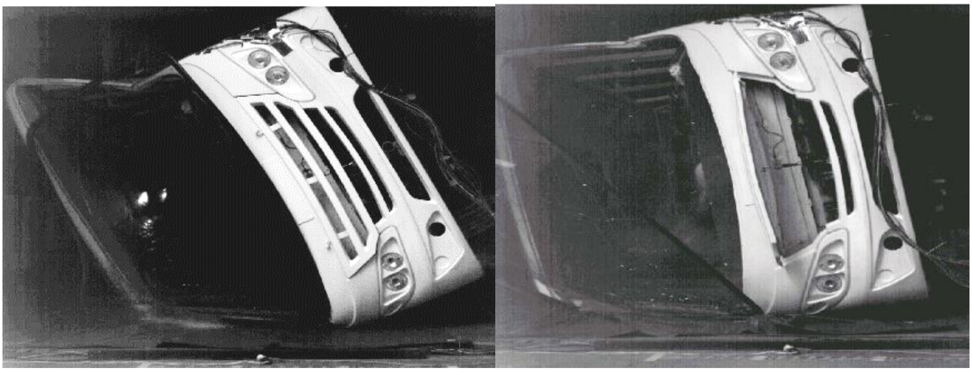

Fig. 5. Rollover test of a body made of composite materials.

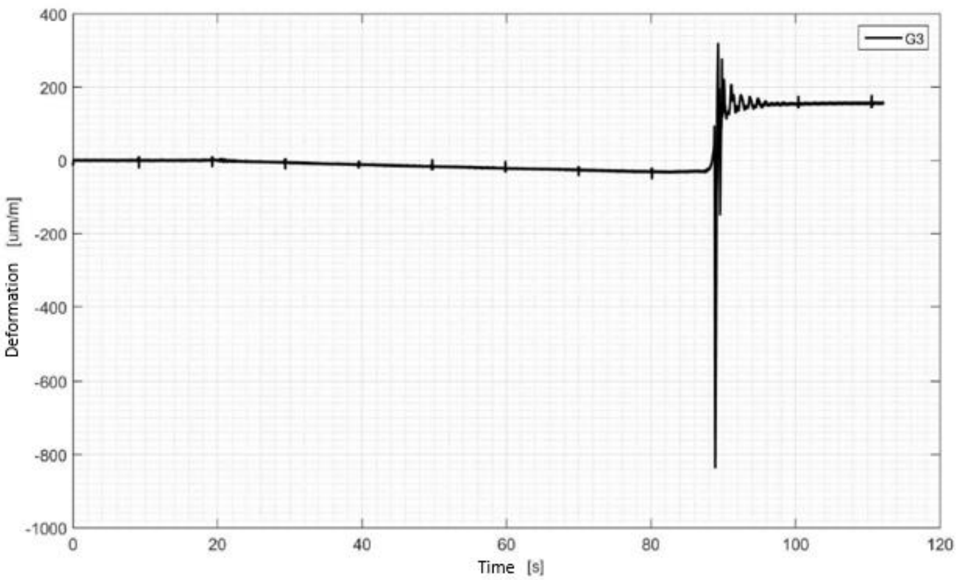

Fig. 6. G3 extensiometric gauge for critical pillar.

The graph shows the displacements registered at the moment of impact by the G3 gauge located in one of the most critical pillar, which corresponds to the one located on the side where the entrance door is located, a geometry that can structurally represent a greater challenge for the integrity of the vehicle. During the test it is observed that this element is the one that is subjected to the highest recorded deformation, however, the piece tends to recover the original shape and position.

It's remarkable to mention that in order to generate alternatives for environmental improvements, the EAFIT university and the company ICOLFIBRA established an alliance to develop a body and a motor module in the feeder microbuses, framed in the context of the Administrative Department of Science and Technology - COLCIENCIAS.

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