Volume 7, Number 4 (August 2014) p. 548-571 • ISSN 1983-4195

IBRACON

REVISTA IBRACON DE ESTRUTURAS E MATERIAIS
IBRACON STRUCTURES AND MATERIALS JOURNAL

Analysis of accidental loads on garage floors

Análise de cargas acidentais em pavimentos de garagem

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Abstract

The focus of the paper is the analysis of accidental loads used for garage floors considering the recommendations of national and international norms on the load values to be applied on those floors. The Brazilian norm NBR 6120/1980 [1], on the subject, does not specify concentrated loads while Euro Code [2] and IBC international [3] norms recommend that distributed and concentrated loads shall be considered. Currently, waffle slabs are widely used in garage floors. In this context, considering the standards of the most used vehicles in the country, we ask: are the values of the distributed loads from the norms suitable for slab design? Or is it necessary to correct these loads to account for concentrated loads on the order of 8.5 kN per share corresponding to a utility vehicle tire? The objective of the present study is to find answers for those two questions through parametric analysis involving the main parameters of a waffle slab, which are: side ratio λ (lambda), spacing between the main ribs and scheme of slab support (one-way or two-way) The set of simulations shows that the loads recommended by the mentioned norms need to be corrected when used in garage floors to reproduce the effect of the loads concentrated in the tires of utility vehicles.

Keywords: accidental load, garage floor, one-way waffle slab and two-way ribbed slam, finite element method.

Resumo

O trabalho tem como foco a análise das cargas acidentais utilizadas para pavimentos de garagem, considerando as recomendações de normas nacionais e internacionais para a definição do valor das cargas a serem aplicadas nas lajes nervuradas. A norma brasileira NBR 6120/1980 [1], que trata do assunto, não especifica nada em relação a cargas concentradas, enquanto normas internacionais como Euro Code [2] e IBC [3], recomendam considerar cargas distribuídas e concentradas. Atualmente, as lajes nervuradas são utilizadas amplamente em pavimentos de garagem. Neste contexto, considerando os padrões de veículos mais utilizados no país, será que os valores de cargas distribuídas das normas são adequados para o dimensionamento das lajes nervuradas? Ou é necessário fazer uma correção destas cargas para levar em consideração as cargas concentradas da ordem de 8,5 kN por pneu correspondente a um veículo utilitário. O objetivo deste trabalho é procurar as respostas para estas duas perguntas através de uma análise paramétrica envolvendo os principais parâmetros de uma laje nervurada, que são: a relação λ (lambda) entre os lados, a distância entre as nervuras principais e o esquema de apoio da laje (uni ou bidirecional). De uma forma geral o conjunto das simulações mostra que as cargas recomendadas pelas normas citadas precisariam de correção quando utilizadas em pavimento de garagem para reproduzir o efeito das cargas concentradas das rodas de veículos tipo utilitário.

Palavras-chave: carga acidental, pavimento garagem, laje nervurada unidirecional e laje nervurada bidirecional, método dos elementos finitos.

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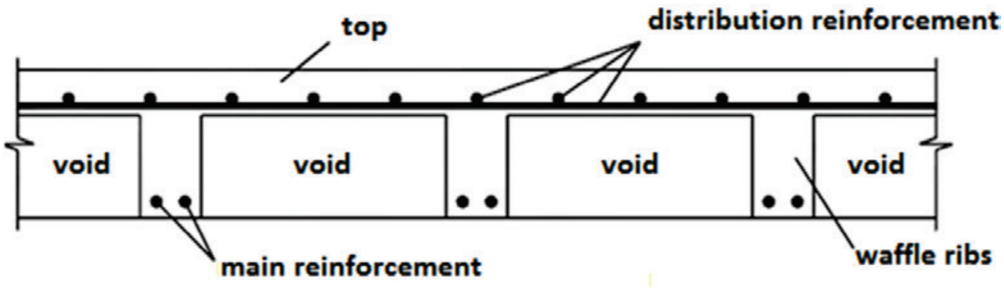
Received: 6 Nov 2013 • Accepted: 14 Apr 2014 • Available Online: 05 Aug 2014

Figure 1 – Cast-in-situ waffle slab structure (Silva, 2005) (4)



1. Introduction

Currently many reinforced concrete building designs include relatively large clear spans for auditoriums, showrooms, garage floors and recreational areas. In those cases, the spans need to have a greater thickness to increase the stiffness and reduce deflection. In this manner, massive slabs considerably increase their own weight. In this scenario, waffle slabs appear as a suitable solution because, while increasing the stiffness, they ensure weight reduction.

Indeed, cast-in-situ waffle slabs (CISWS) have been widely used in such situations because they are more economically advantageous than flat slabs with a lower consumption of concrete and steel, which provides a lighter structure ((Figure 1).

The concept of waffle slab can be described in a relatively easy way. When the spans have 4 m or more (Dantas and Nascimento 2009) [5], flat slabs have a small region of compressed concrete, and therefore, there is excess concrete below the neutral axis of the region under tension, the contribution of which to bending is not taken into consideration in the design. This ends up not helping the flexural strength but significantly increases the slab own-weight. Consequently, nothing more reasonable than substituting it with an inert material or simply leave voids, generating a more economical and efficient slab model, the waffle slab.

In this context of economy and efficiency, we seek to reduce concrete and steel consumption and, increase bending strength through the solution of a waffle slab. In addition, the shuttering techniques applied to waffle slabs aim at reducing the casing cost, avoiding constructing casings for all the ribs. In waffle slabs, this drawback is overcome, for instance, with reusable casings of reinforced plastic, which support not only the weight of the fresh concrete, but also the weight of the reinforcement, the equipment and the workers.

According to item 14.7.7 of NBR 6118:2007 [6], the CISWS present a tension area composed by ribs among which inert material can be placed. The CISWS can be one-way (OWWS) or two-way (TWWS) waffle slabs. TWWS (Figure 2) are used when the side ratio is not higher than two, a situation when there is an effort reduction and distribution of actions in the entire outline. The ribs (stringers) are parallel to the directions of the outline edges, mutually orthogonal and have the same distance between axes in both directions.

OWWS (Figure 3) has a different rib system than TWWS, because it has main and secondary ribs: main ribs on the direction of the smallest span and secondary ribs follow the direction of the largest span. The distances between the rib axes differ between the two directions; they are larger for the secondary ribs and smaller for the main ribs. When the distance between the rib axes are equal in both directions, the waffle slab is no longer one-way and becomes two-way.

Regarding the consumption of steel and concrete, Tenório et al. (2009) [7] published a study showing that OWWS are more economic that TWWS, in situations when the relation between the longest side and the shortest is equal or greater than 1.4. To analyze waffle slabs, it is important to define the acting loads, whether concentrated or distributed.

Live loads in garage floors from different types of vehicles are usually higher than the permanent loads, mainly because currently the new vehicles in the market have loads higher than 30kN, distributed between the tires in contact with the slab. The values and applications of those loads follow specific recommendations of the regulations of each country.

The international regulations, such as the EuroCode 1:2002 [2] and the International Building Code 2009 (IBC (2009) [3] present load values, related to the vehicle weight, that should be applied to the floor, through

Figure 2 –Two-way waffle slab, TWWS

Figure 3 – One-way waffle slab, OWWS

four small areas that represent the contact of the tires with the slab. Those loads distributed in square areas with side sizes ranging from 0.10 to 0.12 m are considered concentrated. On the other hand, the Brazilian regulation NBR 6120:1980 [1] adopts a minimum value of distributed load per square meter of area that should be applied to the slab and does not take into consideration the analysis of the concentrated loads representing the contact of the tire with the slab. Besides, the Brazilian regulation, which is from the 80s,adopts a value of up to 25 kN as the maximum load for passenger vehicles, when nowadays it is common to find vehicles with maximum loads up to 40 kN.

2. Objectives

When making a preliminary design or a simplified analysis, using distributed loads provides greater speed in the calculations. However, it is important that the distributed load used represents the actual situation under analysis. In this sense, the main objective of the present paper is to define an equivalent load that represents the vehicle load applied to the slab through tire contact, for different configurations of waffle slabs whether one-way or two-way. The results obtained applying the vehicle load as concentrated load (CL) and distributed load (DL) according to NBR 6120:1980 [1] are compared for garage floor OWWS and TWWS.

3. Methodology

Considering the basic configuration in Figure 4 of a single waffle slab, launched as OWWS and TWWS, various numerical simulations were performed for different λ (lambda) values, distance between main ribs (MRS), and amount of secondary ribs (ASR) using the finite element method through a specific analysis program.
The analysis of the deflection trend revealed two interesting aspects: the possibility of comparing the deflection generated by the distributed load (DL), recommended by the NBR 6120:1980 [1], with the deflection generated by the concentrated load (CL) and the possible setting of DL values that provide equal deflections to those generated by the CL. In this manner, it might be possible to conduct an analysis using DL and obtain values close to those of an analysis performed with CL, to calculate rib deflections and bending moments, which would be a significant contribution to improve the development of structural designs, once an analysis using CL is much more complex and time consuming than an analysis using DL. The height of the slab is defined by a preliminary design the algorithm of which is based on the recommendations of NBR 6118:2007 [6] for the calculus of beams at service loads (Tenório, 2011) [8]. This preliminary design is performed through the previous knowledge of the other slab dimensions and the requested load. The ABAQUS program, which is widely known in the academic sphere and has a wide range of elements and analysis models was used in the simulations. A sensitivity analysis was performed to define the level of mesh refinement needed to ensure consistent results.

3.1 Model description

After defining the height of the slab on the preliminary design, a set of models combining different values of MRS, ASR and ac-

Figure 4 – Basic structure of calculation models

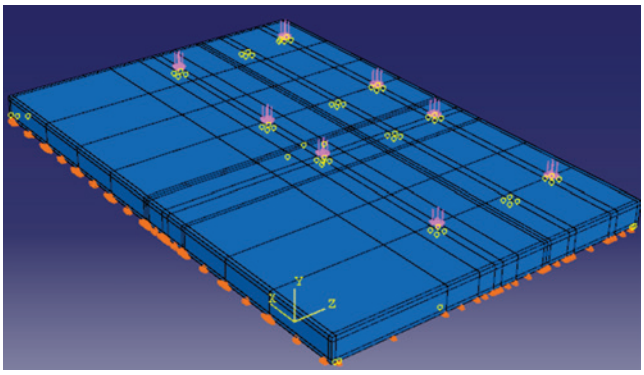
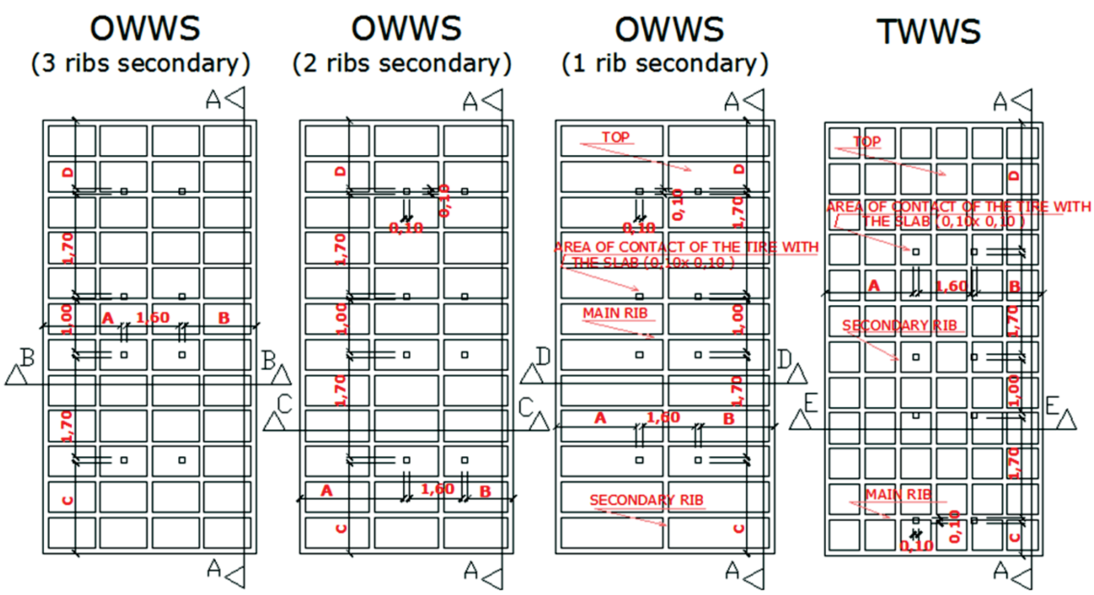


Figure 5 – Geometric illustration of OTE and arrangement of the concentrated loads (measured in 10^{-2}m)



cidental loads was defined. They were treated as modeling examples of one-way and two-way (OTE) waffle slabs, with the following considerations:

1) MRS values are constant and can be taken as equal to 0.50; 0.60; 0.65; 0.70; 0.80; 0.90 and 1.00 m;
2) one-way waffle slabs (OWWS) have main rib spacing (MRS) different from secondary rib spacing (SRS), models with 1, 2 or 3 secondary ribs were considered;
3) for the two-way waffle slabs (TWWS), for each MRS, the necessary ASR is defined so that the spacing between the main ribs (MRS) is equal to the secondary rib spacing (SRS);
4) the applied loads are the self-weight and the regulation live load; thus, for each model, on the one hand, the value of the distributed load recommended by NBR 6120:1980 [1] was considered while, on the other hand, the concentrated loads corresponding to three vehicle classes currently in use in the Brazilian market were also considered.

Figures 5 and 6 illustrate the details of the configuration under consideration and the positioning of the tires (small 0.10 x 0.10 m areas) where the concentrated loads are applied.

In this manner it is possible to combine 7 different MRS with 4 ASR for two types of load and three types of vehicles totalizing 54 different analysis situations. Table 1 lists the geometric data of the different models obtained by combining the parameters defined above,

Figure 6 – Geometric illustration of OTE sections

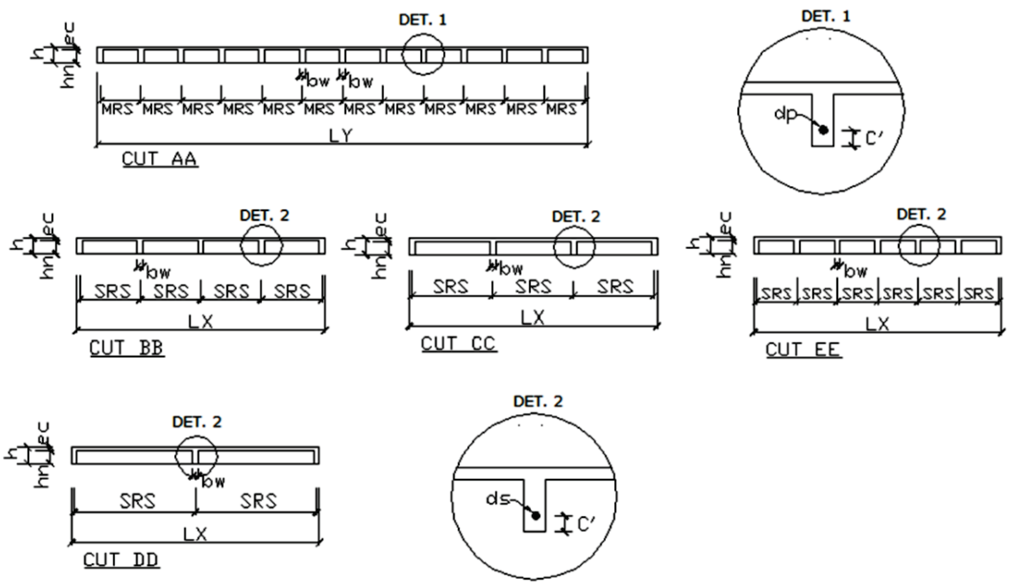


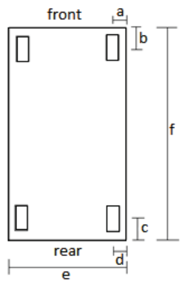
Table 1 – Geometric data of idealized slabs, in m

MRS	LY	A	B	C	D	bw	h	hn	ec	C '	ds	dp
0.50	6.00	2.95	1.35	0.90	0.40	0.09	0.28	0.23	0.05	0.04	0.008	0.0176
0.60	6.00	2.95	1.35	0.85	0.45	0.09	0.28	0.23	0.05	0.04	0.008	0.0176
0.65	6.00	2.95	1.35	1.95	1.15	0.09	0.28	0.23	0.05	0.04	0.008	0.0176
0.70	6.00	2.95	1.35	0.80	0.50	0.09	0.28	0.23	0.05	0.04	0.008	0.0176
0.80	6.00	2.95	1.35	1.15	0.15	0.09	0.28	0.23	0.06	0.04	0.008	0.0176
0.90	6.00	2.95	1.35	0.70	0.60	0.09	0.28	0.23	0.06	0.04	0.008	0.0176
1.00	6.00	2.95	1.35	0.65	0.65	0.09	0.28	0.21	0.07	0.04	0.008	0.0176

Table 2 – Geometric measures and loads of the vehicle types

Vehicle model	Compact	Sedan	Wagon
Total weight of the front axle (kN)	9.00	12.80	16.75
Total weight ofrear axle (kN)	8.60	9.10	13.35
Weight of operating vehicle (kN)	13.00	17.10	20.10
Total gross weight (kN)	17.60	21.90	30.10
a (m)	0.08	0.09	0.09
b (m)	0.80	0.80	0.80
c (m)	0.70	0.90	1.20
d (m)	0.08	0.09	0.09
e (m)	1.80	1.85	1.80
f (m)	4.25	4.80	5.26

Vehicle types



with: h the height of the slab; hn the height of the rib; ec the thickness of the table; bw the width of the rib; MRS the spacing between the axis of the main ribs; SRS the spacing between the axis of the secondary ribs, LX the shorter side of the slab; LY the longest side of the slab; C' the distance from the center of the reinforcement to the rib lower base; ds the diameter of the reinforcement in the secondary rib, dp the diameter of the reinforcement in the main rib

Table 3 – Values of the loads transmitted by the tires and used in the simulations

Vehicle model	compact	sedan	wagon
Load in the tire (kN)	4.50	6.50	8.50

The distributed load applied in the models corresponds to the value currently in force in the NBR6120:1980 [1], i.e., 3 kN/m^2. For the concentrated loads, the weights of three different vehicles are considered, which represent current models in the Brazilian Market: compact, sedan and wagon (utility). Table 2 lists the geometry and load information of the vehicles used.

This data was used to position the vehicle on the slab and to determine the load transmitted by the vehicle to the slab through the contact of the tire with the floor. In the modeling, for each type, the loads in each tire correspond to half the total weight of the "front axle", as indicated in Table 3.

These values define the load values and position used in the analysis. The vehicles are positioned to cover the most unfavorable situation. Considering the adopted control parameter, the position should generate the largest deflections.

Table 4 – Geometric characteristics of the slabs tested by Abdul-Wahab and Khalil (2000) (9)

Sab	Vods	a_1 (cm)	h_f (cm)	b_w (cm)	h (cm)	h/h_f	a_1/l
S1	11 X 11	13.6	2	5.2	9.5	4.8	0.091
S2	9 X 9	16.7	2	5.2	9.5	4.8	0.111
S3	7 X 7	21.4	2	5.2	9.5	4.8	0.143
S4	5 X 5	30	2	5.2	9.5	4.8	0.2
S5	9 X 9	16.7	2	5.2	12.5	6.3	0.111
S6	9 X 9	16.7	2	4.7	6.5	3.3	0.111

Table 5 – Characteristics of slabs tested by Abdul-Wahab and Khalil (2000) (9)

Slab	f_{ck} (MPa)	E_{cs} (kN/cm²)	G_c (kN/cm²)	$P_{cracking}$ (kN)	P_{last} (kN)
S1	31.3	2663.05	399.46	30	105
S2	32.0	2692.66	403.90	20	81
S3	31.4	2667.30	400.10	20	65
S4	28.9	2558.92	383.84	20	48
S5	29.9	2602.81	390.42	40	120
S6	29.1	2567.75	385.16	20	48

3.2 Type of element and refinement

The selection of the type of element and refinement focused on finding good responses with the smallest analysis time. To this end, numerical models were performed of an experimental model of one of the waffle slabs tested by Abdul-Wahab and Khalil (2000) [9]. Tables 4 and 5 and Figure 7 present the geometric characteristics and mechanical properties of the experimental models.

The model numerically simulated was experimental model S1, because it presented the largest deflections. The deflection values of the experimental model were compared with the values of the numerical model. In the numerical simulations, the values of 10 kN and 20kN were used, which still correspond to a linear

Figure 7 – Basic geometry (measures in cm, 10^{-2}m) of the slabs tested by Abdul-Wahab and Khalil (2000) (9)

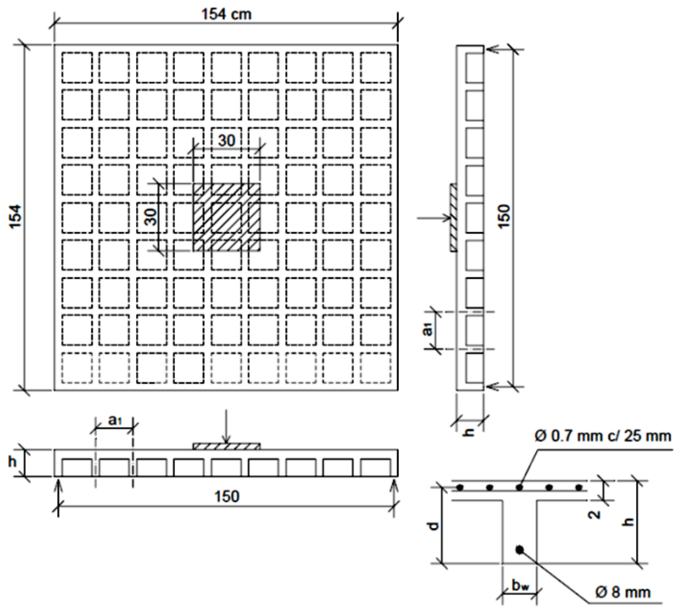
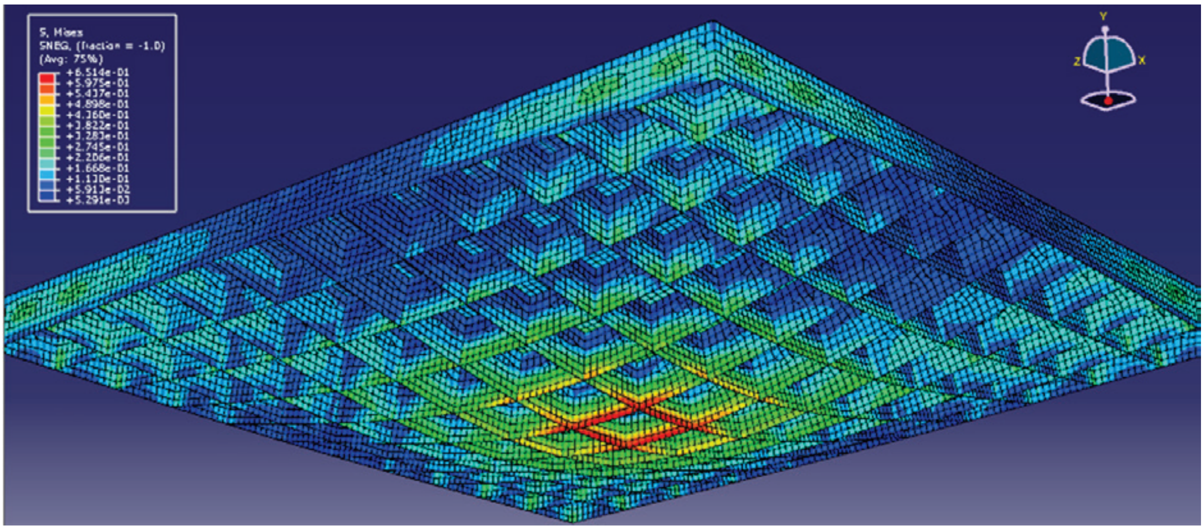


Table 6 – Deflection of experimental and numerical analyses

Load	Experimental analysis	Numerical analysis							
		S4R (10^{-2}m)				C3D20 (10^{-2}m)			
–	(10^{-2}m)	10%	20%	30%	40%	10%	20%	30%	40%
10kN	-0.01	-0.0255	-0.0257	-0.0258	-0.0279	-0.0145	-0.0143	-0.0141	-0.0139
20kN	-0.03	-0.0473	-0.0475	-0.0477	-0.0516	-0.0277	-0.0273	-0.0269	-0.0265

Figure 8 – Stress distribution (10^4 kN m^2) for the S4R - 10% numerical model



behavior, according to the experimental results presented by the authors where a cracking load of 30 kN was observed as shown in Table 5. These loads were applied in a centered area of the slab, as illustrated in Figure 7.

Figure 9 – Ratio between the deflection generated by the vehicles and the distributed recommended by the norm for λ = 1

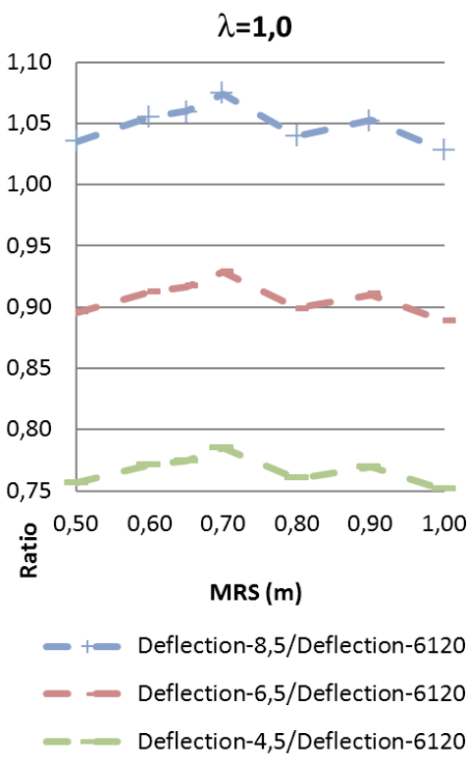


Table 6 presents the deflection values for the numerical and experimental models (experimental model S1). The simulations were performed with surface elements (S4R shell model) and 3D (C3D20 volume model) following the usual ABAQUS nomenclature. For each case, meshes with four element sizes were adopted: 1.36 cm (10% of the span), 2.72 cm (20% of the span), 4.08 cm (30% of the span) and 5.44 cm (40% of the span), with the span defined as the spacing between the rib axes.

In Table 6, it can be observed that the model of 3D element with a size equal to 10% span is the model that presents values closer to the experimental model. However, the deflections that correspond to a 10% size are not very different from those obtained with a 20% size (less than 2%). Therefore, it can be assumed that the deflection values obtained with the 20% size provide sufficient accuracy, because the gain obtained with the 10% size is negligible.

Figure 8 shows the stress distribution without concentration, consistent with the applied load indicating that the mesh refinement is adequate.

This preliminary analysis where the experimental results of Abdul-Wahab and Khalil (2000) [9] were reproduced, allowed defining the types of finite elements that can be used as well as the acceptable level of refinement for consistent results. It is clearly noted that considering shell elements shows a more flexible structure. Then, the same parameters are used to create the models that correspond to the different combinations mentioned in section 3.1.

4. Results

Considering the objectives of the analysis, the results are explored through the comparison of the deflections obtained with the distributed loads from the regulations and those obtained with the concentrated loads. The distributed loads equivalent to the weights of different types of vehicles are also deduced. Due to the large number of combinations, a XX-YY-MRS coding is defined where XX refers to one deflection or vehicle load, YY represents the type of vehicle and MRS the spacing between the main ribs for the combination under study. In general, it is worth highlighting the influence of each parameter on slab behavior.

The results of this parametric analysis can be presented as curves that show the relationship among deflections generated by the concentrated loads and those generated by the distributed loads for different values of the other parameters. In this manner, it is possible to have for each λ value (1; 1.5; 2) curves relating the deflections obtained for each category of vehicle and those obtained for the distributed load recommended by the regulation (Figures 9, 10,11). Those curves correspond to a SRS value = 1.30 m. It can be noticed that the curves present an equal trend.

These curves illustrate the influence of the slab geometry on the value of the necessary equivalent distributed load. On the other hand, the influence of the type of vehicle can also be considered comparing, for each category, the curves obtained for the different λ values (Figures 12, 13, 14).

The deflection ratio increases in all the cases for MRS values between 0.50 and 0.70 m. For higher MRS values the ratio decreases. The analysis of the data of the curves shows for λ = 2 values higher than 1, indicating that for this λ value, the distributed load of 3.0 kN/m² is low. It should be higher to be representative. However, for λ = 1.5 the distributed load is consistent with the concentrated loads of 6.5 kN and 4.5 kN, but the ratio is higher than one for an 8.5 kN load. Thus, the 3.0 kN/m² load cannot be used to represent the live load in this situation. When λ is equal to 1, all the deflection ratios become smaller than 1, indicating that the load of the regulation is representative.

The analysis above shows that for higher loads (CL equal to 6.5 kN or 8.5 kN) the distributed load recommended by the regulation is not representative of the actual slab situation, for any λ value or any spacing between main ribs (MRS).

Therefore, it was considered appropriate to correct the DL values so that it had the same deflection observed with the application of a CL, Table 7. In this table q NUM (kN/m2) is the DL that causes the same deflection than the CL with NUM (kN) value.

Table 7 shows the DL corrected values for each MRS, λ varying from 1.0 to 2.0. The DL corrected values show some linearity in relation to λ variation as shown in Figure 15 where q-NUM1_NUM2 (kN/m²) is the DL that causes the same deflection that a CL of NUM1 (kN) value in the model with MRS of NUM2 (m) value.

However, there are two important observations for this range of λ values. First, analyzing the variation for a particular type of vehicle and the different MRS values (Figure 16), it can be observed that, for the same slab geometry, that is, the same λ, the rate of correction depends on the MRS value.

On the other hand, extracting the curves that correspond to the same MRS, of 0.70 m, for example, it can be observed that the

Figure 10 – Ratio between the deflection generated by the vehicles and the distributed recommended by the norm for λ = 1.5

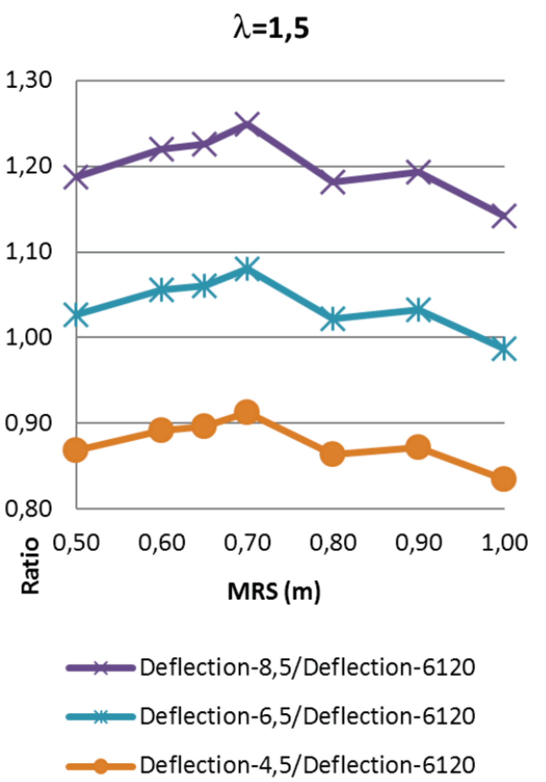
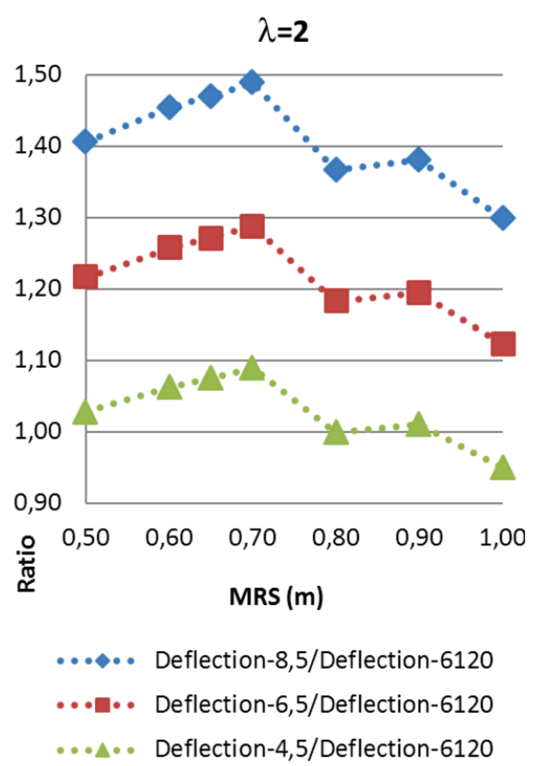


Figure 11 – Ratio between the deflection generated by the vehicles and the distributed recommended by the norm for λ = 2



lines of variation of the corrected distributed loads are parallel, indicating that, for the same MRS value, the correction rate is independent of the load (Figure 17).
All the results presented so far come from simulations performed with a single slab main span value (LY = 6m). To complete the analysis of the distributed load corrected values, additional models were created to check a possible dependence on span length, i.e., models with different sizes although maintaining the same side ratio λ.
Initially, the situations in which the length of the main span LY is varied from 4 to 12 m maintaining the same λ = 2 were analyzed. The analysis took into consideration an MRS of 0.80 m and a CL of 8.5 kN (wagon type vehicle).The DL corrected values corresponding to these models are represented in Figure 18 where the variation trend as a function of LY can be observed. This trend can be easily fitted by a polynomial function.
In a second step, the DL corrected value variation trend was checked considering different λ values for each LY analyzed. Figure19 presents the results obtained. As observed in the analysis with constant LY, the DL correction rate increases with λ value, showing almost the same trend for all the LY values considered. It is important to note that for λ values higher than 2, the correction rate cannot be considered linear.
The values of this analysis for the three vehicle categories in Table 8 show the influence of the slab geometry, defined here by λ value. The distributed load corrected values tend to decrease with the increase of λ.

5. Final considerations

The corrected DL (distributed load) values were defined in the deflection analyses, considering that the vehicle load acting on the floor was of a single type, i.e., only vehicles with maximum loads per tire limited to 4.5 kN, or 6.5 kN, or 8.5 kN, but the performance of them acting together was not taken into consideration, which is usual in garage floors, where all types of vehicles are parked, without distinguishing specific parking places for each model.
According to the National Traffic Department, DENATRAN, the Brazilian fleet of compact, sedan and wagon vehicles is approximately 42 million with 10% wagon and 90% vehicles that withstand up to nine passengers including the driver, which are the

Figure 12 – Ratio between the deflection generated by the distributed load corrected for the compact model (q = 4.5 kN) and the distributed load recommended by the law for λ = 1, 1.5 and 2

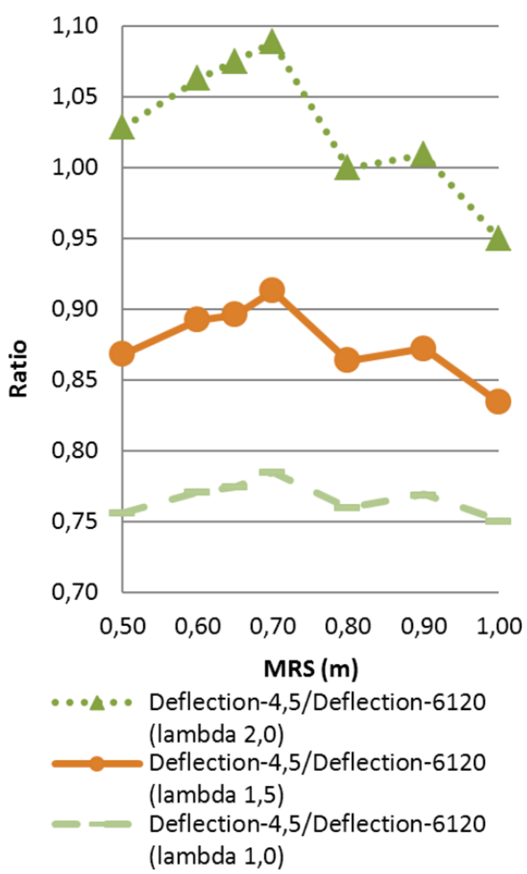


Figure 13 – Ratio between the deflection generated by the distributed load corrected for the sedan model (q = 6.5 kN) and the distributed load recommended by the law for λ = 1, 1.5 and 2

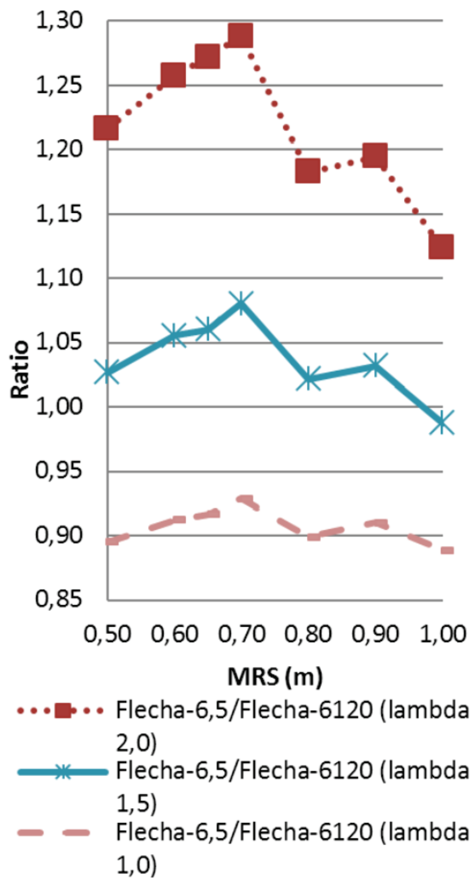
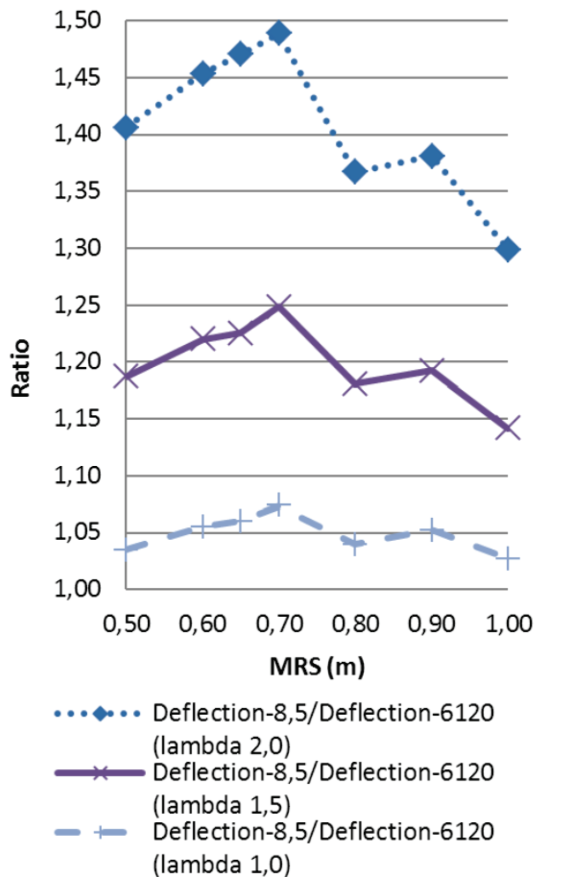


Figure 14 – Ratio between the deflection generated by the distributed load corrected for the wagon model (q = 8.5 kN) and the distributed load recommended by the law for λ = 1, 1.5 and 2



vehicles mentioned in the present paper as sedan and compact. Taking this as a premise, it can be stated that the probability of, on a garage floor, a particular slab having only wagon type vehicles parked, generating the most unfavorable situation for the structure, is very low.

Figure 15 – Distributed load corrected values λ = 1, 1.5 and 2.0

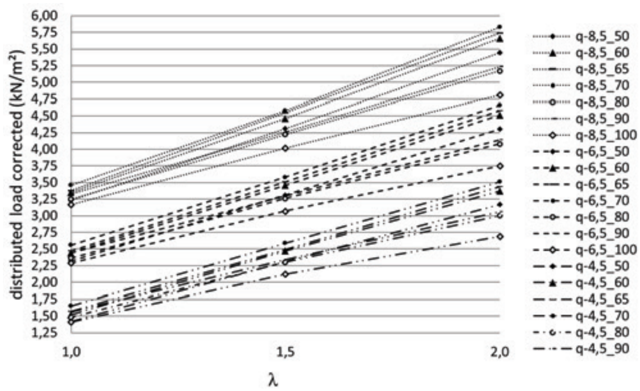
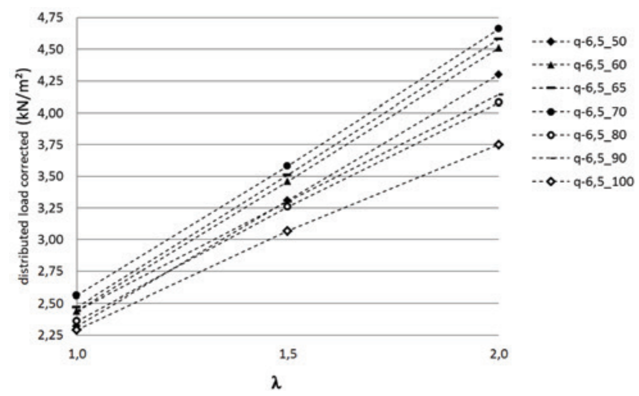


Figure 16 – Corrected values for q = 6.5 kN



Thus, this study suggests, for general use of garage floors, a value of corrected accidental distributed load associated to vehicles with maximum load equal to 6.5 kN per tire, i.e., q-6.5. This load of 6.5 kN per tire also represents wagons, when they

Table 7 – Distributed load corrected values for λ equal to 1.0, 1.5 and 2.0

MRS (m)	0.50	0.60	0.65	0.70	0.80	0.90	1.00
q-8.5 (kN/m²) for λ = 1.0	3.23	3.35	3.38	3.46	3.25	3.33	3.17
q-8.5 (kN /m²) for λ = 1.5	4.31	4.46	4.55	4.58	4.22	4.26	4.02
q-8.5 (kN /m²) for λ = 2.0	5.44	5.66	5.74	5.83	5.17	5.23	4.81
q-6.5 kN /m²) for λ = 1.0	2.32	2.44	2.47	2.56	2.36	2.44	2.29
q-6.5 (kN /m²) for λ = 1.5	3.31	3.46	3.51	3.58	3.26	3.30	3.07
q-6.5 (kN /m²) for λ = 2.0	4.30	4.51	4.58	4.66	4.08	4.14	3.75
q-4.5 (kN /m²) for λ = 1.0	1.42	1.52	1.57	1.65	1.48	1.56	1.41
q-4.5 (kN /m²) for λ = 1.5	2.31	2.47	2.49	2.59	2.30	2.34	2.12
q-4.5 (kN /m²) for λ = 2.0	3.17	3.37	3.44	3.51	3.00	3.06	2.69

Figure 17 – Corrected values for MRS = 0.70 m

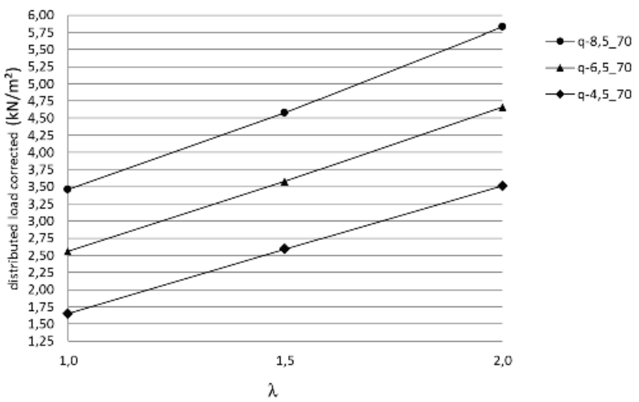
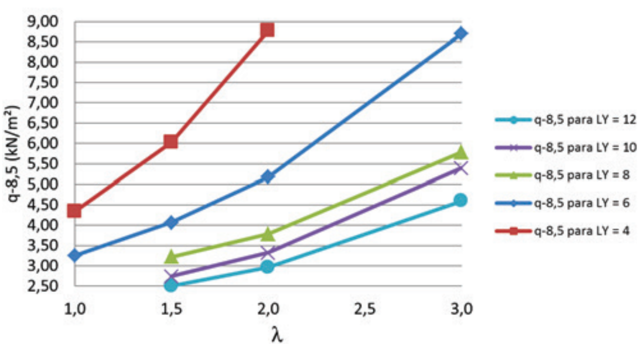
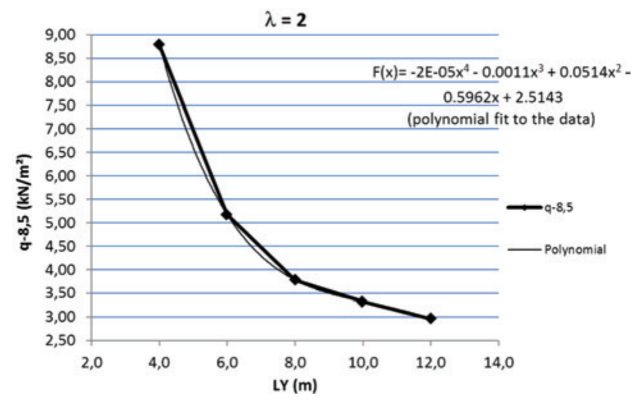


Figure 19 – Distributed load (q-8.5) for the spans from 4m to 12m and λ from 1.0 to 3.0



are not fully loaded, that is, without passengers. Table 9 presents the corrected DL values (q-c), associated only to a concentrated

Figure 18 – Distributed load (q-8.5) for the ce4 m to 12 m spans and λ = 2.0



load (CL) of 6.5 kN. The values show two variation trends: one inversely proportional to LX variation and the other in the same direction than λ, indicating that using the values in Table 10, in structural design is conditioned to the slab geometry according to λ and LX values.

A reasonable distributed load value to be used in garage floors, currently, would be 4.0 kN/m². For slabs with LX smaller than 4m, the values should be raised with a ∅=1,15* (LX/l0),where l0=4.

6. References

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Table 8 – DL corrected values for λ equal to 1.0, 1.5, 2.0 and 3.0 with constant LY

MRS (m)	2	3	4	5	6
q-8.50 (kN/m²) (λ = 1.0)	11.43	8.37	4.34	3.74	3.46
q-8.50 (kN/m²) (λ = 1.5)	10.14	6.43	4.58	3.18	2.51
q-8.50 (kN/m²) (λ = 2.0)	8.78	5.83	3.78	3.32	2.96
q-8.50 (kN/m²) (λ = 3.0)	9.85	5.92	4.43	3.21	2.66
q-6.50 (kN/m²) (λ =1.0)	8.44	6.18	4.55	3.40	2.56
q-6.50 (kN/m²) (λ =1.5)	7.93	5.03	3.58	2.49	1.96
q-6.50 (kN/m²) (λ = 2.0)	7.03	4.66	3.03	2.66	2.37
q-6.50 (kN/m²) (λ = 3.0)	8.13	5.57	3.70	2.68	2.22
q-4.50 (kN/m²) (λ =1.0)	5.46	4.00	2.95	2.20	1.65
q-4.50 (kN/m²) (λ = 1.5)	5.74	3.64	2.59	1.80	1.42
q-4.50 (kN/m²) (λ = 2.0)	6.61	3.51	2.85	2.50	2.23
q-4.50 (kN/m²) (λ = 3.0)	6.47	4.79	3.98	3.52	2.92

Table 9 – Corrected CACD (q-c)values for λ equal to 1.0, 1.5, 2.0 and 3.0

MRS (m)	2	3	4	5	6
q-8.50 (kN/m²) (λ = 1.0)	11.43	8.37	4.34	3.74	3.46
q-8.50 (kN/m²) (λ = 1.5)	10.14	6.43	4.58	3.18	2.51
q-8.50 (kN/m²) (λ = 2.0)	8.78	5.83	3.78	3.32	2.96
q-8.50 (kN/m²) (λ = 3.0)	9.85	5.92	4.43	3.21	2.66
q-6.50 (kN/m²) (λ =1.0)	8.44	6.18	4.55	3.40	2.56
q-6.50 (kN/m²) (λ =1.5)	7.93	5.03	3.58	2.49	1.96
q-6.50 (kN/m²) (λ = 2.0)	7.03	4.66	3.03	2.66	2.37
q-6.50 (kN/m²) (λ = 3.0)	8.13	5.57	3.70	2.68	2.22
q-4.50 (kN/m²) (λ =1.0)	5.46	4.00	2.95	2.20	1.65
q-4.50 (kN/m²) (λ = 1.5)	5.74	3.64	2.59	1.80	1.42
q-4.50 (kN/m²) (λ = 2.0)	6.61	3.51	2.85	2.50	2.23
q-4.50 (kN/m²) (λ = 3.0)	6.47	4.79	3.98	3.52	2.92

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