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Comparative analysis of the efforts in the reinforced concrete of the milking platform in the parallel and tandem milking parlor

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Abstract

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The aim of this study was to investigate efforts in reinforced concrete of platforms in milking parlor "Parallel" and "Tandem". To achieve the objective models have been developed for describing the coordinates of their limbs, to the outline of the milking platform. By specialized software are introduced static models (load combinations) for loading reinforced concrete of the milking platform. Calculated bending moments are introduced to computational load impacts. Studies prove that the location and size of the load directly affect the operational status of the construction of milking platforms. Found that for the same number of animals (equal load) at milking parlor "Parallel" the value of the lower bending moments (MhD = M11) is three times smaller (0.15 kN.m) than in "Tandem" (0.45 kN.m). In a third combination in operation load is reduced by 50% and the lower bending moments and MxD, MyD reduce nearly 5 times. The largest absolute value of bending moments amounts to 1.37 kN.m., from which it follows that adopted reinforcement 5 pieces N8 / m completely "cover (enough)" requirements and can accommodate bending moments to 5.23 kN.m. or nearly three times more than estimated.

Keywords: milking parlor; milking platform; reinforced concrete; load model

Introduction

The milking parlor is an expensive facility and it is advisable to look for a solution to reduce the amount of investment. A large part of the financial resources are allocated for the construction of the engineering and technical infrastructure. There is no specific technical documentation in the information space regarding the design dimensions of the bearing reinforced concrete elements under the milking platforms. This requires research on the nature of the load on them and performing of constructive analysis.

The load on the milking platforms is the sum of the weights of the animals and the pipe fittings, as well as the weight of the structures. The latter load is a function of the design and geometric dimensions, the bulk weights of the materials from which the structures and load factors are constructed, taking into account the possible changes in loads during the design life (Standards 1997, 2003 a, b). All cargo is transmitted to the earth through the main plane of the milking platform (Bozhinov et al., 1987). The main and greatest loads on milking platforms are from animals. In order to create a theoretical model of loading, it is necessary to assume the weight of an animal. The greater the load on the platforms is, the less favorable the effect is on the platforms. In this case, it is assumed that one cow weighs 650 kg. The weight is transmitted to the milking platform through its hooves. Hahn et al. (1984) established that the cow hoof area ranges from 97 to 102 cm². To idealize the load pattern, it is assumed that the cross section of the hoof is circular in shape and has an area of 100 cm².

According to Georgiev (2016) the mass of the animals is distributed between the front and hind limbs 49% for the front legs and 51% on the hind legs respectively, i.e. in this case the front two limbs are loaded with 318.5 kg, (159.3 kg on one leg) and hind legs with a total weight of 331.5 kg (165.7 kg each).

The literature review revealed that there is no structural documentation on the nature of the loads on the milking platforms in the different configuration of the animals on the milking platforms, which necessitates the development of loading models on the reinforced concrete plate of the milking platform.

The objective of this study is to investigate the efforts in the reinforced concrete slab of the milking platforms for cows parallel and transversely positioning animals relative to the longitudinal axis of the channel. To achieve this goal, the following tasks have been set: 1) To develop models for loading the milking platforms in the different variants of the situation of the cows; 2) To develop static models for calculating the loading effects on the reinforced concrete slab of the milking platform.

Material and Method

Object of Study

The object of the study were milking parlors of type "Tandem" (1850/185 cm) and "Parallel" (550/250 cm) with a capacity of 2x6. The milking platforms in the two parlors are made of concrete class C16/20 (B20). The constructive calculations are performed with a specialized software SAP 2000. The flooring is investigated by the finite element method, using a pre-prepared static model of the design for computational loads. Data related to the two milking parlors have been entered in the SAP 2000 program:

Thickness of the milking platform - 15 cm.

- Characteristic of the soil - Winkler constant - Ro = 300 kN/m^2 (Standards, 2003 a)

The coefficient of crushed stone - Winkler constant *cb* = 20000 kN/m^3 (Hamova, 2016; Kolev, 2019).

According to the methodology for calculation of reinforced concrete elements the following formulas have been introduced in SAP 2000:

$$pk=\gamma f \times gk + \gamma f \times \psi 2 \times qk = 1.0 \times gk + 0.6 \times 1.0 \times qk \quad \text{(Standards, 2003 b)} \quad (1)$$

The computational load combination is made after the following factors have been entered:

γf =1.35 - constant load factor;

γf =1.5 - variable load factor;

$\psi 2$=0.6- constant load combination factor for *category F* and in the form:

$$pd = \gamma f \times gk + \gamma f \times qk = 1.35 \times gk + 1.5 \times qk \quad \text{(Standards, 2003 b)} \quad (2)$$

The dynamic loading of the structure has not been described analytically. Their effect is accounted for by introducing a coefficient jf = 2, which increases the static loads:

$$pb = jf \times pd \quad \text{(Standards, 2003 b)} \quad (3)$$

Results and Discussion

When creating a computational model, it is necessary to find the coordinates of the limbs in order to be able to impose the load on the milking platforms. All variants of the situation are for 2x6 capacity as it is common in Bulgaria. Fig. 1. shows a diagram of the coordinates of the limbs of the cows, which stand parallel to the longitudinal axis of the technological channel ("Tandem").

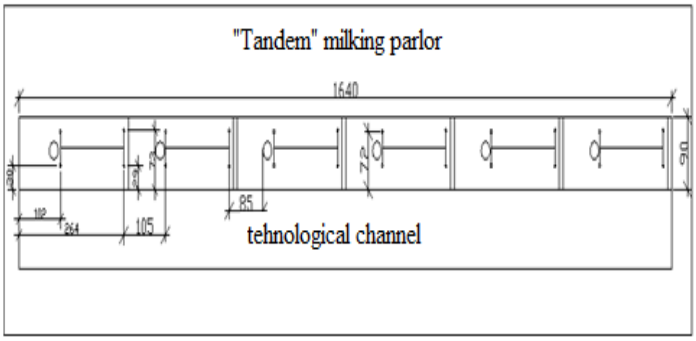

Fig. 1. Position of cows parallel to the technological channel with limb coordinates (cm)

The length of the milking platform is 1640 cm and the width is 90 cm. The forelegs (on the technological channel side) are 30 cm from the edge a, the others are 72 cm. For the hind legs, these distances are 29 cm and 73 cm, respectively. Neighboring cows are at a distance of 85 cm from each other. For "Parallel" milking parlors, the length of the milking platform is 550 cm and is almost 3 times (2.98) shorter than the "Tandem" milking parlor. In contrast, the width is 250 cm (Fig. 2.).

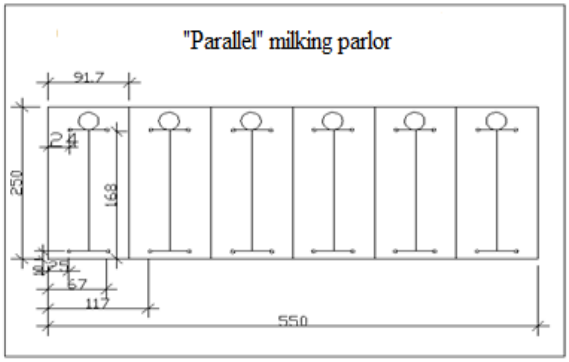

Fig. 2. Position of the cows perpendicular to the technological channel with the coordinates of the limbs (cm)

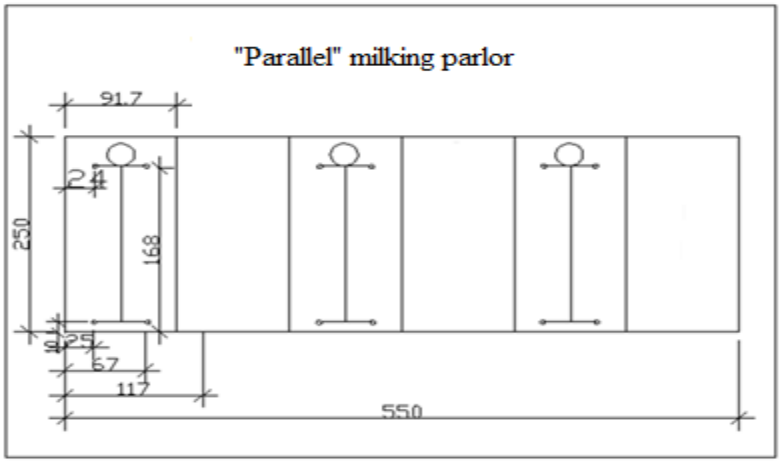

Fig. 3. The second model (II cargo combination)

The third model (III cargo combination) is also for three animals, but they are in the first three milking locations.

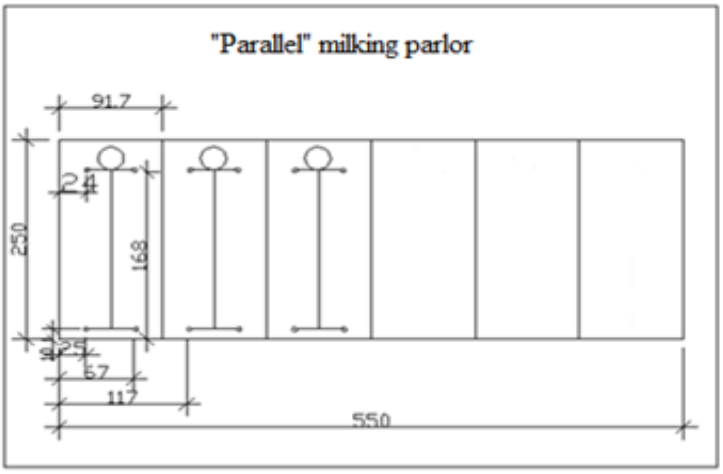

Fig. 4. Load model with three animals located at one end of the milking platform (III cargo combination)

Static analysis was performed for all cargo combinations. The results obtained are presented in the next figures and tables. Fig. 5 shows the combination of the load with all the cows on the milking platforms of the

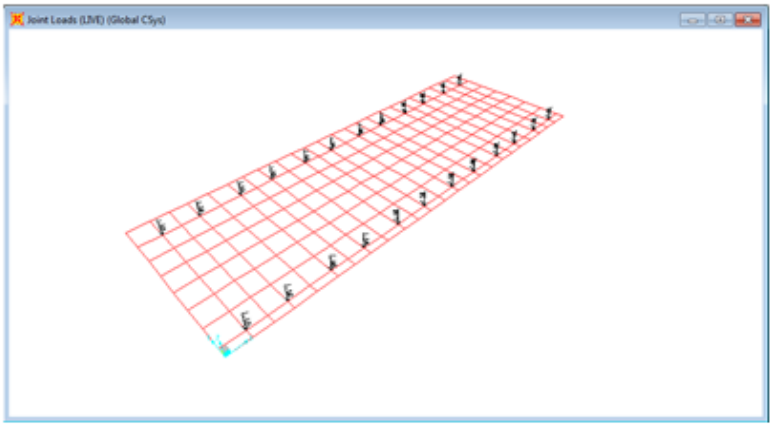

Fig. 5. Static load diagram for "Parallel" milking parlor and I cargo combination (model)

The SAP 2000 software calculates the values of the bending moments for a model of loading with all animals on the milking platform. On the long side these points are marked with Mx and on the short side with My. For all figures, the upper bending moments are denoted by the index G, i.e. MxG and MyG, and the lower bending moments by the index D, respectively MxD and MyD. The values of the lower bending moments of the I load combination (with all cows on the milking points) MxD for "Parallel" and "Tandem" are shown graphically in Figures 6 and 7, respectively.

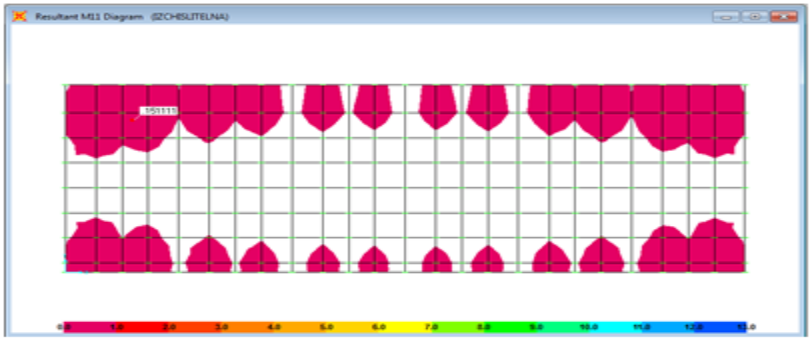

Fig. 6. maxMx = 0.15 kN.m Lower bending moments (Mx = M11) in the reinforced concrete structure of the "Parallel" milking parlor and the I loading combination (model)

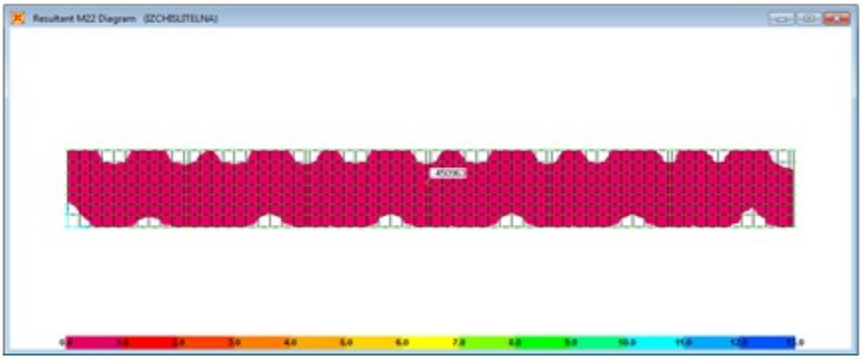

Fig. 7. max MyD = 0.45 kN.m. Lower bending moments (MyD = M22) in the reinforced concrete structure of the milking platform for the "Tandem" milking parlor and the I loading combination (model)

Table 1. Summary values for upper and lower bending moments under milking platforms

Milking parlor	Cargo combination (model)	Bending moments [kN.m]			
		MxG	MyG	MxD	MyD
1	2	4	5	6	7
"Tandem"	I cargo combination (model)	- 0.69	-0.23	0.41	0.45
	II cargo combination (model)	-0.37	-0.03	0.10	0.08
	III cargo combination (model)	-0.19	-0.02	0.09	0.20
"Parallel"	I cargo combination (model)	-0.28	-1.37	0.15	0.15
	II cargo combination (model)	-0.57	-0.79	0.40	0.16
	III cargo combination (model)	-0.36	-1.30	0.22	0.14

From the values of the figures it can be seen that for the same number of animals positioned parallel and perpendicular to the longitudinal axis of the channel, different values of the lower bending moment are obtained. In this case, the value of (MxD = M11) for "Parallel" milking parlor is three times smaller (0.15 kN.m) than for "Tandem" (0.45 kN.m). This pattern is valid for all load combinations (Table 1). Fig. 8 shows the values of the upper MyG bending moments for the "Parallel" milking parlor at II cargo combination.

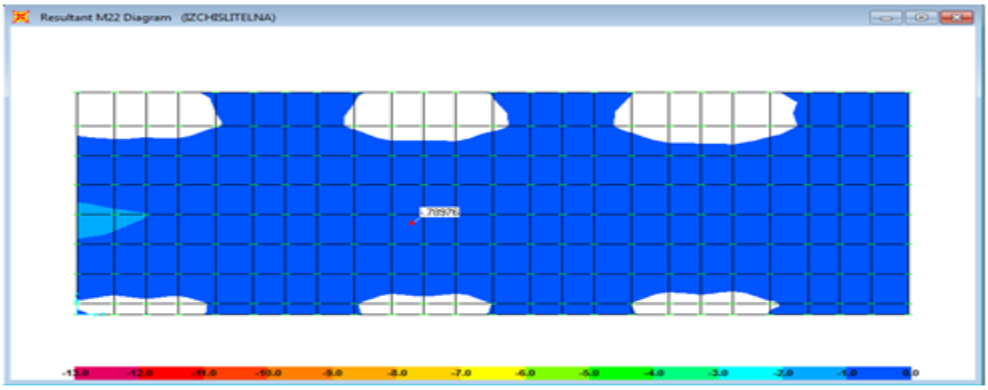

Fig. 8. max My = - 0.79 kN.m Upper bending moments (My = M22) in the reinforced concrete structure of the "Parallel" milking platform and the II cargo combination (model).

The value (- 0.79 kN.m) is negative because at these moments the upper threads of the reinforced concrete structure are stretched. Positive values are when the lower threads are stretched in an element.

According to Eurocode 2 (Dinev, 2005; Daalov & Daalov, 2010; Rusev et al., 2011; Berkowski & Dmochowski, 2019), the minimum permissible reinforcement for reinforced concrete slabs is 5N8/m reinforcement, located in the form of a double row grill as upper and lower. This means that every linear meter of the structure contains 5 pieces of this reinforcement every 20 cm.

The upper reinforcement on the short and long sides "covers" the upper bending moments (MxG, MyG) and the lower reinforcement respectively the lower bending moments (MxD, MyD). In accordance with the requirements of European standards for the design of reinforced concrete structures (Dinev, 2005; Daalov & Daalov, 2010; Rusev et al., 2011), the designer is obliged to comply with the minimum requirements for reinforcement of reinforced concrete slabs and to provide reinforcement 5N8/m.

In the III cargo combination, although the load is reduced by 50%, i.e. only 3 animals are positioned on milking sites, the MxD and MyD moments are reduced nearly 5 times. This proves that the positioning of the animals directly affects the magnitude of the lower and upper bending moments in the reinforced concrete structure of the milking platform. The values confirm the need for plate study for different load combinations.

The highest value for the upper bending moment is for the I load combination (with all animals on the milking platform) for the "Parallel" milking parlor. The lowest value is in the "Tandem" milking parlor for the III cargo combination when the animals are in the first three milking locations

The lower bending moments MxD, MyD in the reinforced concrete structure for the two coordinate axes are in columns 5 and 6. The smallest MxD = 0.09 kN.m for "Tandem" at the III load combination. At lower bending moments MyD along the ”Y“axis, the lowest value (MyD = 0.08 kN.m) is at the Tandem milking parlor and the II cargo combination.

After analysis of the results, it was found that different load patterns (combinations) have a great influence on the values of the upper and lower bending moments MxG, MyG MxD and MyD.

The highest absolute value for these moments is 1.37 kN.m. (Table 1). After calculations, it was found that reinforcement 5 pieces of N8/m (i.e. mounted over 20 cm) could "cover" bending moments up to 5.23 kN.m (Gochev et al., 2009).

From this it becomes clear that the accepted reinforcement is sufficient to absorb the occurring moments in the reinforced concrete construction of the milking platforms.

Conclusions

1. Situation models for the animals, describing the coordinates of the limbs of the animals at their different location relative to the longitudinal axis of the milking canal, have been developed.

2. Developed static models (load combinations) of the reinforced concrete structure of the milking platform computational load impacts.

3. The location and magnitude of the load have a direct effect on the operational condition of the reinforced concrete structures of the milking platforms and the ground beneath them.

4. The bending moments were calculated and it was found that for the same number of animals (equal loading) at the "Parallel" milking parlor, the value of (MxD = M11) was three times lower (0.15 kN.m) than that of "Tandem" (0.45 kN.m).

5. In the III combination the load is reduced by 50% and the lower bending moments MxD and MyD are reduced almost 5 times.

6. The maximum absolute value of bending moments is 1.37 kN.m., which means that the accepted reinforcement of 5N8 m completely “meets” the requirements and can absorb bending moments up to 5.23 kN.m. or nearly three times the estimate.

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