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TECHNICAL SOLUTION PROBLEMS OF CONCRETE INDUSTRIAL GROUND FLOORS IN LATVIA

Sandra Gusta[1, a], Silvija Strausa[2, b], Mareks Pavars[3, c]
[1,2,3] Latvia University of Life Sciences and Technologies, Latvia, Akademijas street 19, Jelgava, Latvia
[a]sandra.gusta@llu.lv,[b]silvija.strausa@llu.lv,[c]pavars.mareks@gmail.com

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Abstract. The construction industry in Latvia has been developing very rapidly in recent years, and especially construction of public and industrial buildings. All these new buildings are characterized by a large volume of floors with specific characteristics and quality requirements, which are based either on the reception of heavy loads or on certain requirements for surface level and flatness of the surface. The research focuses on the requirements of the floor surface in different countries. The standards and standards of surface tension and flatness as well as the technology and measurement equipment used to determine surface tension and flatness are summarized in countries such as United States, United Kingdom and Germany. Having assessed the foreign experience in determining and controlling the quality of industrial floors, we noted the importance of this process in terms of building exploitation. Upon acquainted with the specification of the technical design of floors of public and industrial buildings, we found a lack of standard requirements. When describing and measuring the precision and flatness of concrete floors in Latvia, we also found insufficient quality assurance. Using analytical, statistical and empirical research methods and using appropriate measuring devices, we obtain the results, which are summarized, analyzed and conclusions drawn, which indicates the need to develop standards for determining the surface quality of floors.

Introduction

Construction output was by 21.7% higher than in 2016 (see in table 1). This is largely due to the launch and implementation of European Union Structural Fund projects, which have a positive impact on the sector.

Table 1

Construction Output by Type of Construction; 2015, 2016, 2017 in Latvia

At current prices (thsd.euro)

	2015		2016		2017	
	thsd.euro	%	thsd.euro	%	thsd.euro	%
Total	1 743 726	100	1 425 952	100	1 735 952	100
Residential buildings	223 394	12.8	234 576	16.5	216 044	12.5
Non-residential buildings	634 154	36.4	610 941	42.8	754 416	43.5
Industrial buildings and warehouses	99 941	5.7	101 395	7.1	139 917	8.1

Created by the authors according CSB data [7]

As it is seen in table 1, in 2017 the volume of industrial production buildings and warehouses has reached 13,991 thousand euros, or 8.1% of the total construction output (1 735 952 thousand euros).

Table 2 gives a breakdown of the volume of construction output by type of work in 2016-2017.
In 2017, the volume of construction products increased both in buildings and in engineering structure basic categories.The fastest increase was observed in the construction of engineering structures. Compared to the previous year, construction output was 31.9% higher. In terms of volume, the largest increase was observed in the construction of highways, streets, roads, aerodrome runways and railways. It is expected that construction of civil engineering structures will continue to grow in the coming years, taking into account the implementation of European Union structural funds projects and large-scale infrastructure projects.
The purpose of the research work is to evaluate the quality of concrete floors located on the ground in commercial buildings built in Latvia, mentioning applied construction technology and making a comparison in accordance with the standard used in England. An analytical, statistical, and empirical research method has been used in the work, using measuring devices to measure physical quantities and calculus for mathematical and logical operations with measurable values.
Building construction in general increased by 14.8%. This was achieved by an increase of 23.5% in the construction of non-residential buildings, while in the group of residential buildings there was a decrease of 7.9%. In non-residential buildings, the largest contribution to growth was in industrial buildings and warehouses (by 33.3%) and office buildings (by 28.7%).

Table 2

Construction Output by Type of Work; 2016, 2017

At current prices (thsd.euro)

	2016			2017		
	Total	New construction	Repairs	Total	New construction	Repairs
Total	1 425 952	696 333	729 620	1 735 952	1 996 428	739 524
Residential buildings	234 576	142 133	92 443	216 044	165 474	50 569
Non-residential buildings	610 941	295 841	315 100	754 416	425 017	329 399
Industrial buildings and warehouses	101 395	71 412	29 982	139 917	85 136	54 781

Created by the authors according to CSB data [7]

In the 4th quarter of 2017, construction output increased by 24.4% compared to the 4th quarter of 2016. The growth was observed in construction of buildings and civil engineering structures, the growth was 19.6% and 31.1%, respectively, in the construction of buildings in the 4th quarter construction of non-residential buildings increased rapidly (by 30.7%), while the volume of construction of residential buildings decreased by 9.8% [6].
According to the data of the Central Statistical Bureau, in 2017 2540 building permits for the construction, reconstruction, reconstruction and restoration of one-apartment houses for the total area of 531.1 thousand m^2 were issued, including 1948 construction permits for a new building with a total area of 395.8 thousand m^2. 202 construction permits were issued for the construction of industrial production buildings and warehouses for the total area of 336 thousand m^2. Of these, 113 construction permits were issued for new buildings with a total area of 134.7 thousand m^2. Due to the increase in the volume of construction of industrial buildings and warehouses, the issue of the quality of floors becomes more and more relevant.

Technological solutions to the problems of concrete industrial floors on the industrial ground floors in Latvia.

This research explores what makes industrial concrete floors different from ordinary concrete floors and what are the main requirements and their indicators for the quality of floors in individual countries.

Flooring depends on the design, specifications and construction technology. The flooring quality is based on a complete understanding of the requirements of use and necessity.
The essential requirements for concrete flooring are as follows:

- They must maintain their applicability according to the planned conditions;
- The floor should receive the designed static concentrated and dispersed loads without causing unacceptable deformation, cracks, joint damage;
- Position of the joints must take into account the position of the shelves and columns;
- Seam arrangement must be in line with the design layout;
- Seam and reinforcement layout should be fully protect floors against cracking;
- The floor surface must be in regular compliance with the regulatory requirements;
- Floor should be appropriately rough and chemically resistant;
- Floor finishing must be in accordance with the requirements.

In this research key attention is paid to the regularity of the surface of industrial concrete floors in accordance with requirements and quality control.
In the past, for quality control for concrete floors used only tape measures and 3 meters long lats, as well as ruler for slit size determination. Such measurements were not very precise and depended on the lighting, shading, room size, and many other factors.
Today, floors are divided into classes and each class has strict requirements for quality. A number of precise instruments for determining the quality parameters have also been developed.
Each country has its own standards for determining the floor quality [1].

Table 3

Comparison of Standards by Country

Country	For free traffic	For defined transport movement
UK and areas of UK influence	Concrete Society's Technical Report 34 (TR34) Free Movement Specification Table	Concrete Society's Technical Report 34 (TR34) Defined Movement Specification Table
USA and areas of American Influence	ASTM F-number system	The ACI F min number system
European countries	DIN 18202	DIN 15185, EN15620
Germany	DIN 18202	VDMA Guideline

Created by the authors

In the England area, the floor surface is evaluated for flatness and levelness. Typically, the surface flatness is determined at 600mm section, while the levelness is 3m margin. If materials are moved with specialized lifting equipment, the leveling is determined according to the size of the machine. The vertical deviation is allowed within ± 15 mm of an accepted or fixed zero mark.
In industrial buildings, two traffic areas are divided into floor areas: with free movement and a certain movement direction. In buildings with free transport there are no specially designated transport routes and they are production buildings with low stacks (up to 4 meters high). Buildings with a certain movement have high stacks and narrow fixed roads that are adapted to a specific size transport.
For free movement in buildings, the quality of the floor surface is determined by two parameters: levelness E and flatness F. For determining E the floor is conditionally divided into 3m long cuttings. Measurements are made with precision optical level meters at each intersection. The values of F are measured with a special digital measuring instrument in parallel with the previously marked lines.
Data analysis and tolerances: 95% value method is used, which determines that 5% of the largest deviations are rejected and 95% is evaluated.
The quality of the floor is inadequate if:

- Max of the permissible 95% values exceeds the normative;

- One of points from the E measurement is out of range ± 15mm.

Table 4

Flooring tolerances depending on their application

Floor type	Floor application	E value	F value
FM1	Very high demands on surface flatness and level. 13m without transport change	4,5	1,8
FM2	8-13m without transport change	6,5	2,0
FM3	Lower floors with 8-13 m without transport change	8,0	2,2
FM4	Lower floors where the height of the cargo is limited to 4m	10,0	2,4
	Transport shifts are designed to branch out		

Using the **Lats Method (Straightedge Method)**, the supervisor places the lats in a freely chosen direction and measures the gap between the floor and the lats with the special metal calibrators (Lenght of lats in Europe 2m, ASV-3m). The slit size is compared to the standard tolerance. Local roughness is measured with shorter ruler (in Europe - 0,2 m; US-0,3 m). In England, using the latte method, the tolerances are determined by BS EN 13670. Standard BS 8204 defines tolerances for the floor level depending on the finish of the floor support plate.

Table 5

Standarts requests to the floors levelness and flatness

Normative	Floor classification	tolerance to the level, mm	tolerance for flatness, mm
BS EN 13670	Unformed surface Flat surface	15 9	6 4
BS 8204	SR3 SR2 SR1	10 5 3	No norme
ACI 117	Usual100% 90% moderate level 100% 90% Flat100% 90%	19 13 16 10 10 6	No norme

This method is widely used because it is inexpensive, easy to understand, but has several drawbacks: difficult to measure larger floor space, difficult to obtain random results, and multiply test results.Therefore, less labor-intensive and more sophisticated measurement technologies, such as the F-Number method, Terrestrial Laser Scanning (TLS), BIM quality control, have been developed.

The US and its impact countries use the ASTM F-Number System. (F Number systems) The ASTM E-1155 test method results in measurements of a plurality of floor surfaces, from which the floor surface flatness F_F and levelness F_L are statically calculated [2].

Table 6

Floor surface classification	General flatness SOF_F	General plain SOF_L
Normal	20	15
Moderately smooth	25	20
Smooth	35	25
Very smooth	45	35
Excellent smooth	60	40

F numeric meter F Speed Reader moves through the floor between start and stop points and collects data digitally [15]. Such measurements carrie out on the entire intended floor. Data is entered on a computer and processed by the F Speed Reader program. The computer performs a survey analysis and generates general and local F numbers, as well as summarizes the table.

Terrestrial Laser Scanning (TLS) is a new measurement technology the Laser Camera moves through the surface of the measuring floor and, with laser light, obtains accurate data in 3D dimensions at high speeds. The scanner inputs data into the data cloud, from which you can obtain specific sizes, visualizations, and save valuable information. Also, the results obtained are not consistent with current standards. According to scientists, this method is not yet fully suitable for floor quality control [3].

BIM quality control. BIM is a smart digital model-based process for designing and managing building and infrastructure construction. Control takes place at two levels: firstly at the level of specifications. In England, the BIM model is closely linked to the NBS (National British Standard). Consequently, the user of the program specifies the type of floor, for example, the concrete floor and indicates a specific NBS. The specification automatically displays all the requirements for execution and tolerances for this floor type. All BIM users, both contractors and control bodies, receive precise specifications for a particular site on a specific construction site.

Secondly, the BIM model with integrated specifications ensures effective and good quality control. English authors present the experience that using the 4D BIM model with integrated specifications, the program automatically creates a list of construction components that should be controlled at each stage of construction. A control plan and controller equipment are prepared. Real measurements on a construction site are automatically compared with specifications and certain deviations.

Technology for obtaining excellent industrial building floor quality

By working with hands, the coarse bending of concrete can be done with a rake, but smooth alignment with the aluminum surface lining. In Latvia, the specialized equipment for aligning concrete "Laserscreed technology" is being used more and more.

The production of the product was based on the demand growth for high quality requirements for the level and flatness of the concrete floor surface. The machine alignment mechanism is equipped with a laser using 3-dimensional profiling system. Concrete insertion takes place with special wings. The vibrating and leveling of the concrete surface is carried out with the aluminum vibro lats installed in the unit. This technology is fast, high precision and high productivity, reaching up to $20m^2$ flattened surface per minute. Consequently, one day a large-size warehouse floor can be built and construction deadlines can be significantly shortened. One of these devices is shown in Figure 1.

Fig.1 „Laserscreed" Insertion technology [16]

Surface quality measurements

At the end of 2017, concrete floor surface quality measurements were carried out in a public building in the Vidzeme region, Latvia. The total building area is 3048.2m^2. Concrete floor surface quality measurements were made in a trading hall with a total area of 2458.0m^2. The data obtained and calculated are summarized in 4 graphs. Concrete additions to this site were carried out using comparatively traditional methods, that is, using a concrete pump. Concreting was done with self-made scaling using human hand work, such as garden rakes and aluminum lats. Concrete in the construction site is delivered with a concrete mixer from a concrete production unit. The concrete grade used is C25/30 with blended steel fibers. The amount of steel fiber per 1m^3 of concrete is 20kg. The total thickness of the concrete floor is 100mm. The built-in floor structure is based on 300mm thick thickened sand layers, 150mm thick densified dolomite chips, 100mm thick extruded polystyrene and 200μ thick PVC waterproofing.

Figure 2 shows the levelness measurement device. It is a laser leveler and lata laser detector. According to the standard floor surface flatness mesurment technology, according to the British technical report, a floor surface survey plan has been drawn up and a relative mark has been determined from which measurements have been made. A measurement grid is designed to measure the floor surface in steps of 3.0m * 3.0m and measurements at intersection points of the network axis [12].

For measurement of surface flatness, according to the British technical report, the measurement value is 1/10 of the total area of the floor. In our case, the required level of flatness of the floor surface is 2458.0 / 10 = 245.8 t / m. Using a surface levelness measurement network, the number of measurements is sufficient if we use each second measurement network in each direction, it is every ~ 6.0m, which collects 360.0 t / m or 16.6% of the total surface area of the floor.

To measure the plain we used 3.0m long aluminum lata [12] and Wurth electronic caliper, as well as pencil and paper for recording. Figure 3 shows a device for measuring the surface flatness of the floor.

The results of the experiment, the surface plain, the obtained data graphically depicted in Figures 4 and 5. Figure 4 shows the curve when measured in the longitudinal direction of the building, while in Figure 5, when measurements are made in the building transverse. The curves shown in Figures 4 and 5 clearly show us the maximum and minimum values obtained as a result of the calculation, which is within ± 15mm. The values obtained are consistent with the standard floor usage. By eliminating the data obtained in the largest calculations up to a 95% limit [8]; [17], it is obtained that the maximum surface irregularity in both the longitudinal and transverse directions is within an acceptable range of 9.0mm.

Fig.2, Floor levelness measuring equipment (photo by M.Pavars).

Fig.3, Floor flatness measuring equipment (photo by M.Pavars).

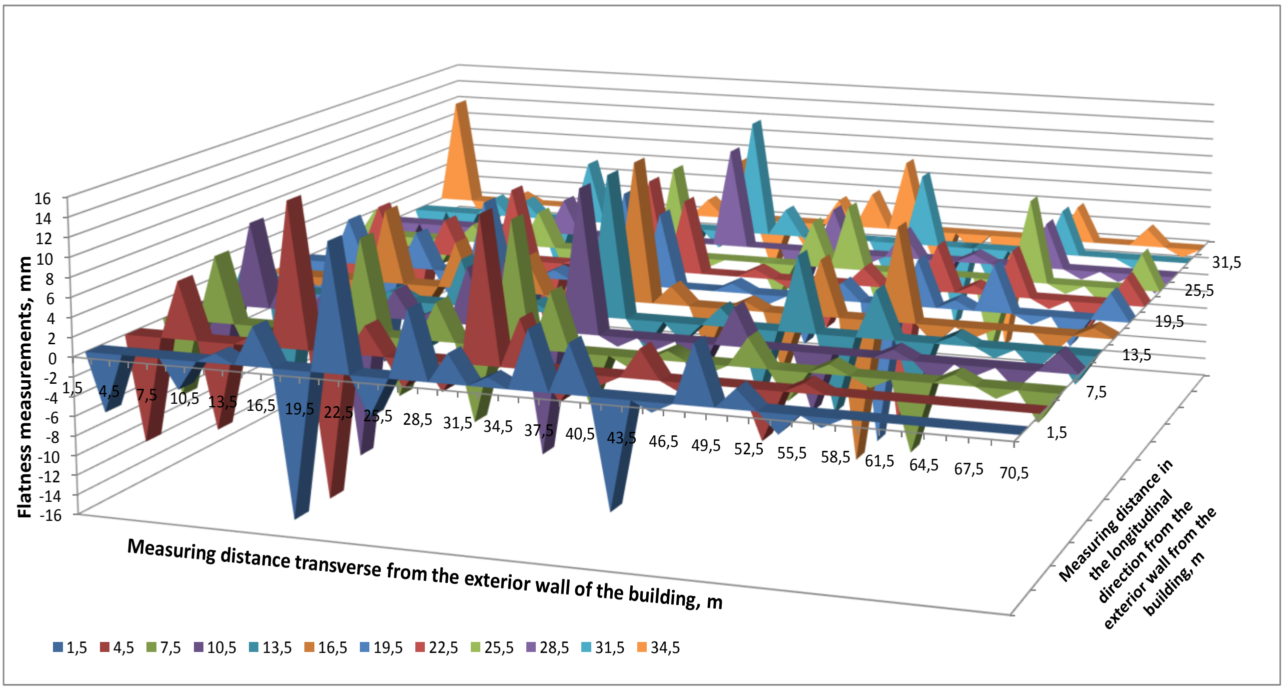

Fig.4, Graphic representation of the floor surface levelness in the longitudinal direction of the building (graph by M.Pavars).

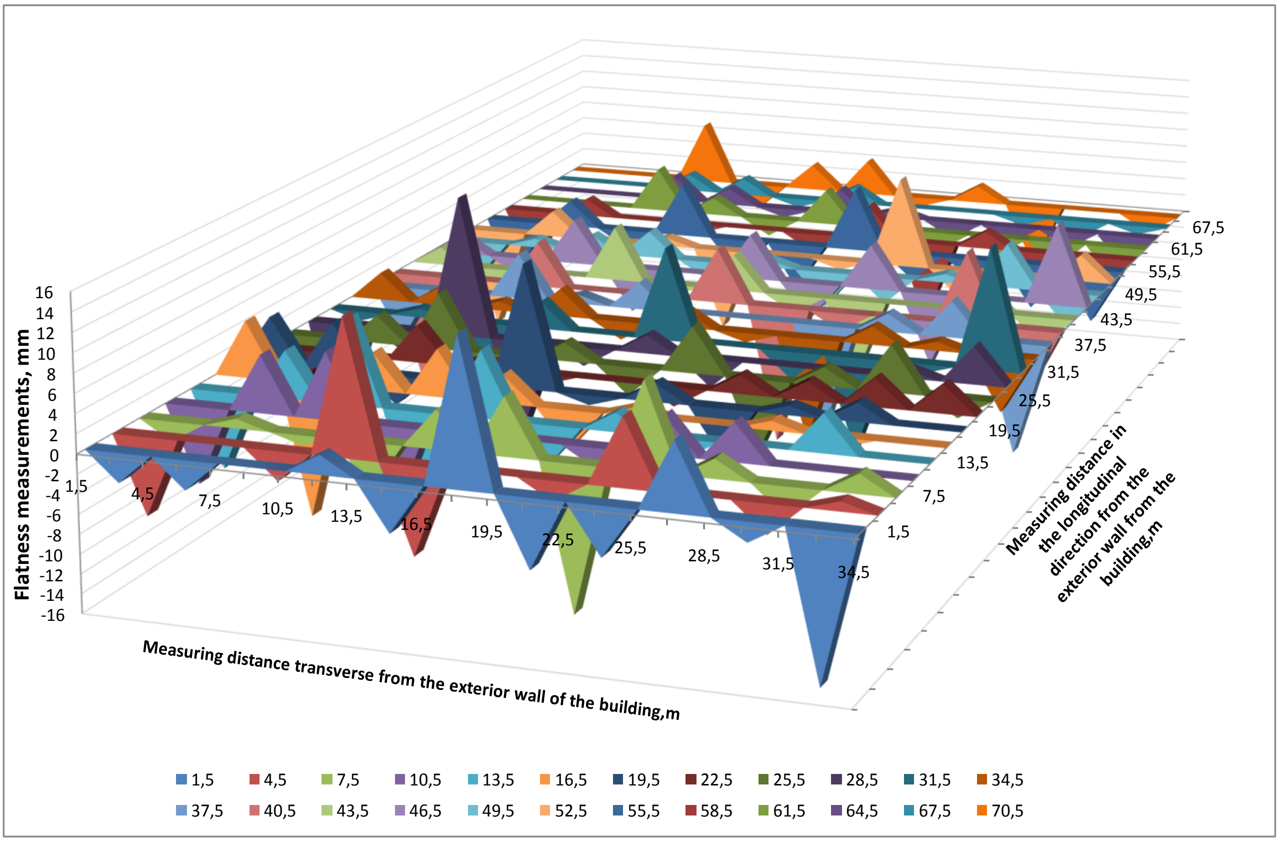

Fig.5, Graphic representation of the floor surface levelness in the transverse direction of the building (graph by M.Pavars).

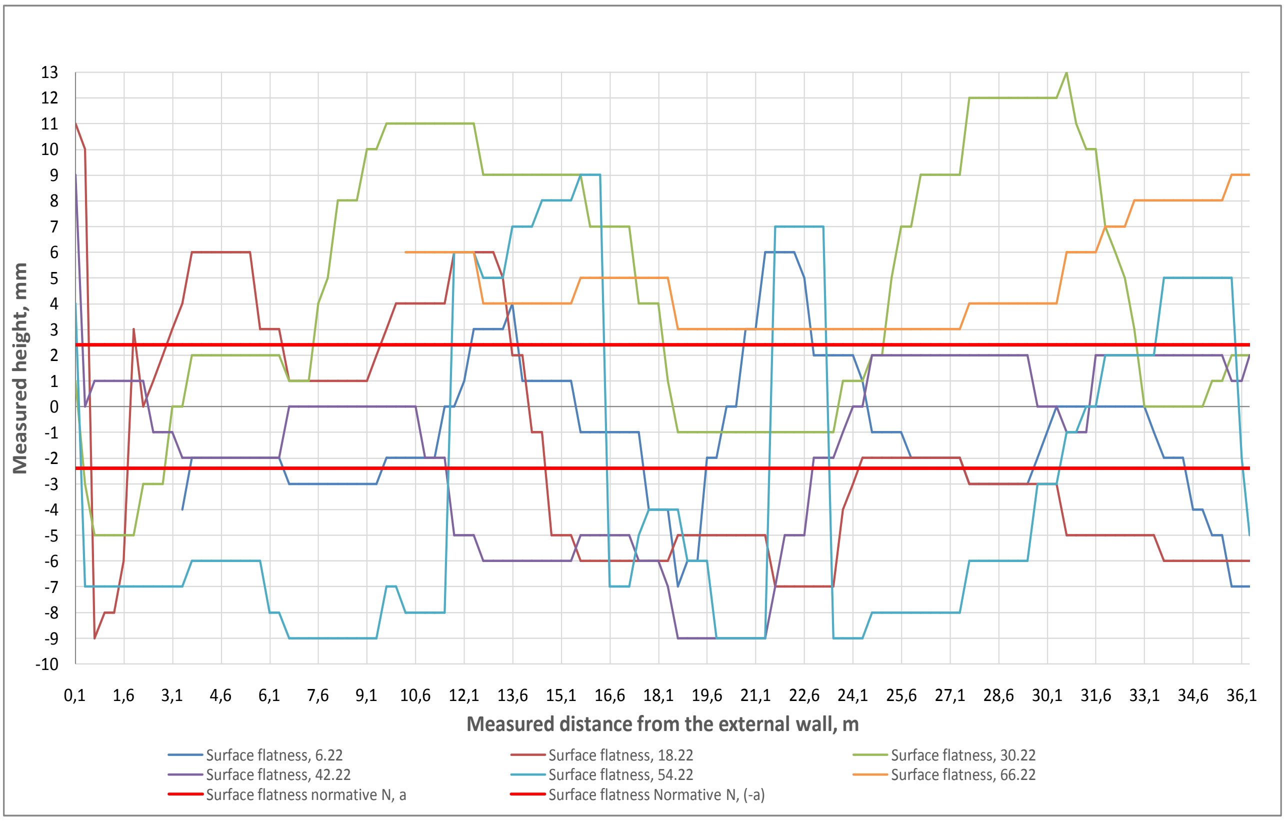

Fig.6, Graphic representation of the floor surface flatness measured in the transverse direction of the building (graph by M.Pavars)

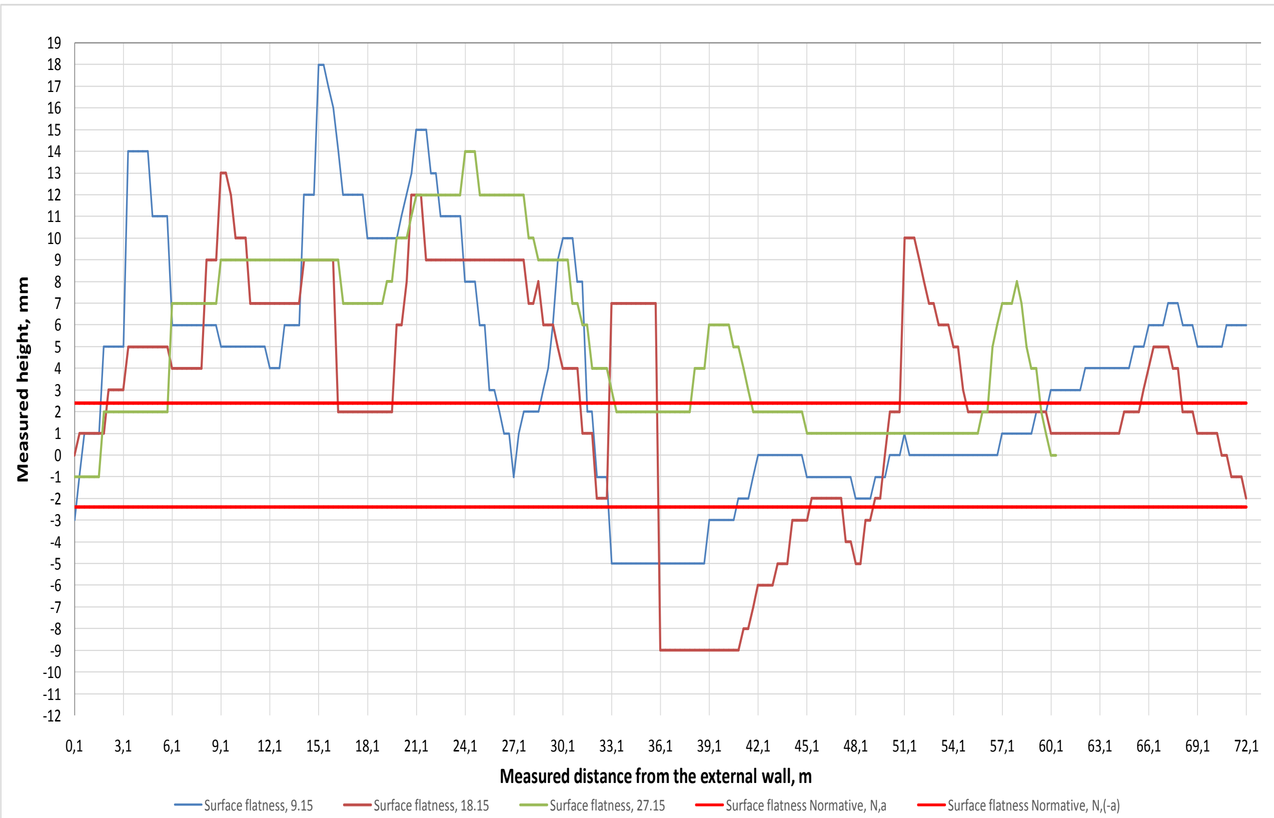

Fig.7, Graphic representation of the floor surface flatness measured in the longitudinal direction of the building (graph by M.Pavars)

Conclusions

With the concrete leveling technology used in this facility, it is not possible to obtain a standard floor surface maturity, while the surface plain is at a critical boundary reaching the maximum values specified in the Standard.

Responsible designers should, in the design process, include standard requirements for the floor use.

For Latvian buisnesmans engaged in the construction of concrete floors, think about the use of advanced technologies in their operation, such as „Laserscreed" installation equipment.

In Latvia it would be necessary, at the national level to develop appropriate standards for determining the quality of surfaces of industrial concrete floors.

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