ANNALS OF THE FACULTY OF ENGINEERING HUNEDOARA
2005, Tome III, Fascicole 2

THEORETICAL AND EXPERIMENTAL RESEARCHES REGARDING THE ESTIMATION ON THE SAFETY IN EXPLOITATION OF INDUSTRIAL CONSTRUCTIONS

[1.]Carmen Inge ALIC; [1.]Imre Zsolt MIKLOS; [2.]Nicolae MANDA

[1.] UNIVERSITATEA „POLITEHNICA" TIMIŞOARA,
FACULTATEA DE INGINERIE HUNEDOARA
[2.] S.C. „TOPOCOM" – HUNEDOARA

ABSTRACT

This paper presents recent studies on the problem of safety and stability of industrial buildings, performed through the application of procedures and techniques of interdisciplinary research.

The study, realized on buildings put in exploitation on a platform of an industrial unit in siderurgy, is illustrated in this work by analyzing the wall support from a furnace and beams of run of a traveling crane from the hall fineries.

In the end of the paper, practical criteria to elaborate forecast elements for the behavior of the buildings in exploitation are proposed, through schematization of physical real phenomenon and utilization of mathematical statistics methods.

KEYWORDS

industrial workshop, imperfections, deformations, displacements, safety in exploitation

1. INTRODUCTION

Pursuing in time the behavior of the structures of resistance under the act shipments of exploitation constitutes, as stated by the current legislation, an activity having as aim the reduction of the risks that are represented by the touch of limits states that involves in general, the loss of their capacity to satisfy the natural conditions of exploitation.

For predicting the safety of a structure in exploitation, it is necessary to recognize, in appropriate time, the moment, in which the evolution of the determinant parameters present a deviation from the evolution of the correspondent natural state of exploitation. Therefore, it is enforced to realize systematic observations and measurements, with a certain periodicity, on the deformations and movements of structural elements, with the help of which one can appreciate their evolution in time. The difference between the results of the measurements at a certain moment and the values predicted by the model indicates the normality degree of the analyzed parameters in time evolution.

2. GEOMETRICAL ASPECTS OF THE CYCLIC PURSUIT BEHAVIOR OF INDUSTRIAL HALLS

2.1. General aspects

The dominant actions carried out on the metallic halls structure with traveling crane are determined by the particularities of the technological process in action. The existence of imperfections and inoperative, which affect the resistance structures in exploitation, enforces the necessity to define an ideal scheme and , respectively, a real scheme structure, in order to have a general study on the safety in exploitation. The ideal scheme of a structure is considered to be the one compliant to the execution project; the real scheme, is defined from a geometrical and physical viewpoint, considering the imperfections, the inaccuracies and the deflections which inevitably affect the resistance structures finded out in exploitation. From a geometric viewpoint, the real structure is affected by deformations and movements that appeared in the execution and montage fazes, as well as in the period of construction exploitation. The cyclic evidenciation of the modifications on the real scheme of the resistance structure is possible through measurements and technico-topographic studies. These studies give the possibility to create a structure base "input data" for statistical prognosis study of behavior in time and safety in exploitation.

2.2. The program of topographic measurements

Analyzing the way in which the resistance structure of a industrial hall was composed, indicates the measurable sizes using specific methods of engineering topography. In the case of the hall with metallic resistance structure submitted to study, finded out in exploitation on a siderurgical metal workshop platform, the Measurements Program contained the following steps:

A. Topographic measurements of position in plan the pillars of transversal frameworks, for determining: the distances between the strings of pillars; the transversal and longitudinal inclinations of the pillars corresponding to the transversal frameworks; the longitudinal and transversal line-up of the pillars of the hall.

The building of the structure, the location of the equipments and the necessity of inclusion in the support reticulation of some topographic marks of knowed coordinates, situated outside the hall, determined the structure of the topographic meshes in the configuration presented in Fig. 1.

The meshes of topographic points of detail were developed into the horizontal plan in the longitudinal direction and into the vertical plan on three levels: at the level of the bend of the rolling tracks on the pillars; at the superior face of the shoes of the rolling tracks, respectively at the level of the crown of the rails of the runways; on the route of superior branch of the pillars.

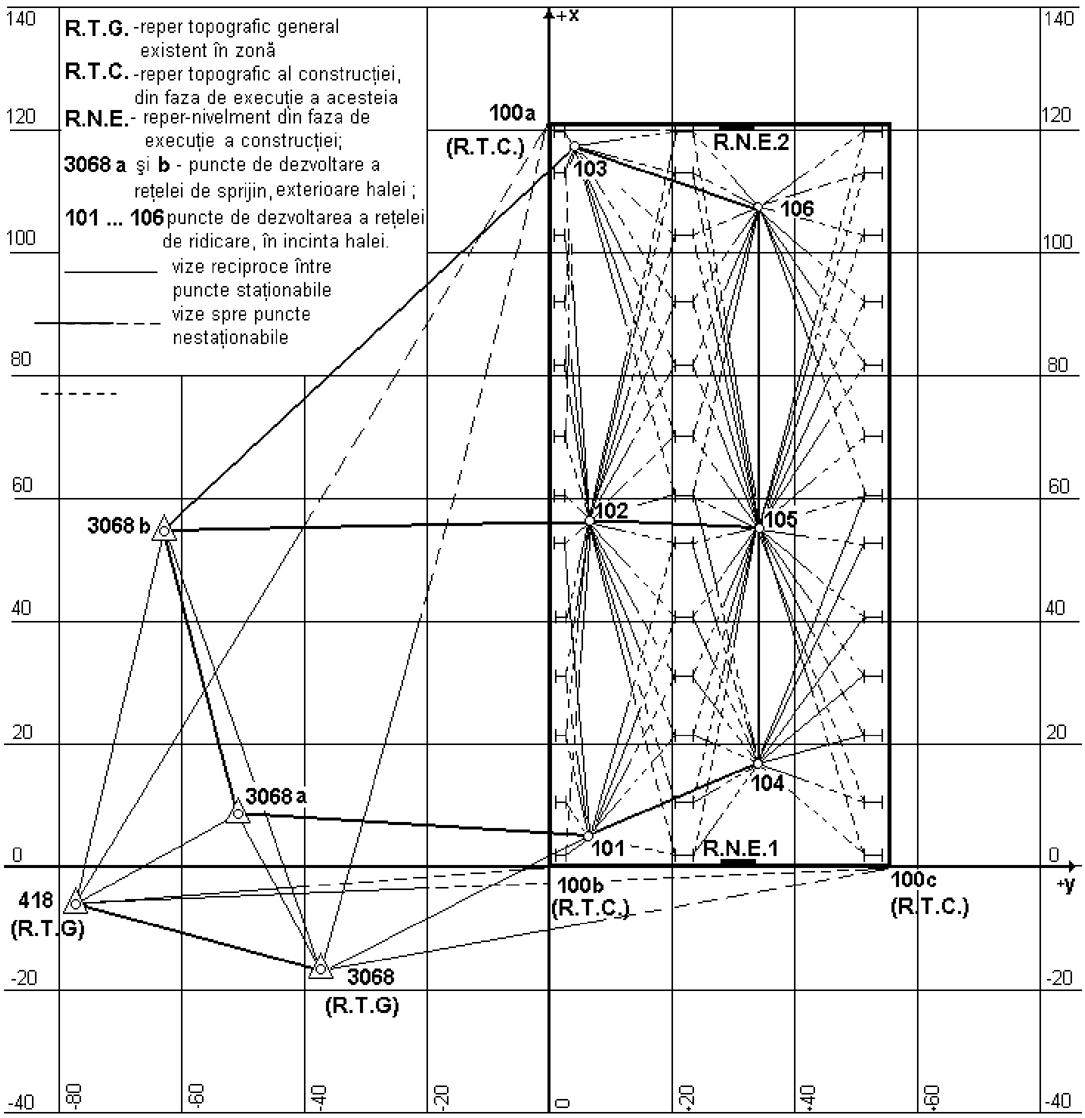


Fig.1 The configuration and the routes meshes of support, meshes of lift and the position of the existing topographic marks

In order to mark the topographic points of detail for planimetrics measurements, one uses a metallic demountable device, conceived of the authors of this paper. The component elements and the device geometry, Fig. 2, as well as the solution of fixing it on the transversal framework pillars, ensures a reduced self-weight and easy leverage, considering the quota of the work place, between 12m and 19m above the level of the finite floor. The effectuation of the planimetrics lifts through readings at the level of the axis of the branches of the pillars. This simplifies the following calculations and ensures the precision evaluation of the deformations and displacements of the structure.

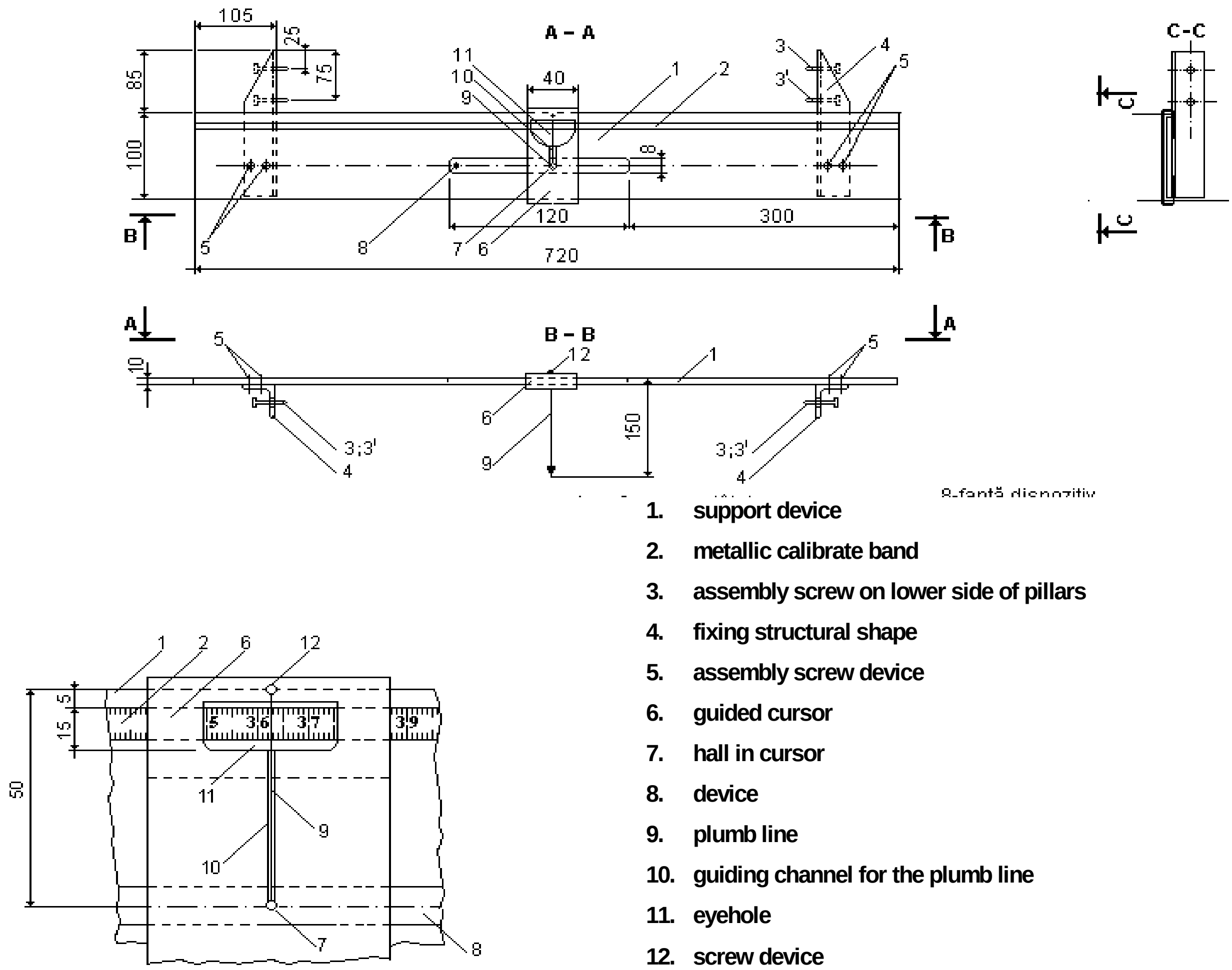


Fig.2. The demountable device/mobile mark for planimetrics measurements

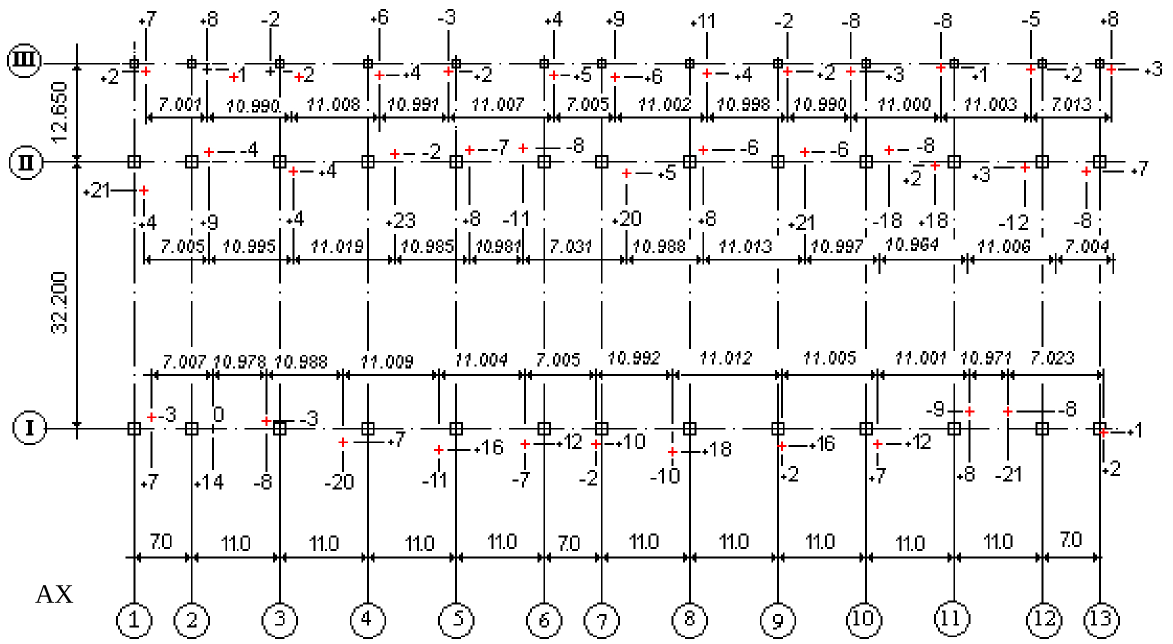
After the effectuation of the topographic measurements and the corresponding calculations, the final table of results was obtained. It is illustrated in Table 1 for the second level of measurement.

Graphic processing of the results of measurements, depicted in Fig. 3 and Fig. 4., show the differences between the ideal structure and the real structure and allow the verifying if the deflection is the limits of the safety measures normatives, from the viewpoint of functionality and safety in exploitation.

Table 1. The ultimate picture of output measurements

No. ax	Level 2 of measurement, [mm]									
	Detail point	Exploitation coordinates			Project coordinates			Aberrance		
		x	y	z*)	x	y	z*)	Δx	Δy	Δz
1	12201	0.257	43.847	250.899	0.250	43.850	250.880	7	-3	19
2	12202	7.264	43.850	250.901	7.250	43.850	250.880	14	0	21
...	...	...	...	...	...	...	...	...	...	...
10	12210	91.257	43.862	250.904	91.250	43.850	250.880	7	12	24
11	12211	102.258	43.841	250.896	102.250	43.850	250.880	8	-9	16
12	12212	113.229	43.842	250.897	113.250	43.850	250.880	-21	-8	17
13	12213	120.252	43.851	250.895	120.250	43.850	250.880	2	1	15

*) Level on the superior face shoes of runways



Position compliance project : + Real position / measure

Fig. 3. Scheme of the pillars positions, to the level of lean of rolling tracks

B. Topographic measurements on the geometry of the rolling tracks

The beams of run spans were determined through direct measurement and introduced in diagram-tables. As a result of the nivelment operations, the longitudinal profiles positions of superior shoe of the beams of run were obtained, Fig. 5.

C. Topographic measurements on ensemble runways

The following results were determinated: the quotas of the points situated at the crown of the runway in the area of the pillars and in the middle area of the cross-beam (through geometrical nivelment), for the plotting of the longitudinal execution profile; the transversal spans between the longitudinal axis of the threads of runways (using lasermeter and electronic tachymeters); deviations from the rectilinear form of the threads of runways (applying the personalized method of the alignment and using mobile marks in the device form with the metallic ruler from Fig.4, conceived by the authors of the paper).

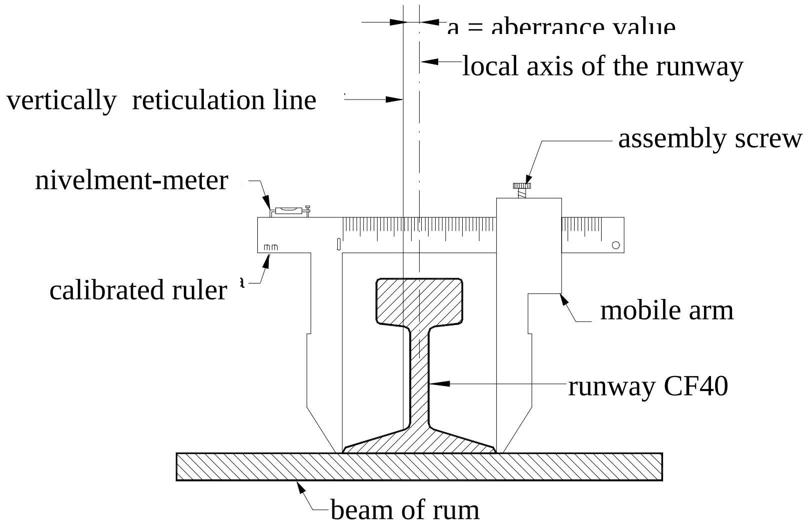


Fig. 4. Device of mobile mark type with metallic ruler

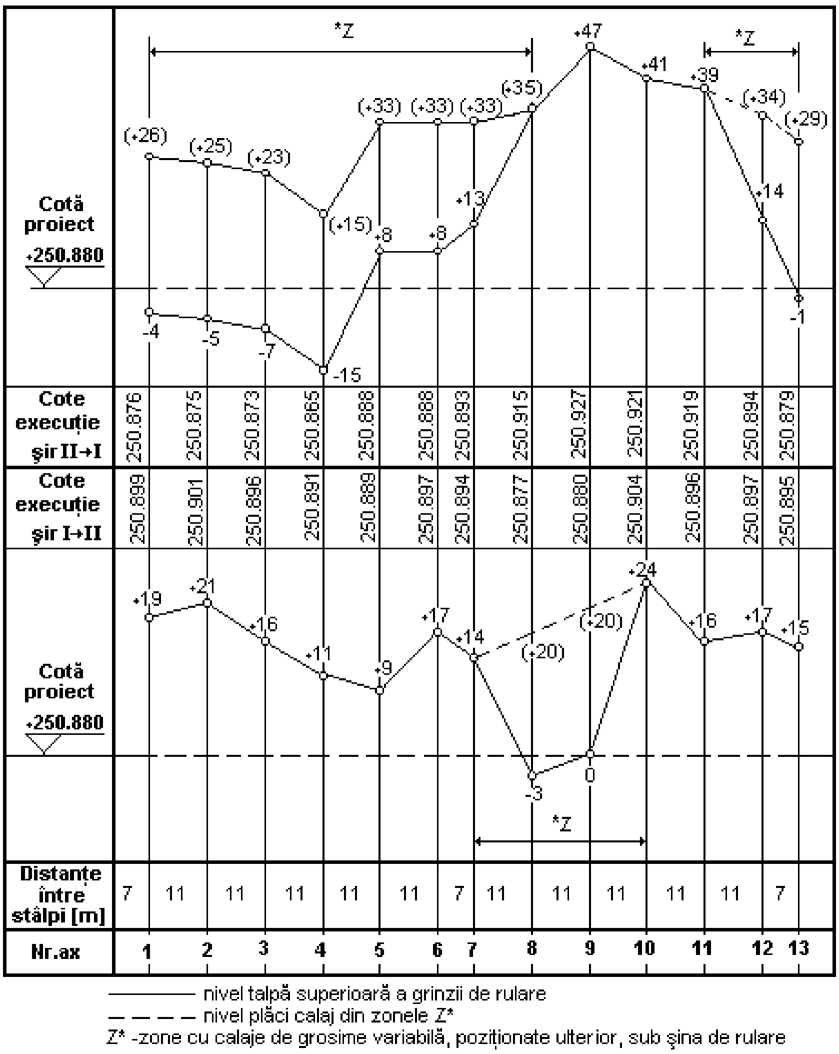


Fig. 5. The longitudinal execution shape of the beams runways.
Length scale 1:100; Height scale 1:1

3. THE CYCLIC PURSUIT OF THE BEHAVIOR OF A SUPPORT WALL

3.1 General aspects

The object of investigation is the wall support presented in Fig.6, executed for sustaining a versant, which was later the object of new investments. The necessity to adopt a program, to follow the behavior in time, was necessary because of the displacements of order 5-7 cm found in the central area, as well as the fissures and the cracks existing on the entire surface. The program scrolled over a period of 2 years, with quarterly measurements.

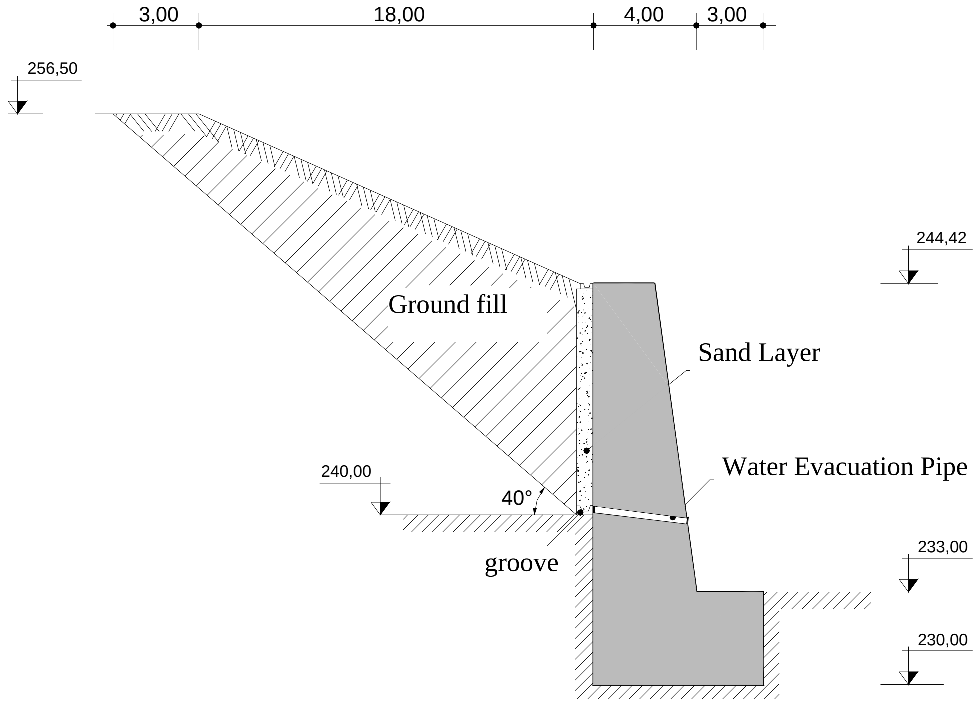


Fig. 6. Support wall from a furnace area

Because of the difficult conditions for building a local complete microtriangulation grid (the existence of annex buildings), we used the microtriangulation method with fixed base, delimitated with reinforced-concrete pillars, marked with A and B in Fig.5. The heads of the microtriangulation base were located outside of the influence zone of the support wall, parallel with the longitudinal axis and at a distance of around 20m.

The topographic measurements were realized with a theodolites THEO 010A and, in the initial cycle of measurements, the microtriangulation base was measured directly, in both ways. The cycles of measurements were undertaken at intervals of 3 months. Based on the experimental values and the values obtained from the calculations, *Files of measurements* from the special pursuits program were completed.

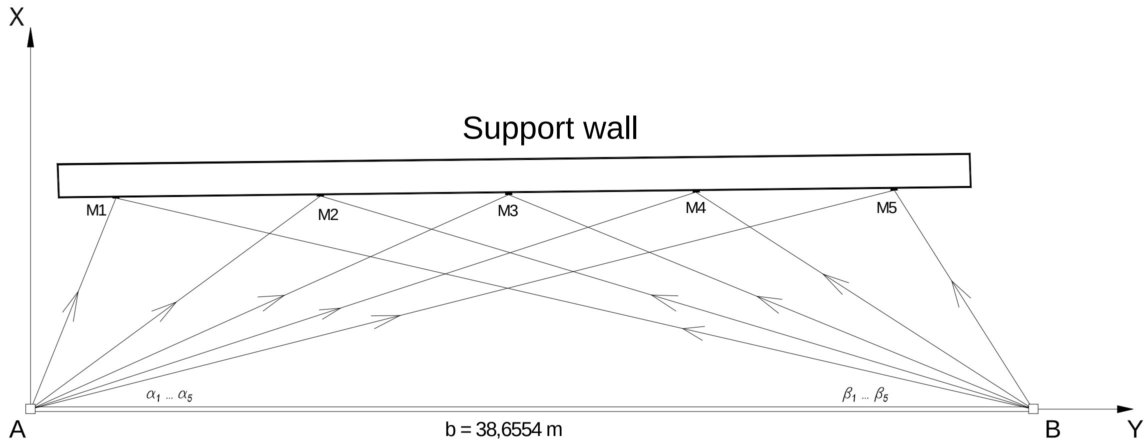


Fig. 5. Positioning of control marks

For each cycle of measurements, the Calculation file of the horizontal displacement of auditing marks was realized. Finally, the partial and the total displacements between the consecutive cycles of observation were introduced in the Centralized file, which is exemplified in table 2 for the I and II observation cycles.

Table 2. The file presentation for displacements between the I and II observation cycles

Mark	PARTIAL DISPLACEMENT [mm]		Entire displacement between cycle I and II [mm]
	initial – cycle I	*initial – cycle II*	
M1	1,201	1,470	0,269
M2	1,213	1,384	0,171
M3	1,605	1,851	0,246
M4	0,975	1,284	0,309
M5	1,133	1,564	0,431

4. PREDICTION ELEMENTS OF BEHAVIOR IN TIME. CONCLUSIONS

The possibility of realizing some elements of temporal behavior prediction is presented afterwards for the studied industrial workshop.

Following the geometrical aspects of the answer under the exploitation charges, the effectuated measurements evidenced also excessive displacements of some structure elements, displacements which generated perturbations in the normal exploitation regime of the workshop. In fig.6 presents the graphic of a points altimetry level dimensions, placed on the upper shoe of the beam of run. The displacements variation polygon is traced with the values obtained from the measurements effectuated before, as well as after the works for positioning the seat-plat in Z* area, needed to bring the thread of the bearing of run to the level prescribed in the execution project of the workshop. Then, with the level values determinated after the setting of the tables to remake the position, the curve of future values prediction was built.

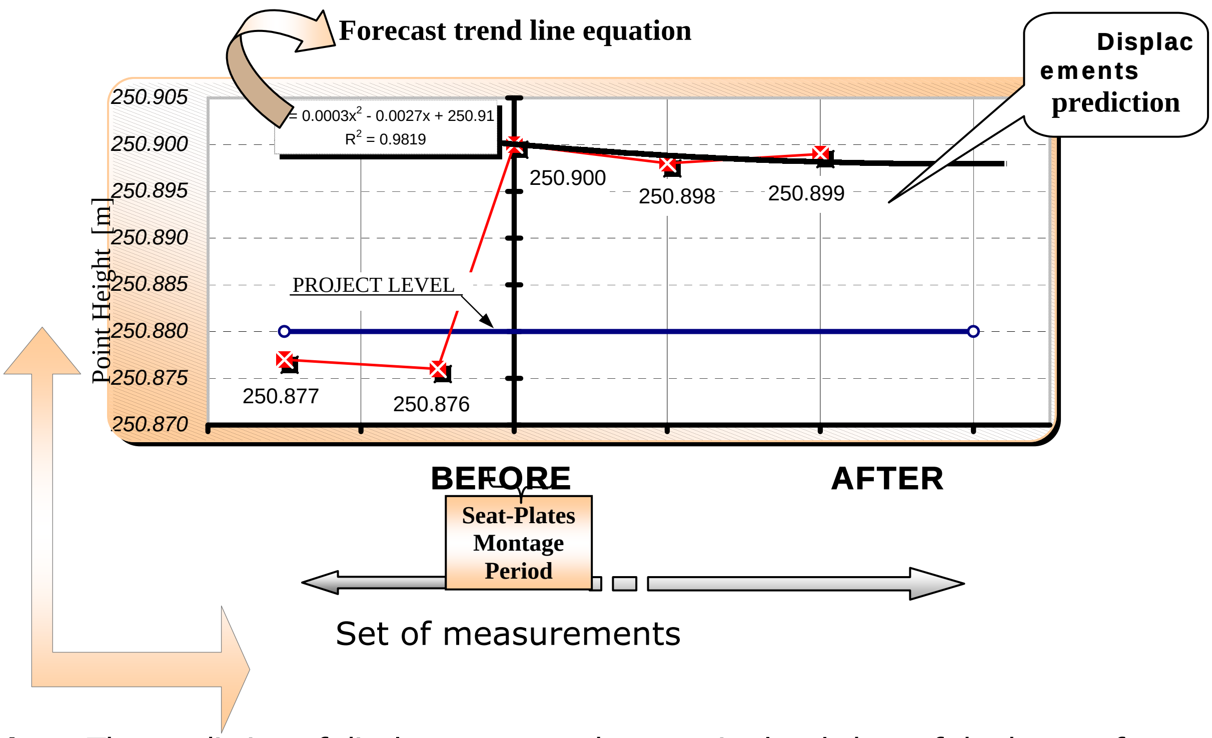


Fig.6. The prediction of displacements at the superior level shoe of the beam of run

The estimation of the deviation evolution is presented in fig.7, the forecast resulting from building the tendancy line based on the extension of the forward forecast trendline.

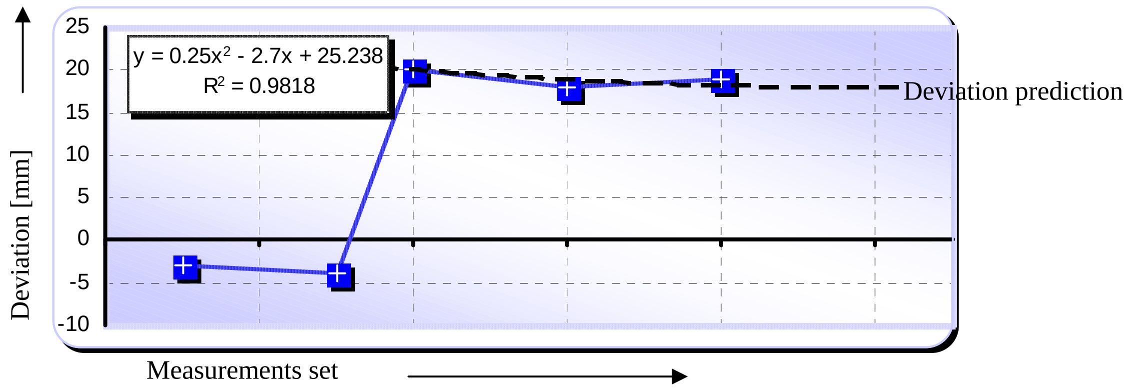


Fig. 7. The prediction of deviations from the level of thee shoe of rolling beams

Analizing the shape of the forward forecast trendline curves and the algebric coeficients of the corresponding equations, one notices a tendincy of stabilisation through temporal atenuance of the vertical displacements, which could be justified through the fenomen of spatial conlucration at displacement of the transversal frames. The authors formulate this hypothesis because the phenomenon of spatial conlucration forces the movements of the most technological loaded frameworks at a certain the moment, to be rigid or elastic correlated with the displacements of the neighboring frameworks, which are less loaded; the effect is to reorder the loads who produced lateral displacement and some of the solicitations, to which the frameworks are submitted, will be redistributed also to the neighboring frameworks.

Results from the study and investigation program: the research work that we carried out, demonstrates the importance of applying experimental research methods in correlation with interdisciplinary studies on the exploitation behavior and temporal prediction programs of safety in construction.

BIBLIOGRAPHY

[1.] Alic, C. Contribuţii la evaluarea gradului de siguranţă al halelor metalice din siderurgie, ţinând seama de condiţiile reale de exploatare - Teză de doctorat, Universitatea "Politehnica" Timişoara, 1998.
[2.] Oprescu, N., ş.a, - Manualul inginerului geodez, vol.I,II,III. Editura Tehnică, Bucureşti, 1973.
[3.] Cristescu, N.- Topografie inginerească, E.D.P. Bucureşti, 1978.
[4.] ∗ ∗ ∗ STAS 8018-80 – Construcţii pentru căi de rulare ale macaralelor şi podurilor rulante. Prescripţii generale.
[5.] ∗ ∗ ∗ STAS 6911-80 – Căi de rulare şi opritoare pentru poduri rulante şi macarale. Prescripţii generale.
[6.] ∗ ∗ ∗ Legea nr.10/1995 privind calitatea în construcţii
[7.] ∗ ∗ ∗ Regulament privind urmărirea comportării în exploatare, intervenţiile în timp şi postutilizarea construcţiilor, H.G.R.766/10.12.1997, Anexa 4
[8.] ∗ ∗ ∗ CTICM - EUROCOD No.3 Calcul des structures en acier. Regles generales et regles pour les batiments (V.2-1991).